Comparison of various estimates relevant to total CA households, 2011

Estimated non overlapping technical eligibility for 2011, all IOU households "deduped" using small area comparison approach:	
A.1 CARE technical eligibility statewide	12,703,914
A.2 LIEE technical eligibility statewide	13,594,146
Current year (2011) vendor household count:	
B.1 2011 vendor data (AGS 2011) household count estimate	12,703,857
B.2 Vendor count over block groups with 5 or utility households	12,566,394
Census 2010 -- long form data from SF1 file:	
C. 2010 Census (SF1) file household count	12,577,498
Census 2011 estimates:	
D.1 2011 Census population estimate (Census Quickfacts)*	37,691,912
D.2 2010 Census group quarter population (SF1)	819,816
D.3. stimated population in households, 2011	36,872,096
D.4 Average household size estimate, American Community Survey 2006-2010	2.89

D.5 Implied 2011 household count	12,758,511

California Department of Finance:

E.1 Population change 2010-2011, DOF **	261,000
E.2 Rough implied household growth at household size 2.89	90,300
E.3 Rough implied household count, 2011 (C., E.2)	12,667,798

* http://quickfacts.census.gov/qfd/states/06000.html
** http://www.dof.ca.gov/research/demographic/reports/estimates/e-2/view.php

Comparison of various estimates relevant to total CA households, 2012

Estimated non overlapping technical eligibility for 2012, all IOU households "deduped" using small area comparison approach:

A.1 CARE technical eligibility statewide	12,718,104
A.2 LIEE technical eligibility statewide	13,620,776

Current year (2012) vendor household count:

B.1 2012 vendor data (AGS 2012) household count estimate	12,811,083

B.2 Vendor count over block groups with 5 or utility households	12,658,703
Census 2010 -- long form data from SF1 file:	
C. 2010 Census (SF1) file household count	12,577,498
Census 2012 estimates:	
D.1 2012 Census population estimate (Census Quickfacts)*	38,041,431
D.2 2010 Census group quarter population (SF1)	819,816
D.3. stimated population in households, 2012	37,221,615
D.4 Average household size estimate, American Community Survey 2006-2010	2.89
D.4A Average household size estimate, American Community Survey 2007-2011	2.91
D.5 Implied 2012 household count (D.3/D.4A)	12,879,452
California Department of Finance:	
E.1 Population change 2010-2011, DOF **	261,000
E.1A Population change 2011-2012, DOF **	256,000
E.2 Rough implied household growth 2010-2011 at household size 2.89	90,300
E.2A Rough implied household growth 2011-2012 at household size 2.91	88,000
E.3 Rough implied household count, 2012 (C., E.2,E2A)	12,755,798

* http://quickfacts.census.gov/qfd/states/06000.html
** http://www.dof.ca.gov/research/demographic/reports/estimates/e-2/view.php

Estimated non overlapping technical eligibility for 2013, all IOU households "deduped" using small area comparison approach:

A.1 CARE technical eligibility statewide	12,727,336
A.2 LIEE technical eligibility statewide	13,631,879

Current year (2013) vendor household count:

B.1 2013 vendor data (AGS 2013) household count estimate	12,869,097
B.2 Vendor count over block groups with 5 or more utility households	12,717,759

Census 2010 -- long form data from SF1 file:

C. 2010 Census (SF1) file household count	12,577,498

Census 2013 estimates:

D.1 2013 Census population estimate (Census Quickfacts)*	38,332,521
D.2 2010 Census group quarter population (SF1)	819,816
D.3. Estimated population in households, 2013	37,512,705
D.4 Average household size estimate, American Community Survey 2007-2011	2.91
D.4A Average household size estimate, American Community Survey 2008-2012	2.93
D.5 Implied 2012 household count (D.3/D.4A)	12,890,964

California Department of Finance:

E.1 Population change 2010-2012, DOF **	did not estimate
E.1A Population change 2010-2013, DOF **	895,193
E.2 Rough implied household growth 2010-2012 at household size 2.91	did not estimate
E.2A Rough implied household growth 2010-2013 at household size 2.93	305,527
E.3 Rough implied household count, 2013 (C., E.2,E2A)	12,883,025

* http://quickfacts.census.gov/qfd/states/06000.html
** http://www.dof.ca.gov/research/demographic/reports/estimates/e-2/view.php

Estimated non overlapping technical eligibility for 2014, all IOU households "deduped" using small area comparison approach:

A.1 CARE technical eligibility statewide	12,785,130
A.2 LIEE technical eligibility statewide	13,689,728

Current year (2014) vendor household count:

B.1 2014 vendor data (AGS 2014) household count estimate	12,877,873
B.2 Vendor count over block groups with 5 or more utility households	12,723,432

Census 2010 -- long form data from SF1 file:

C. 2010 Census (SF1) file household count	12,577,498

Census 2013 estimates:

D.1 2013 Census population estimate (Census Quickfacts)*	38,332,521
D.2 2010 Census group quarter population (SF1)	819,816
D.3. Estimated population in households, 2013	37,512,705
D.4 Average household size estimate, American Community Survey 2008-2012	2.93
D.4A Average household size estimate, American Community Survey 2009-2013	2.94
D.5 Implied 2013 household count (D.3/D.4A)	12,802,971

California Department of Finance:

E.1 Population change 2010-2012, DOF **	did not estimate
E.1A Population change 2010-2013, DOF **	1,251,129 (2010-2013 was est 895,193, DOF 2013-201
E.2 Rough implied household growth 2010-2012 at household size 2.91	did not estimate

E.2A Rough implied household growth 2010-2013 at household size 2.94	425,554
E.3 Rough implied household count, 2014 (C., E.2,E2A)	13,003,052

* http://quickfacts.census.gov/qfd/states/06000.html
** http://www.dof.ca.gov/research/demographic/reports/estimates/e-2/view.php

All counties but Del Norte, Modoc
are "touched" by IOUs.

A.1, but fall short of
A.2, despite efforts to
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Vendor counts reasonably
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PRISM: An Introduction

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(Received January 1986)

WHY KEEP SCORE?

In the past, programs designed to induce energy conservation in housing have nearly all been casual about their measurement of energy savings. In many cases, savings are unashamedly asserted without being measured: the monitors keep score with a yardstick scaled by the number of participants or number of dollars spent rather than the actual amount of energy saved, or they rely on engineering models which, lacking calibration to real-world experience, notoriously overestimate the actual savings. This is particularly distressing given that the single most important objective of these programs, the saving of energy, is intrinsically quantifiable and relatively accessible by means of energy consumption data recorded systematically for another purpose — billing. Furthermore, weather adjustments are easily made from readily available temperature data, so that effects of conservation need not be obscured by differences in weather from one year to the next.

The need for reliable scorekeeping in energy conservation is increasing. Many utilities in the U.S. have undertaken extensive retrofit assistance programs for their customers, not only because of the federal Residential Conservation Service (RCS) [1], which mandates nearly free energy audits for customers, but also because of a growing commitment to energy conservation as a utility investment strategy. RCS audits have reached millions of homes. The Low-Income Weatherization Program, federally funded but managed at the community level, is bringing to many more homes an extensive, often costly, set of retrofits in addition to the energy audit. New conservation strategies, involving monetary rewards for conservation actually achieved (for example, payments from the utilities serving the retrofitted houses to the conservation company carrying out the retrofits [2]) or shared-savings arrangements between building owner and energy service company, require the savings estimates to be both accurate and unambiguous. Finally, the homeowner, whether participating in these programs or acting independently, needs feedback on the effectiveness of his or her conservation investments.

Companies which offer conservation services invariably need help in informing the customer about how much energy — and money — his or her purchase is likely to save. With records of actual savings achieved, companies could understand, quantitatively, the value of what they sell. The resulting picture could become one of satisfied, savvy customers dealing with a company able to convey accurately the value of its own services.

IT'S EASIER THAN IT MAY SEEM

Perhaps surprisingly, keeping accurate scores on the actual amount of energy saved is straightforward, and the required data, whole-house meter readings and average outdoor temperatures, are readily available. The PRInceton Scorekeeping Method, PRISM, uses utility meter readings from before and after the retrofit installation, together with average daily temperatures from a nearby weather station for the same periods, to determine a weather-adjusted index of consumption, Normalized Annual Consumption or NAC, for each period. The procedure is depicted in Fig. 1(a). Analogous to (and, based on field measurements, clearly more accurate than) the U.S. federally mandated miles-per-gallon rating, the NAC index provides a measure of what energy con-

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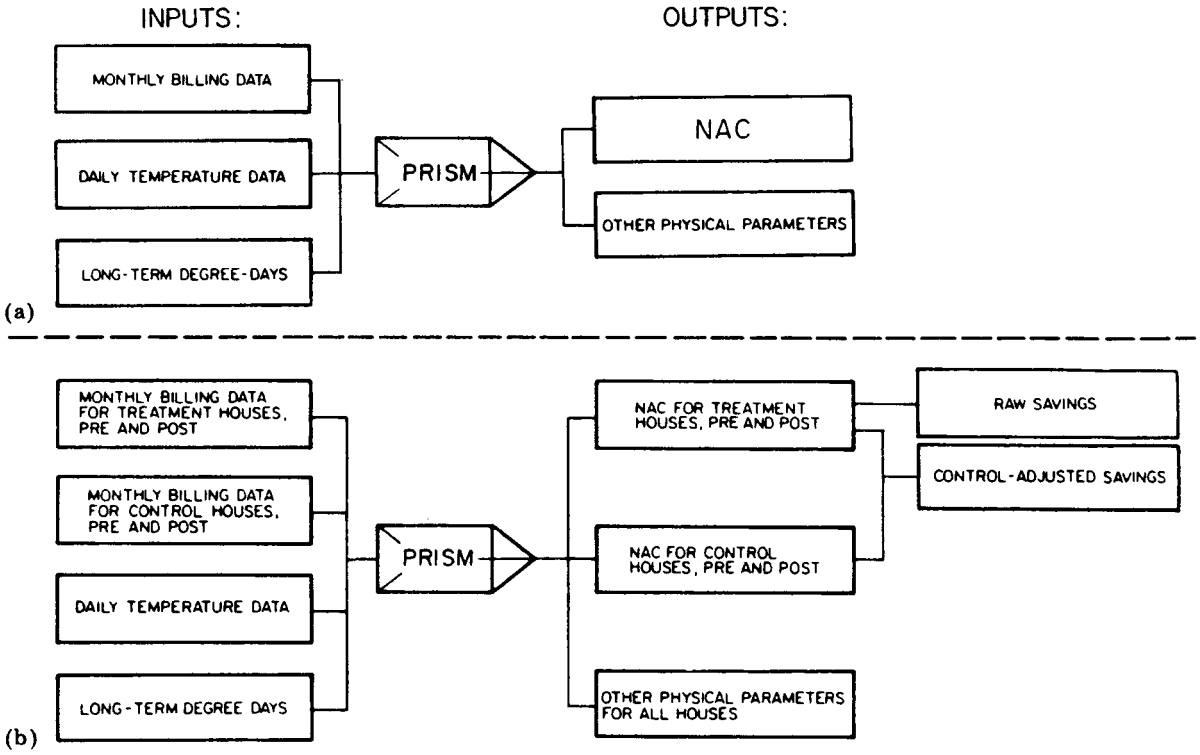

Fig. 1. Schematic diagram showing the data requirements for the Princeton Scorekeeping Method (PRISM) and the estimates that result from it: (a) the basic procedure for one house; and (b) the procedure for calculating control-adjusted savings for a group of treated houses.

sumption would be during a year under typical weather conditions. Total energy savings are derived as the difference between NAC in the pre- and post-periods. A conservation effect is thus neither masked by a cold winter nor exaggerated by a warm one, nor is it obscured if the time covered by billing periods in one "year" is longer or shorter than in another.

PRISM is certainly not the first method to include weather normalization. In fact, the simple relationship between a house's energy consumption for space heating and outside temperature was recognized, in the published literature, at least 80 years ago [3]. Even before natural gas pipelines were available, weather information was crucial input to gas dispatching and production decisions [4]. In the current literature, there is a variety of methods that have features similar to PRISM's [5].

The origins of PRISM date back to Princeton University's earliest energy analyses of buildings, in the 1970s [6, 7]. In its current form, PRISM differs from other approaches in several important ways: in its *physical foundation*, which allows a physically meaningful interpretation of the results; in its emphasis on *reliability*, particularly of the NAC index, which in general is extremely well determined; in its *standardized output*, which facilitates comparisons across programs, and its accurate *error diagnostics* attached to all the estimates it produces; in its *availability*, to a wide variety of potential scorekeepers; and, finally, in its objective of *generality*, to all fuel types and to a wide range of building types and climates.

We define the word "scorekeeping" to mean the measurement of actual energy savings. PRISM is thus a particular scorekeeping method. Its purpose is to describe the past rather than predict the future. A static model, PRISM is not appropriate, as some dynamic models are, for the management of a building — to schedule thermostat setbacks, for example. On the other hand, these dynamic models are overly complicated for scorekeeping, which requires only long-term averages of consumption, i.e., data that

are readily available for large numbers of houses, or buildings in general. PRISM is designed to be a scorekeeping tool that makes the best possible use of such data.

TOWARD A STANDARDIZED APPROACH

Until recently, the haphazard array of approaches used to evaluate retrofit programs has made it impossible to compare savings from one program to another, or to aggregate the effects across programs. When the first "scores" came in from selected RCS and weatherization programs, many of them were disappointing [8]; yet, the lack of a coordinated approach has made it impossible to learn from mistakes or to plan for more effective programs in the future.

The progression of recent conferences testifies to the increased commitment to scorekeeping based on real data [9 - 14]. At an evaluation conference in Columbus, Ohio, held in 1982 (the first of its kind), many participants disputed the merits of billing data and argued the success of their programs either on the basis of number of participants or from engineering estimates of the energy saved, rather than from knowledge of actual savings achieved [9]. Since then, especially at biennial summer studies in Santa Cruz, California, the discussion of evaluation has shifted from "whether" to "how" to use real data [11, 12]. Now, as seen at the 1985 evaluation conference in Chicago, there is agreement on the importance of a standardized approach for measuring energy actually saved, and, among many, consensus on PRISM as the method of choice [14]. (Two of the several PRISM-based evaluations reported at the conference are summarized in refs. 15b and 15c, in this issue.) The seemingly inevitable, and occasionally embarrassing, shortfall of actual savings relative to engineering estimates is now part of the common experience. Further, the availability of a well tried method for measuring these savings is allowing the concern to shift to broader issues: how to choose the control group, how to use the savings estimates to evaluate a program's cost-effectiveness, and what conservation lessons can ultimately be learned from comparisons across programs.

Adjustment for the performance of a group of untreated, "control" houses can be an important part of scorekeeping, when it is desirable to decouple the savings induced by the measures of interest from the savings that would otherwise have occurred due to external events (such as increased energy prices). Evidence of extensive and continuing conservation over the decade since the Arab oil embargo, in the population at large, confirms the importance of adjusting the savings by a control group (see ref. 15p, in this issue). PRISM applied to both treatment and control houses, as shown in Fig. 1(b), gives a measure of control-adjusted as well as weather-adjusted savings for the treatment group. The analysis can then be updated for succeeding years, to track the durability of the savings (see ref. 15c, in this issue).

Invariably, an evaluation of a conservation program ought to go beyond the PRISM analysis, to determine the cost-effectiveness of various tried approaches to conservation, for example, or to clarify the reasons why some households saved more than others. The savings estimates, along with other PRISM outputs, provide reliable input to such analyses. Thus the PRISM analysis depicted in Fig. 1 may be thought of as standardized scorekeeping, representing stage one of the evaluation, while subsequent analyses, limited by available data and shaped by the specific needs of the project being evaluated, constitute stage two.

In this special double issue, PRISM is presented as a standardized, easy-to-use approach which utilities, communities, researchers and entrepreneurs throughout the country can adopt for measuring energy savings. Fifteen applications of PRISM are reported, ranging from specific studies of the interpretation of PRISM parameters to full-scale evaluations of retrofit programs [15].

A brief outline of these papers is given at the end of this introductory paper. We present now a description of the method: its physical rationale, the statistical procedure underlying it, and a sample savings analysis to illustrate its use. Our description here is fairly detailed; it is intended to serve as a reference for the other papers. The occasional variation on the method presented here is identified in the relevant paper.

SUMMARY OF THE METHOD

The Princeton Scorekeeping Method (PRISM) is a statistical procedure for calculating changes in energy consumption over time. For each house (or building) being analyzed, the procedure requires meter readings (or, for fuel oil, delivery records) for approximately one year in each period of interest. The consumption data are then corrected for the effects of weather, which of course is never the same for two different years, and also for differences in the time spanned by the different periods.

PRISM differs from other weather-normalization procedures in that the house's break-even temperature is treated as a variable, rather than a constant such as 18.3 °C (65 °F). Three physical parameters result from the model applied to the billing data for the heating fuel* of an individual house: *base-level consumption*, as a measure of appliance usage in the house; *reference temperature*, as a reflection of interior-temperature settings; and *heating slope*, as a measure of the lossiness of the house. Derived from these parameters, the NAC index is the reliable estimate of the consumption which would occur in a year of typical weather.

The physical basis for the model

Generally, whether for natural gas, oil or electricity, a house's heating system is first required when the outdoor temperature (T_{out}) drops below a certain level (the heating reference temperature τ), and for each additional degree drop in temperature a constant amount of heating fuel (the heating slope β) is required. Thus, the required heating fuel is linearly proportional to $(\tau - T_{out})$, and the proportional constant β represents the house's effective heat-loss rate. In addition, the house may use a fixed amount of the heating fuel per day (the base level α) in an amount independent of T_{out}. Formally, the expected fuel consumption per day, f, as illustrated in Fig. 2 for an idealized house, is given by

$$f = \alpha + \beta(\tau - T_{out})_+ \qquad (1)$$

*We use the word "fuel" to mean electricity as well as natural gas, fuel oil, or any external energy source.

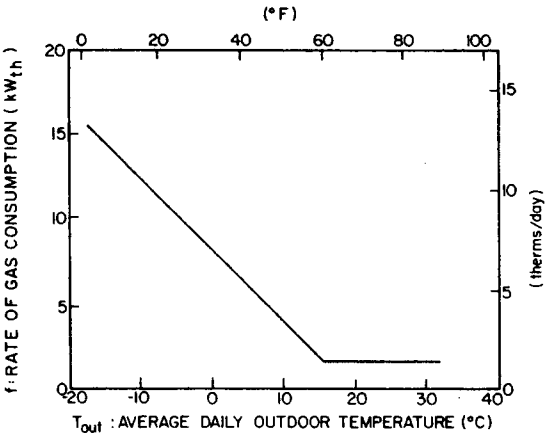

Fig. 2. Daily gas consumption (f) as a function of outdoor temperature (T_{out}), for a single idealized house. The house's energy signature is defined by a base level of 2.0 kW_{th} (equivalent to 1.7 therms/day in natural-gas units), a heating slope of 480 W_{th}/°C (0.22 therms/°F-day), and a reference temperature of 15.6 °C (60 °F).

where the term in parentheses is the heating degree-days h to base τ, i.e., $h(\tau)$, and the "+" indicates zero if the term is negative. This relationship is derived in Appendix 1.

The derivation of eqn. (1) leads to a simple physical interpretation for each of the three parameters. The reference temperature τ, which will vary from house to house, is likely to be influenced primarily by the indoor temperature T_{in} (which may be regulated by a thermostat setting)* and, in addition, an offsetting contribution from intrinsic gains (i.e., heat generated by appliances, occupants, and the sun). The heat-loss rate β depends on the conductive and infiltration heat losses, and, inversely, on the furnace efficiency, while the base level α represents the fuel requirements of appliances (including lights, for electricity, and the water heater if fueled by the heating fuel).

If τ is not accurately determined, or if it changes significantly over the time periods studied, the error or change in τ will inversely affect α, and β as well. Figure 3 illustrates this for the idealized house by plotting f vs. $h(\tau)$ for one correct and two incorrect values of τ. A straight-line fit through each set of points will have a different slope and

*In a large centrally heated building, the main boiler may be directly controlled by the outdoor temperature rather than a thermostat, thus replicating the constant-τ assumption of PRISM. Such a building is the subject of a paper in this issue [15f].

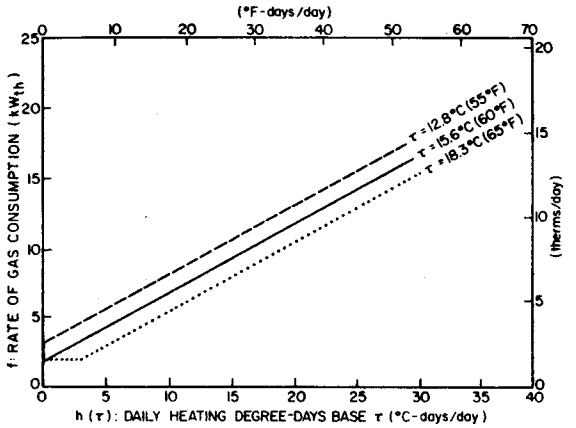

Fig. 3. Daily gas consumption (f) as a function of degree-days base τ [$h(\tau)$], for a single idealized house. The three curves correspond to the same consumption and temperature data, with degree-days calculated to different bases τ.

intercept. Therefore, an assumed (incorrect) reference temperature, such as the value of 18.3 °C so commonly used, is likely to lead to less physically meaningful values of the base level and the heat-loss rate.

Individual-house analysis

Based on this physical interpretation, the two data requirements for the analysis are actual meter readings (approximately monthly), from which consumption is calculated, and local average outdoor temperatures (daily), from which heating degree-days to different reference temperatures are computed in exact correspondence to the consumption periods. Generally, the most reliable results are obtained from a year's data [15n]. The input to the procedure is then F_i and H_i where:

F_i = average daily consumption in time interval i

$H_i(\tau)$ = heating degree-days per day computed to reference temperature τ in time interval i.

Here F_i is computed as the consumption in interval i divided by N_i, the number of days in that interval, and $H_i(\tau)$ is computed from T_{ij}, the average daily outdoor temperature for the jth day of interval i, over N_i days, i.e.,

$$H_i(\tau) = \sum_{j=1}^{N_i} (\tau - T_{ij})_+ / N_i \qquad (2)$$

The set of data points $\{F_i\}$ and $\{H_i\}$ for an approximately year-long period are then fit to a linear model:

$$F_i = \alpha + \beta H_i(\tau) + \epsilon_i \qquad (3)$$

where ϵ_i is the random error term. For a guessed value of reference temperature τ, the base-level and heating-slope parameters α and β are found by standard statistical techniques (ordinary least-squares linear regression). Using an iterative procedure based on Newton's method [16], "best τ" is found as the value of τ for which a plot of F_i vs. $H_i(\tau)$ is most nearly a straight line. Formally, τ is determined as the value for which the mean-squared error is minimized, or equivalently for which the R^2 statistic is highest. The corresponding values of α and β are the best estimates of base level and heating slope*.

The application of PRISM to real data is illustrated in Fig. 4, for a gas-heated house. The gas consumption data, F_i, plotted against time in Fig. 4(a), fall into a very straight line in Fig. 4(b) when plotted against heating degree-days H_i computed to best τ, the reference temperature determined by the model. The complete PRISM results for this house and this period are given in Table 1. At 0.985, the R^2 statistic indicates a very good straight-line fit, corresponding to the line drawn in Fig. 4(b).

The house's index of consumption for its heating fuel, NAC (Normalized Annual Consumption), is obtained from the model parameters, α, β and τ, applied to a long-term (say, ten-year) annual average of heating degree-days. NAC is calculated as follows:

$$\text{NAC} = 365\alpha + \beta H_o(\tau) \qquad (4)$$

where $H_o(\tau)$ is the heating degree-days (base τ) in a "typical" year. Once a normalization period is established, the values of H_o over the range of possible τ require a one-time cal-

*The SI units we recommend for PRISM parameters are: kW for α, W/°C for β, °C for τ, and GJ/year for NAC and other annual consumption estimates. Fuel-resource energy (for natural gas and oil) and site electrical energy are differentiated by the subscripts "th" for thermal and "elec" for electrical, respectively. The corresponding imperial units (therms for natural gas, etc.) are given in the list of conversion factors in the Foreword to this issue.

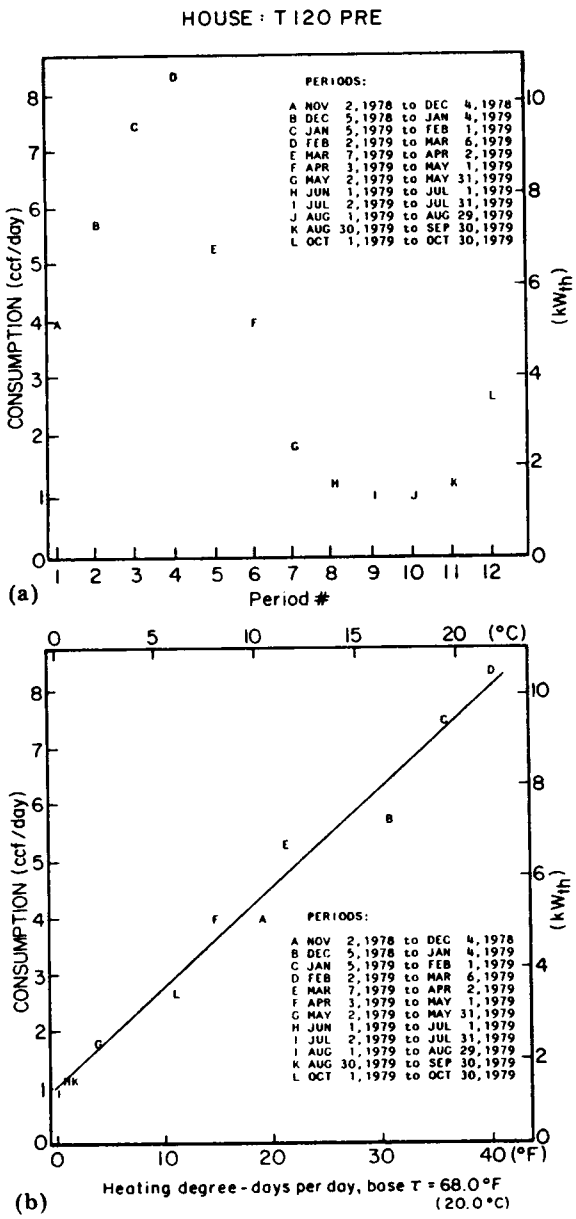

Fig. 4. Plots of consumption data (F_i) for sample gas-heated house in New Jersey. In (a) F_i is plotted against i, the (monthly) time period; in (b) F_i is plotted against $H_i(\tau)$, i.e., heating degree-days computed to best τ determined by PRISM. The straight line is the least-squares fit of the data, giving the results shown in Table 1.

culation only for each weather station used*. For standardization, we recommend a consistent normalization period; we use the twelve-year period from 1970 through 1981.

*Daily temperature data to compute H_i for each period and H_0 for the normalization period, to any integer value of τ, are available from the National Weather Service for the appropriate weather station [17]. Degree-days to non-integer τ are found by linear interpolation.

TABLE 1

Sample PRISM results for a gas-heated house*

τ	= 20.0 (±1.5) °C [68.0 (±2.8) °F]
α	= 1.12 (±0.33) kW_{th} [0.90 (±0.26) ccf/day]
β	= 400 (±30) W_{th}/°C [0.18 (±0.01) ccf/°F-day]
βH_0	= 107.1 (±9.1) GJ_{th}/year [996 (±84) ccf/year], or 75% of NAC
NAC	= 142.5 (±4.0) GJ_{th}/year [1324 (±37) ccf/year]
R^2	= 0.985

*The sample gas-heated house is house T120 from the Modular Retrofit Experiment [15a]. The estimates are derived from PRISM applied to the pre-retrofit consumption data shown in Fig. 4. Each number in parentheses is the standard error of the estimate.

Reliability of the estimates

In general, the NAC estimate provides a reliable consumption index from which energy savings and conservation trends may be accurately estimated. The small standard error of NAC for our sample house, at 3% of the estimate, is typical of PRISM results. On the other hand, the three parameters, α, β and τ, which define a house's energy signature, are less well determined, as is confirmed by the standard errors for the sample house (Table 1) as well as by other studies in this issue (see Table 2 of ref. 15k). As a result, the parameters' changes over time are often difficult to interpret due to the interference of physical and statistical effects.

The stability of the NAC index is evident in Fig. 5, which shows, for the sample house, the progression of NAC as the estimation year is slid forward one month at a time. The drop in consumption after the retrofit is evident. Note the larger standard errors of NAC for the periods falling between the pre- and post-retrofit periods. In general, NAC is quite insensitive to exactly which months are included. (The gap in the plot reflects an inevitable characteristic of real-world data sets, namely, estimated or missing readings.) The analogous plots for the individual parameters demonstrate the temporary instability as the estimation window passes through the retrofit period, and thus the importance of excluding the retrofit period from the estimation periods used for scorekeeping (see examples in ref. 15f, in this issue).

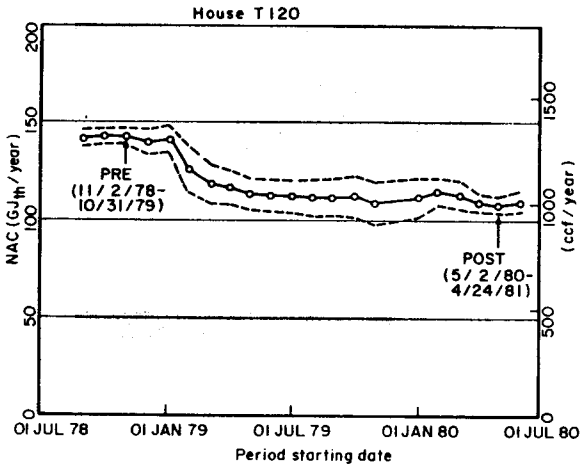

Fig. 5. Illustration of sliding PRISM, in which the one-year estimation period, starting on the date indicated, is moved forward one month at a time. NAC estimates are shown, for the sample gas-heated house used for Fig. 4 and Table 1. Dashed lines give standard errors of the estimate. Pre- and post-retrofit periods used for scorekeeping are indicated.

When a continuous series of consumption data is available, a sliding analysis such as this one can be a powerful tool not only for selecting the final estimation periods, but also for flagging anomalies in the data, and, more generally, for monitoring gradual changes in consumption. This technique has been used in a systematic study of the stability of PRISM parameters (see ref. 15n, in this issue).

While it is tempting to attribute a change in α to water-heater wrap or more efficient appliances, for example, or a drop in $\beta H_o(\tau)$ to added ceiling insulation or other measures to tighten the structure (through β) or to lowered thermostat settings (through τ), such simple physical inferences from individual-house results are usually not valid (see Appendix 1). For one thing, events affecting only one parameter are not likely to occur in isolation. For another, PRISM's assumptions that α, β and τ are constant on average from month to month over a year-long estimation period are not likely to hold perfectly in any real house. The change in the temperature-dependent component of NAC, $\beta H_o(\tau)$, is usually better determined than the change in β or τ individually, just as NAC is better determined than either that component or the base-level component, 365α. Nevertheless, the effect of the seasonal variability of appliance and water-heater usage, investigated elsewhere in this issue [15m], interferes with the interpretation of these components.

As is well demonstrated by the studies reported in this special issue, NAC is a reliable and stable *index* of consumption. At best, the other PRISM parameters provide physically meaningful *indicators*, whose changes may not be statistically significant but whose behavior can often suggest the reason for a consumption change. The need for careful interpretation of these indicators is an important theme of this issue. Accurate standard errors for all the parameters [α, β, τ, $\beta H_o(\tau)$, and NAC] are part of the standard PRISM output. Developed for this model, the "composite" method for estimating the errors includes the uncertainty in the estimation of τ as well as the estimation error from fitting eqn. (3) [16]. It turns out that α and β are much more sensitive to variations in τ than is NAC (see Fig. 2 of ref. 15k). Even in extreme cases when one or more of the parameters is poorly determined, the standard error of NAC is usually only 2 - 4% of the estimate*. This stability of NAC is PRISM's most important feature.

Estimation of group savings

The NAC estimate provides the basic index for measuring energy savings, in groups of houses from one to thousands. Computed as the change in NAC between two periods of interest, the savings estimates are weather-adjusted, and thus are independent of changes in the weather between the two periods.

When adjustment by a control group is needed, an ideal control group is one constructed by random selection of participants from a larger set, where some or all of those not selected for treatment become the controls. (This approach is used in ref. 15a.) Often such advanced planning is not possible. A less ideal though generally adequate pro-

*NAC can be reliable even in the event of an extreme anomaly, for example, when best τ is established at the highest value of daily temperature for the estimation period. (The associated standard error of τ is infinite.) Only two such anomalies occurred in the data set of 276 cases from which the example in Fig. 4 was taken [15a]. For each of the two cases, only six (bimonthly) data points were available. In both cases, NAC was well determined: the standard errors of NAC were 3.0% and 6.0% of the estimate, and the corresponding R^2 values were 0.99 and 0.94, respectively.

cedure is to match non-participants to participants after the fact, so that the control and treatment groups have similar profiles, defined, for example, by energy consumption (i.e., pre-retrofit NAC), energy prices, household size and income, and house area. Another possible, and less cumbersome, alternative is to make the aggregate of the utility serving the retrofitted houses into a surrogate control group (see Table 7 of ref. 15a, and ref. 15p).

The scorekeeping procedure presented here includes both weather and control adjustments. Using billing and weather data for approximately year-long periods before and after (and not including) the period during which the retrofits were performed, PRISM is applied to each control and treatment house included in the program. From the resulting NAC_{pre} and NAC_{post} estimates, representing respectively a house's NAC for the pre- and post-retrofit periods, the raw, weather-adjusted savings for each house is then computed as:

$$\text{(absolute)} \quad S_{raw} = NAC_{pre} - NAC_{post} \qquad (5a)$$

$$\text{(percent)} \quad S_{raw,\%} = (1 - NAC_{post}/NAC_{pre}) \times 100 \qquad (5b)$$

From the individual-house estimates, average values (medians or means*) are calculated for each group: $NAC_{pre}(T)$, $NAC_{post}(T)$, $S_{raw}(T)$ and $S_{raw,\%}(T)$ for the treatment group, and $NAC_{pre}(C)$, $NAC_{post}(C)$, $S_{raw}(C)$ and $S_{raw,\%}(C)$ for the control group. The savings for the treatment group (or for an individual treated house) may then be adjusted by the control houses, as described in Appendix 2, to give $S_{adj}(T)$ and $S_{adj,\%}(T)$.

It is important to know the errors associated with the various savings estimates. For a group of houses, the standard error of the median provides a robust measure of whether the savings in the treatment group(s) are distinguishable from the savings in the control group. For individual houses, the standard error of each savings estimate is readily computed from the standard error of NAC for each house, as given in Appendix 3.

*Although either median or mean values of NAC may be used, we recommend the median as the more 'robust' (i.e., insensitive to outliers) measure of the center of a group's distribution, and the standard error of the median as the measure of its accuracy (see Appendix 3).

SAMPLE SCOREKEEPING ANALYSIS

Our sample house (Table 1 and Figs. 4 and 5) is one of the 58 "house doctor" houses in the Modular Retrofit Experiment (MRE), a collaborative project between Princeton University and the natural gas utilities in the New Jersey area (see ref. 15a). The control group consisted of 40 additional houses. To illustrate the scorekeeping approach, we start from the savings estimated for the single house and continue through the computation of control-adjusted savings for the entire house-doctor group.

As indicated in Fig. 5, for the pre- and post-retrofit periods indicated, NAC for the sample house dropped from $NAC_{pre} = 142$ (±4) GJ_{th}/year to $NAC_{post} = 107$ (±4) GJ_{th}/year. The resulting raw savings were*:

$$S_{raw} = 35(\pm 6) GJ_{th}/\text{year}$$

or, relative to NAC_{pre}

$$S_{raw,\%} = 25(\pm 4)\%$$

The small standard errors in the savings indicate that the savings were significant.

This house saved more than the average house in the house-doctor group, for which the median savings were*:

$$S_{raw}(T) = 21(\pm 3) GJ_{th}/\text{year}$$

or, relative to NAC_{pre}

$$S_{raw,\%}(T) = 15(\pm 2)\%$$

The median savings in the control group were considerably lower, though far from negligible:

$$S_{raw}(C) = 14(\pm 3) GJ_{th}/\text{year}$$

or,

$$S_{raw,\%}(C) = 10(\pm 1)\%$$

The median control-adjusted savings for the house-doctor group, computed by the procedure described in Appendix 2, were:

$$S_{adj}(T) = 9(\pm 2) GJ_{th}/\text{year}$$

or,

$$S_{adj,\%}(T) = 8(\pm 1)\%$$

*The number in parentheses for the individual-house savings is the standard error of the corresponding estimate. The number in parentheses for the group savings (T or C) is the standard error of the corresponding sample median (see Appendix 3).

As has been the case in other retrofit programs, the control adjustment substantially deflates this experiment's raw savings. Nevertheless, the savings in the house-doctor group relative to the control group were highly statistically significant (see ref. 15a).

OTHER APPLICATIONS

The accuracy of the estimates from our sample analysis is typical of other applications of PRISM, both to gas-heated and oil-heated houses and to electrically heated houses without cooling. Summaries of model performance are found elsewhere in this issue (for example, refs. 15a and 15b for natural gas, ref. 15k for oil, and refs. 15c and 15h for electricity). For houses in heating-dominated climates, we have found R^2-values to average 0.97, and standard errors for NAC to average 3 - 4% of the NAC estimate. Even in the face of some anomalies in the individual-parameter results, NAC and the corresponding savings estimates are usually stable and reliable.

The model used in the above example, and in almost all papers in this issue, is the "heating only" PRISM model for individual houses. Two adaptations of this model have also been developed, for individual houses with electric cooling as well as heating [15h], and for large aggregates of gas-heated houses for which only total utility sales data are available [15p]. For the former, cooling analogues of β and τ are added to the model in eqn. (3). For the latter, a variation of $H_i(\tau)$ in the same equation is used to account for the billing lag. For both adaptations, NAC is on average as well determined as it is in individual-house, heating-only applications.

OVERVIEW OF THE ISSUE

PRISM was first developed for our own buildings research program. Its 1982 application to the Modular Retrofit Experiment is presented in this special issue as a prototype PRISM-based evaluation [15a]. Since then, PRISM has been widely applied to other groups of single-family houses. The Statistics Laboratory at the University of Wisconsin has used PRISM for the evaluation of Wisconsin's low-income weatherization program involving 1000 houses [15b]. Researchers at Oak Ridge National Laboratory are using PRISM as stage one of a two-stage approach, to evaluate RCS and other utility conservation programs, such as Bonneville Power Administration's Residential Weatherization Pilot Program [15c]. The Center for the Biology of Natural Systems at Queens College has applied PRISM to a smaller sample of houses in New York City, for a detailed comparison of two approaches to low-income weatherization [15d]. The method is being used extensively in Minnesota to monitor the success of a variety of city and state programs; using PRISM, the Minneapolis Energy Agency has carried out a definitive comparison of predicted vs. actual savings from RCS retrofits [15e].

Recently, researchers have begun to recognize the almost untapped resource of energy savings in multifamily buildings. In apartments in New Jersey, for example, the average energy usage per unit floor area may be double what it is in single-family houses, in spite of potential benefits from common walls in apartments*. As part of its shift in research emphasis from single-family to multifamily buildings, the Center for Energy and Environmental Studies at Princeton has extensively instrumented a 60-unit gas-heated apartment building in Asbury Park, New Jersey [15f]. High interior temperatures coupled with an unusual boiler configuration challenge the interpretability of the PRISM estimates; an engineering analysis of additional data provides an improved understanding of the results. Lawrence Berkeley Laboratory's study of a complex of apartment buildings in the San Francisco Housing Authority offers another test of the applicability of PRISM to large multifamily buildings [15g].

*For example, the per-unit NAC in a 126-unit gas-heated apartment complex in New Jersey gave 3.5 GJ_{th}/m^2 before a major retrofit and 1.7 GJ_{th}/m^2 after it [18], vs. 0.9 GJ_{th}/m^2 [15p] for the average gas-heated customer in the state. (The comparison assumes an average area of 150 m^2 per house, vs. 65 m^2 measured for the apartment complex.) The 60-unit building studied in this issue showed a similarly high average NAC per unit area [15f].

Whereas the methodology development initially emphasized gas-heated houses, special problems relating to other fuels have been the focus of recent research. Analysis of electrically heated houses can be confounded by electric cooling, even in a heating-dominated climate [15h], or by the presence of a heat-pump system which, to some extent, violates the assumptions underlying PRISM [15i]. Otherwise, gas and electricity have much in common: the data bases of monthly (or bimonthly) meter readings are equally accessible, and the seasonal dependence of non-heating consumption has a similar effect on the PRISM parameters for both fuels [15m]. Further, the effect of supplemental heating by wood on a PRISM analysis of the consumption of a conventional heating fuel is likely to be independent of whether the fuel is gas or electricity; the effect is explored here for electrically heated houses in the Portland, Oregon, region [15j]. Oil heating poses a new set of problems, not the least of which is infrequent, unevenly spaced deliveries [15k]. For any fuel, sufficent data over a year or more are needed for PRISM to work reliably; a systematic study of the stability of the model parameters provides some guidelines concerning PRISM data requirements [15n].

Often, anomalies that occur for individual houses are no longer evident in aggregated PRISM results. One short-cut aggregate approach is to apply a variation of PRISM to total utility sales data for residential heating customers (gas or electricity); extensive analysis of gas-heating customers in New Jersey has yielded promising results [15p]. Taking the analysis a step further, for the same data set and for another group of houses, the relative roles of two possible sources of conservation — shell tightening and lower thermostat settings — are inferred from the PRISM analyses [15q].

In all of these studies, NAC emerges as an extremely reliable index of consumption. The other PRISM parameters provide useful indicators of the components of NAC, but they require a sensitive interpretation with a careful consideration of their errors.

The fifteen papers presented in this special double issue provide convincing evidence that a simple method applied to whole-building billing data can become a powerful consumption monitoring, or scorekeeping, tool. The papers report progress on a particular method, PRISM. It would be naive to expect all houses, and especially the people occupying them, to obey the simple principles embodied by this method. Nevertheless, the truth told by actual meter readings, the basis of PRISM, cannot be ignored. The success of the studies thus far confirms that PRISM, though not without room for improvement, is a particularly useful way of extracting scorekeeping information from billing data.

FUTURE DIRECTIONS

The papers in this special issue emphasize applications of PRISM to conventional housing in heating-dominated climates; for climates in which the energy used for cooling rather than heating dominates, and for houses with a large solar component in their design, more research is needed. The studies in this issue focus on the fuel (gas, electricity, oil) used for space heating; in future work, the method should allow for the interaction between fuels when more than one fuel is used in a house by its furnace and appliances ("total energy scorekeeping"). The statistical procedure used for PRISM analyses is based on least-squares regression; more robust techniques, under development, would reduce the influence of anomalous data and improve the reliability of the estimates. The data bases for the analyses are primarily energy bills; the extent to which the value of billing data will be enhanced by additional data available from instrumentation, such as submeters and temperature sensors, needs to be explored. Thus far, the studies demonstrate the applicability of PRISM at two levels of analysis, to individual-house data for large samples of houses, and to utility aggregate data representing large fractions of the population; in between these two extremes, there may be additional strategies for dealing with large numbers of houses, such as clever statistical sampling of the houses being monitored, or substation or trunk-line metering to represent community-level consumption.

The primary objective of our current scorekeeping research is to realize the full potential of billing data for monitoring consumption in all climates and building types. The most

productive approach, for addressing these scorekeeping concerns and ultimately for learning about the effectiveness of conservation measures, will be studies of actual consumption data. We anticipate that the best research laboratory for these studies will continue to be real-world conservation projects.

APPENDIX 1

Derivation of physical model underlying PRISM

The space heating energy, E_h, required to maintain a house at temperature T_{in}, is proportional to the difference $(T_{in} - T_{out})$, where T_{out} is the outdoor temperature. The proportionality constant L represents the lossiness of the house. Thus, when $T_{out} < T_{in}$,

$$E_h = L(T_{in} - T_{out}) \quad \text{(A1)}$$

The lossiness has two contributions, from air infiltration losses L_i and from transmission losses L_t, i.e., $L = L_i + L_t$*. Some of this heating is supplied by the house's intrinsic gains Q, representing heat gains from appliances, occupants and the sun**, and the rest by an amount of fuel f_h burned at efficiency η, i.e.,

$$E_h = \eta f_h + Q \quad \text{(A2)}$$

Therefore, the required external fuel for space heating is

$$f_h = L(T_{in} - T_{out})/\eta - Q/\eta \quad \text{(A3)}$$

which may be rewritten:

$$f_h = \beta(\tau - T_{out}) \quad \text{(A4)}$$

where

$$\beta = L/\eta \quad \text{(A5)}$$

and

$$\tau = T_{in} - Q/L \quad \text{(A6)}$$

Thus the house's reference temperature τ (the outdoor temperature below which external fuel is required for heating) is below T_{in}, by an amount proportional to the house's intrinsic gains.

If the heating fuel is also used for other purposes such as water heating, appliances, and (for electricity) lighting, at a rate α, then the rate at which heating fuel is consumed per day is given by:

$$f = \alpha + \beta(\tau - T_{out}) \quad \text{(A7)}$$

for $T_{out} < \tau$. This is the relationship shown in Fig. 2, and corresponds with eqn. (1) in the text (see also refs. 6 and 7).

In a single-family house, the usual control system is a thermostat, which regulates the indoor temperature T_{in}. In this case, the constant-τ assumption of PRISM requires that several factors be constant from month to month: average indoor temperature T_{in}, average internal gains Q, and average house lossiness $L = \eta\beta$ (see eqn. (A6)). The constant-β assumption requires that L and η do not vary on average from month to month (see eqn. (A5)). The constant-α assumption requires non-varying energy usage for appliances, etc., fueled by the heating fuel.

Given these assumptions, several classes of interventions will induce predictable changes in α, β, and τ. Reduction of monthly average thermostat settings will decrease τ. Structural retrofits will affect β and τ: in an ideal house (seen through PRISM), a decrease in L will decrease both β and τ. An improved furnace efficiency η will also decrease β. A shift to more efficient appliances will lower α. However, by decreasing internal gains Q, this shift will increase τ (leaving β unchanged), and thus lead to an increased requirement for heating fuel that will partially offset the benefits from more efficient appliances. Any change in Q will affect τ: the addition of a household member might lower τ, for example, whereas the shift to a more efficient appliance (fueled by the heating or a non-heating fuel) will raise τ.

These theoretical expectations are valid for the ideal house such as was used in Fig. 2. When PRISM is run on real data, for which α, β and τ are not truly constant over any

*The transmission lossiness $L_t = \Sigma U_j A_j$, where A_j is the area of each exposed surface, and U_j is the corresponding transmission coefficient. To a good approximation, the infiltration lossiness $L_i = V\rho C_p$, where V is the volume flow rate of outdoor air entering the building, ρ is the density of air and C_p is the heat capacity of air; this ignores moisture-related heat loss (due to latent heat to evaporate water inside the house). See Chapter II of ref. 6, as well as the discussion in ref. 15f, in this issue.

**Our definition of intrinsic gains adds solar gains to the comprehensive list compiled by Shurcliff [19].

estimation period, statistical covariance among the three parameters often interferes with simple associations between known interventions and the observed trends in the parameters. The problem is particularly acute when the periods of estimation include major changes. Pre-retrofit and post-retrofit periods should therefore be selected to exclude interventions wherever possible.

APPENDIX 2

Computation of group savings estimates

We let the notation $[X]|_T$ and $[X]|_C$ represent the median (or mean) of the set of values of the quantity X for the treatment (T) or control (C) group, respectively.

In analogy with the individual-house savings in eqns. (5a) and (5b), the raw, weather-adjusted savings for the treatment group is given, in absolute terms, by:

$$S_{raw}(T) = [NAC_{pre} - NAC_{post}]|_T \quad (A8a)$$

and, in percent terms relative to NAC_{pre}, by

$$S_{raw,\%}(T)/100 = [1 - NAC_{post}/NAC_{pre}]|_T \quad (A8b)$$

Using similar pre- and post-periods, raw savings for the control group are analogously given by:

$$S_{raw}(C) = [NAC_{pre} - NAC_{post}]|_C \quad (A9a)$$

and

$$S_{raw,\%}(C)/100 = [1 - NAC_{post}/NAC_{pre}]|_C \quad (A9b)$$

To adjust the savings in the treatment group by the control, we define a control-adjustment factor:

$$C_{adj} = [NAC_{post}/NAC_{pre}]|_C \quad (A10)$$

Then the control-adjusted savings of the treatment group are obtained by the following:

$$S_{adj}(T) = [C_{adj} \times NAC_{pre} - NAC_{post}]|_T \quad (A11a)$$

and

$$S_{adj,\%}(T)/100 = [C_{adj} - NAC_{post}/NAC_{pre}]|_T \quad (A11b)$$

which can be simplified for a single treatment and control group as

$$S_{adj,\%}(T) = S_{raw,\%}(T) - S_{raw,\%}(C) \quad (A11c)$$

These formulae apply to an individual treated house (i.e., to a treatment group of one) as well as to the entire group. (For the MRE results presented earlier and in ref. 15a, eqn. (A11b) was applied individually to each location (module), for which a separate C_{adj} was calculated.)

APPENDIX 3

Standard errors of savings estimates

The standard errors of the savings estimates are obtained from the standard errors of NAC_{pre} and NAC_{post}, i.e., $se(NAC_{pre})$ and $se(NAC_{post})$, which are computed by a method developed for PRISM [16] and are included in the standard output for each house analyzed. For an individual house:

$$se(S_{raw}) = [se^2(NAC_{pre}) + se^2(NAC_{post})]^{1/2} \quad (A12)$$

$$se(S_{raw,\%})/100 = \{(NAC_{post})^2[se^2(NAC_{pre})]/(NAC_{pre})^4 + [se^2(NAC_{post})]/(NAC_{pre})^2\}^{1/2} \quad (A13)$$

where S_{raw} and $S_{raw,\%}$ are computed from eqns. (5a) and (5b), respectively.

When a group of houses is analyzed, the center of the distribution of the quantity X may be represented by either the mean or median value of X, i.e., by mean(X) or median(X). For each measure, there are corresponding measures of the width of the distribution of X: the standard deviation, sd(X), is generally used with mean(X), and the interquartile range, IQR(X), i.e., the length of the interval containing the middle 50%, with median(X).

The standard error of the sample mean, se[mean(X)], gives a measure of the variability of the sample mean. For a group of N houses, this is computed from sd(X) as follows:

$$se[mean(X)] = sd(X)/\sqrt{N} \quad (A14)$$

In direct analogy with eqn. (A14), the standard error of the sample median may be computed from IQR(X):

$$se[median(X)] = IQR(X)/\sqrt{N} \quad (A15)$$

This provides a measure of the variability of the sample median*. For a given quantity X, eqn. (A14) or (A15), respectively, tells how accurately the mean or median has been estimated for the larger group of houses from which the study group was drawn. Thus two alternative representations for the center of the distribution of X for a set of houses may be written:

$$\text{mean}(X) \pm \text{se}[\text{mean}(X)]$$

and

$$\text{median}(X) \pm \text{se}[\text{median}(X)].$$

In that they are more insensitive to outliers, the median measures (median value, interquartile range, and standard error of the sample median) are robust alternatives to the mean measures (mean value, standard deviation, and standard error of the sample mean). Since outliers may strongly influence the mean value, in an amount that may substantially distort the resulting representation of a group's savings (for $X = \text{NAC}_{\text{pre}} - \text{NAC}_{\text{post}}$), the median measures are usually more meaningful. On the other hand, mean measures are occasionally more convenient, since classical t-tests of significance are readily available for them. In addition, a comparison of the mean and median values is often useful, for obtaining a sense of the skewness of the distribution.

For scorekeeping, we recommend computation of both sets of measures for the quantities of interest. In general, we rely on the median measures, after they have been compared with the mean measures.

For the sample scorekeeping analysis presented in the text, the standard errors of the savings for the single gas-heated house were computed from eqns. (A12) and (A13); these represent measurement errors. The standard error of the sample median of the house-doctor group's savings, from eqn. (A15), was used to represent a measure of the variation across houses. To some extent, the latter includes the effect of the measurement error for each house (eqns. (A12) and (A13)), which is generally, for all PRISM parameters, much smaller than the corresponding estimate's variation from house to house.

*The standard error of the median is a new quantity inferred from other work [20, 21]. Use of eqns. (A14) and (A15) for the standard error of the mean or of the median implicitly assumes that the errors in estimating a given quantity in different houses are uncorrelated. If this assumption is invalid, these formulae understate the uncertainty of their respective mean and median estimates, though not by much if (as is usually the case) the measurement errors are small relative to the house-to-house variation of the estimate.

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HVAC Impact Evaluation FINAL Report

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Executive Summary

The 2010-12 investor-owned utility (IOU) energy efficiency program portfolios included a statewide program and various third-party programs targeting commercial and residential unitary HVAC systems. The impact measures for HVAC systems are categorized into three measure groups: Quality Maintenance (QM), Quality Installation (QI), and Upstream Equipment Incentives. Combined, the ex-ante saving estimates for these programs comprise approximately 177.2 gigawatt-hours (GWh) across investor-owned utility portfolios adopted for the 2010-12 cycle; and more importantly, they comprise 60.2 megawatts (MW) of electric demand savings claims.

Commercial Quality Maintenance

The evaluation team evaluated the installation rate and gross savings associated with the IOU Commercial Quality Maintenance (CQM) programs.[1] There were two program types for commercial quality maintenance (CQM): the statewide program, which promoted "standards-based maintenance", based on the ASHRAE/ANSI/ACCA[2] 180 standard and addressed a package of measures, and the third-party/local programs, which continued to implement individual maintenance measures similar to the 2006-08 programs. Within the statewide programs there were also claims in 2010 that were based on the previous program models with individual measures. While it was anticipated that a significant amount of savings would come from the statewide CQM packaged measures, they ultimately only accounted for 5% of total CQM ex ante energy savings and 3% of total CQM ex ante demand savings. The effort to assess installation rates for third-party/local programs was added to the scope of the evaluation after realizing the lower relative amount of savings being claimed from the statewide CQM packaged measures.

Evaluation of Statewide CQM Measures

The evaluation initially focused on the statewide programs. The statewide program workpaper assumed all units treated by the program would be brought to a performance baseline after maintenance. The conditions before maintenance vary according to the unique deficiencies present in each unit. The statewide CQM workpaper took an "expected value approach" based on assumptions about the frequency and combinations of measures that would be implemented, on average, across all projects.

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[1] The evaluation team developed net to gross surveys and completed a small sample for contractors and customers, but did not calculate a net-to-gross ratio due to methodological issues.

[2] American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), American National Standards Institute (ANSI), Air Conditioning Contractors of America (ACCA)

Evaluators coordinated with the statewide programs to sample and monitor units pre- and post-maintenance. Evaluation pre-maintenance site visits focused on inspecting the units and installing data loggers to collect pre-maintenance performance data. The evaluation requested schedules and updates to allow for direct observations of program technicians addressing the measures claimed in the workpaper. Sites were then monitored in the post-maintenance period. Some units may have multiple post periods due to program technicians returning as needed for multiple visits. The evaluation analyzed logger and measurement data to estimate the initial and final performance after all reported service visits.

The evaluation completed a much smaller and more clustered sample of units than originally planned. The program design and evaluation timing led to issues with gaining access for pre-measurement. The evaluation timing required pre-measurement with expedited measure installation and program inspections to confirm measures claimed by the program. Better coordination and cooperation between implementers and evaluators would have mitigated many issues associated with site access and maintenance inspection, but absent this coordination we have reported the savings based on the sample available sample. Data collection included multiple service visits by the program, but the actual tasks accomplished by the implementer at each site were not always reported or ultimately claimed in final tracking data. In the course of conducting the pre/post monitoring activities, observations of technicians performing maintenance indicated issues with the maintenance procedures and protocols, prompting an enhanced focus on observation activities and post-service inspections. Additional direct observations and inspections of units where savings claims were conducted at sample of sites that included contractors responsible for the majority of the Statewide CQM program savings claims. The results of these inspections are documented in Appendix B. Since these sites lacked pre-measurements, they were not used to estimate savings.

The evaluation team found that across all sampled units with pre/post monitoring, the gross savings per ton were negative for the statewide package of measures (Table 1). The results are from a limited sample and are considered indicative, but not definitive based on the calculated uncertainty in the measured savings. The variability in the per-unit savings was much larger than assumed by workpapers or in evaluation planning. The average savings was positive for SCE (but error bounds were greater than the estimate) and negative for SDG&E with significant uncertainty. SDG&E did not claim savings in 2010-12[3]. The overall pooled results across all sites with pre/post monitoring indicate impacts were not statistically different than zero savings with individual results at positive and negative extremes. These results indicate there is not a reliable average savings that can be deemed for the 2010-12 statewide package of measures.

[3] Savings claims were withdrawn from the final tracking data and in some cases units were further serviced and claimed in 2013-14 programs, but some units were dropped from the program and never claimed.

The evaluation team performed a detailed engineering assessment of all of the pre-post performance data[4]. Units with insufficient pre-maintenance data were eliminated from the analysis. The assessment found specific reasons leading to the outcome for each unit. For example, the assessment confirmed that maintenance has the possibility of increasing unit energy consumption. Program workpapers assume that bringing units up to a performance baseline can increase the efficiency and capacity, but do not account for the increase in energy consumption of the treated unit measured in this evaluation.[5] This evaluation also confirmed new findings from laboratory testing on significantly higher than expected measurement uncertainty for rooftop package unit performance.

Table 1: Final Estimated Gross Savings for Statewide Commercial Quality Maintenance (2010-12)

IOU Statewide Program	Ex Ante Average Savings Claimed	Ex-Post Pre-Post Average Savings Estimate	Sample Size	Standard Error	90% Confidence Interval Error Bound	Relative Precision	Lower Bound Savings	Upper Bound Savings
	Energy Savings (kWh/ton)							
SCE	307	705	17	605	994	141%	-290	1699
SDG&E	0	-1486	12	551	907	61%	-2393	-580
Total	N/A	-202	29	462	760	376%	-962	558
	Demand Savings (kW/ton)							
SCE	0.06	0.06	17	0.15	0.25	409%	-0.19	0.31
SDG&E	0	-0.43	12	0.13	0.21	50%	-0.64	-0.21
Total	N/A	-0.14	29	0.11	0.18	132%	-0.32	0.04

Note: PG&E had limited participation in the statewide program that addressed packages of measures.

The resulting energy savings estimates were driven by marginal unit efficiency changes from most maintenance activities coupled with significant increases in unit energy consumption caused by increasing the opening of the minimum outside air damper. The increased loads from opening economizer dampers diminished any efficiency improvement benefits obtained from implementation of other maintenance measures. In these cases, the economizers did not function effectively before or after maintenance, and opening of dampers resulted in additional ventilation air loads.

[4] A summary of the site by site assessments is shown in Appendix B.

[5] Increasing the capacity of the treated unit may reduce the load on an adjacent unit serving the same space. This interaction was not considered in the evaluation.

The analysis and assessments also confirmed laboratory findings on significantly higher than expected measurement uncertainty for measuring rooftop package unit performance. Changes in outside air damper position (a common maintenance treatment) changed air flow patterns in the mixing box, affecting measurement uncertainty and introducing bias in mixed air temperature and humidity measurements. While changes in measured space loads were unaffected, changes in the unit's overall performance (space load plus ventilation load) upon which unit savings are calculated were found to be unreliable. Importantly for this effort, unit power was available to assess overall program impacts, allowing a pre/post time series analysis of interval kW data at the individual unit level.

Evaluation of Third Party and Local Program CQM Measures

A verification analysis was conducted for key individual maintenance measures promoted by third party and local programs. Resulting installation rates were applied to ex ante savings estimates to provide installation rate adjusted ex post evaluation results. Economizer repair and refrigerant charge installation rates relative to program criteria across all of the IOU local programs are shown in the following tables. The installation rate for refrigerant charge measures represents the fraction of refrigerant circuits that achieved claimed benefits based on post-maintenance observations. The original planned verification analysis refrigerant charge diagnostics method which relied on refrigerant temperature and pressure measurements proved inaccurate based on field and laboratory findings, thus a refrigerant evacuation and weigh-out procedure was used to assess state of charge. The installation rate for economizer repairs represents the fraction of economizers that demonstrated basic functionality in post-maintenance observations. The evaluation developed installation rates for refrigerant charge adjustment and economizer repair measures only. Observations on other measures and additional faults were reported in Appendix B, but these observations were not used to adjust program savings claims.

Refrigerant Charge Measures

Refrigerant charge was evaluated in the field by measuring ex-post diagnostic performance on 66 units where technicians made adjustments. The results of these tests were ultimately not used to assess installation rate as new information was produced in the laboratory on the uncertainty in the accuracy of charge diagnostics. Towards the end of the evaluation the team revised the charge assessment procedure and conducted the procedure on a random sample of five single-compressor and two dual-compressor units for a total of nine refrigerant circuits. For each circuit, the EM&V master technicians recovered and weighed out charge, evacuated to 500 microns, held at or below 500 microns for 20 minutes, weighed in factory charge, and measured performance with factory charge. The average refrigerant charge adjustment reported by the

local program[6] for the units evaluated was 19.4 ± 5.7%. This indicates that, on average, units had a significant amount of charge added. Recovery and weigh-out of these units indicated both over and undercharge conditions after service. Units that were still undercharged after maintenance realized some benefits, but additional potential remained. Units that had charge added and ended up overcharged had multiple outcomes including positive, zero, or slightly negative benefits.

Table 2 presents installation rate adjustments for 2010-12 refrigerant charge measure savings. A 79% install rate was developed by calculating the average achieved benefits across units based on the method used in the 2009 PG&E refrigerant charge workpaper, which was recommended by the ex ante review team as the best available data at the time. Individual units exceeded, met, or partially met the workpaper charge adjustment assumptions, with one unit showing negative benefits. Due to the small samples size, precisions are not reported by IOU. A detailed description of sample and analysis results is provided in the main report.

Table 2: Final Installation Rate and Adjusted Gross Savings for Refrigerant Charge Measures (2010-12)

IOU	Program Name	Ex Ante Energy Savings (kWh)	Installation Rate	Installation Rate Adjusted Energy Savings (kWh)
PG&E	Air Care Plus	2,339,072	81%	1,894,648
SDG&E	Non-Res HVAC Tune-up/Quality Installation	2,390,079	77%	1,840,361
TOTAL		4,729,151	79%	3,735,009

Note: Ex ante demand savings were negligible for this measure.

Recent laboratory test results from CPUC-sponsored testing and results reported by Purdue laboratories (Braun[7,8]) informed the evaluation of refrigerant charge measures. After evaluation

[6] Note that the amount of charge added or removed and unit factory charge was not always collected systematically in databases for the statewide program. This data was recorded systematically for the third party and local programs.

[7] Braun, Jim, David Yuill, and Howard Cheung. *A Method for Evaluating Diagnostic Protocols for Packaged Air Conditioning Equipment*. Purdue University and the California Energy Commission, 2012.

of the refrigerant charge measure claimed by the local and third-party programs the team determined that:

- Based on a limited sample, program refrigerant charge service achieved a combination of full workpaper benefits, partial benefits, and negative benefits, but the overall result was positive.
- Linking fault detection diagnostics (FDD) values to benefits is difficult. This means program FDD methods are not effective in assessing savings or bringing the unit to correct factory charge
- Manufacturer protocols perform better than generic third party protocols in determining whether a unit has achieved factory charge
- It is possible to assess savings benefits when using the weigh-out, weigh-in protocol, as long as the service adjustment is known.
- Title-24 protocol only looks at measuring subcooling for thermostatic expansion valve (TXV) units and superheat for non-TXV units and cannot diagnose faults in units with dirty coils, non-condensables, or refrigerant line restrictions. Observations of program trainings and review of training materials for 2010-12 programs indicate no specific FDD to address non-condensables and restrictions.

None of the FDD methods based on refrigerant temperatures and pressures can provide information on program benefits, since efficiency improvement calculations are not possible from the available data. However, the recovery/re-charge method does provide valuable insight on potential program benefits. This method should be considered in evaluating future iterations of the program. Once we weighed in the correct charge, the Title 24 and generic program protocols indicated 4 of 9 were incorrectly charged while manufacturer's data said 2 of 9 were incorrectly charged.

Based on the weighed charge method, 7 of 9 units were not within 5% of factory charge after program service. Therefore, the Title 24 or generic protocols were not an effective method to bring the unit to correct charge or assess program benefits. This field finding confirmed initial laboratory test results that FDD can lead to incorrect diagnosis. Additional common faults, which also affect the pressures and temperatures measured (e.g., contaminants, especially non-condensables and line restrictions), are not addressed by the Title 24 and generic methodology and lead to incorrect charge adjustment when not identified. Direct observations indicated that technicians in the field did not test for these additional faults and they were not covered in the observed 2010-12 technician trainings.

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[8]Braun, Jim, and David Yuill. Evaluation of the Effectiveness of Currently Utilized Diagnostic Protocols. Purdue University. 2014.

This field result combined with laboratory test results supports a recommendation for the recovery/re-charge method as the only reliable method to assess program benefits. Manufacturer protocols are better than the other methods at assessing factory charge, but they are not perfect and therefore do not always result in the program-expected benefits of the refrigerant charge adjustment. Programs should use manufacturer methods for FDD and/or confirm the preferred method is at least as accurate as the manufacturer method. Recovery/re-charge should be used by program administrators for verification on a sub-sample of circuits, and EM&V should use a recovery/re-charge method going forward to assess the benefits of program charge adjustments.

Economizer Repair Measures

For economizers, the majority of units the team inspected that reported repairs were not found to be performing their primary function of changing damper position in response to temperature. The overall verification rate was estimated at 23% which assumed that due to the claimed three year EUL and timing of inspections, 20% of inspected units should have failed functional tests. In the sample, Table 3 shows adjusted gross savings for economizers resulting from the application of this verification rate. In some cases, the technicians opened the position of the dampers but the EM&V team did not observe other changes to sensors, linkages, or control settings. In one program, technicians from multiple contractors installed new controllers and sensors, but the controls were not set up properly. Additionally, although most systems with economizers required economizer repairs, none of the technicians were observed to perform them. .Non-operable economizers were the most common fault found in post-maintenance visits. In addition to the limitations of the refrigerant charge fault detection diagnostics applied in the maintenance programs, the evaluation team believes that un-diagnosed economizer faults and uncontrolled economizer leakage presents an additional challenge and future opportunity. The evaluation team made observations of economizers for the statewide programs as well, but those results were part of the CQM package and were not disaggregated. The findings of observed economizer functionality in the statewide program are included in the main report.

Table 3: Final Installation Rate and Adjusted Gross Savings for Economizer Measures (2010-12)

IOU	Program Name	Ex Ante Energy Savings (kWh)	Ex Ante Demand Savings (kW)	Sample Size	Relative Precision	Install Rate	Installed Energy Savings (kWh)	Installed Demand Savings (kW)
PG&E	Air Care Plus	6,938,405	3,488	16	20%	25%	1,734,601	872
SDG&E	Non-Res HVAC Tune-up	3,884,115	2,571	10	26%	20%	776,823	514
TOTAL		10,822,520	6,059	26	16%	23%	2,511,424	1,386

Other Program Observations

The following additional observations were not used in determining energy savings or installation rates, but these findings are presented to suggest possible causes for the high uncertainty in savings and relatively low installation rate for economizer repairs. Master technicians performed direct observations of program service. They also observed training sessions, reviewed training materials, and reviewed QC procedures. Note the review and observations were not conducted of all trainings and QC procedures within all programs.

Although both the statewide and third-party/local programs included common measures, such as refrigerant charge adjustment and economizer repair incentives, the trainings and guidance provided by programs varied. This likely led to direct observations of technicians not repairing non-functional economizers and claimed economizer repairs not working in post-maintenance inspections. For refrigerant charge the various FDD procedures were shown to not perform as well as manufacturer protocols and ultimately only direct weight out and recharge provided enough information to estimate the benefits of program charge adjustments.

Conclusions and Recommendations

The current program and commercial unitary HVAC maintenance measures in general face various inherent challenges, many of which were not addressed by 2010-12 program workpapers. For example, the programs provide incentives for adding or removing refrigerant charge without diagnosing other faults that affect refrigerant temperatures and pressures, such as restrictions or non-condensables, that can lead to incorrect refrigerant charge diagnostics.

For CQM, the evaluation team learned it is very difficult to perform refrigerant charge correction through indirect diagnostics. A comprehensive approach is needed to optimize the efficiency of an existing system and bring the unit to a performance baseline. A comprehensive approach requires that repairs be completed that may be outside of measure definitions, such as restrictions and non-condensables noted earlier. See the laboratory testing section for additional issues that may also need to be addressed. The less-than-expected savings and installation rates from both the 2006-08 evaluation and this evaluation stem from trying to address individual faults or subsets of all faults without accounting for underlying system issues. Future field and laboratory research hold the best promise to determine the impacts of addressing faults and methods to diagnose and repair them.

The recommendations provided in this report do not cover all of the changes between the 2010-12 and 2013-14 programs. These recommendations have not been tested for cost effectiveness and they are intended as areas that should be considered and, if feasible, developed further, piloted, and tested for cost effectiveness.

To address these findings, we recommend that IOU programs coordinate to clearly define measures and ensure program workpaper assumptions match the implementation process of the measures. The terminology (maintenance, repair, retro-commissioning) is less important than defining the specific actions that take place and how those actions lead to energy savings. The IOU programs should focus on activities that will lead to energy and peak demand savings, rather than trying to address all repairs and actions. A focus should also be placed on the one-time and ongoing maintenance activities that lead to more persistent savings. Other repairs and maintenance activities that improve comfort, indoor air quality, or unit reliability may increase energy consumption or peak demand, and should be accounted for if performed.

We recommend piloting approaches that have demonstrated measurable savings. For each approach with measureable savings, the program should provide a definition and examples of the effective energy efficiency measures. In 2010-12 some programs provided lists of tools that were acceptable while others did not, but these reference documents did not list the acceptable tool for each procedure. The measure definitions should include specific training requirements, approved tools based on accuracy requirements, protocols to perform and inspect the measure, and data collection requirements. We also recommend that incentives be provided for measures with the highest probable applicability, FDD repair rate, and savings. Measure recommendations include:

- **Seal Unit Leaks.** Sealing the junctions between economizers and unit cabinets may have large opportunities as they are not part of routine maintenance. Pilot efforts should measure the change in performance in the field and use reliable sealing methods such as properly rated metal taping and mastic. This recommendation requires coordination with certified test and balance (TAB) technicians to ensure minimum requirements for ventilation are met. It is not likely that economizer perimeter leakage is intended to help

meet ventilation requirements. Economizer perimeter leakage will be further studied in the 2013-14 laboratory tests. The evaluation recognizes that any recommendation regarding reductions in outdoor air quantity raises liability concerns, but over-ventilation does waste energy. Some units are operated with fans that cycle on with compressors and may not meet ventilation requirements even when accounting for leakage. Outside air rates need to be evaluated and the leakage must be taken into account such that it is known and part of calculations.

- **Reconsider Generic Diagnostic-Based Refrigerant Charge Measures.** Identifying and adjusting units with incorrect charge proves to be extremely difficult on commercial units with outdoor air intakes and more difficult if multiple faults are present. A key issue becomes determining appropriate coil-entering sensor placement due to unmixed and temperature-stratified air on the inlet side of the coil, since the ideal placement changes with damper position. Evacuation and recharge is recommended as the best method to assess exact charge level. The evaluation team understands that this method may not be cost-feasible for program implementation, and thus the program recommendation is to follow unit specific manufacturer diagnostic procedures (see next bullet). We recommend that programs implementing this measure perform quality control verifications on a sample of completed jobs using recovery, weigh-out and re-charge.
- **Use Manufacturer Maintenance and Diagnostic Protocols or Compare Program Methods to them for Reference.** Manufacturer protocols provide important instructions on troubleshooting multiple faults for units including refrigerant charge, restrictions and non-condensables. These methods were found in field and laboratory testing to be more reliable than generic FDD protocols. Manufacturer protocols also may provide new methods for adjusting airflow based on static pressure measurements. Manufacturer protocols provide instructions on proper tensioning and alignment of fan belts. This recommendation does not preclude future FDD protocol development that provides better energy efficiency optimization. Any new methods should be compared to manufacturer methods to demonstrate they are better at achieving optimal unit performance. The accuracy of manufacturer and other FDD methods across ranges of airflow conditions and other faults continues to be a subject of laboratory testing.
- **Develop Criteria to Replace Rather than Repair Economizer**s. Repairing old economizers can be expensive and difficult due to limited availability of parts and the need to address old design issues. Economizer replacement offers an option that may overcome some of the fundamental economizer repair issues and should be explored. De-commissioning is not an energy efficiency measure and this recommendation calls for a replacement measure which would also entail installing Title 24 compliant controls with FDD. Unit age should also be considered in determining whether to repair or replace an economizer. Also note that integrating new economizer controls with older unit controls may present an issue. It should be considered whether this measure also

requires changes to settings or upgrades to unit controls (thermostat or energy management systems).

In the long term, HVAC manufacturers, industry associations, state licensing boards, and the U.S. Department of Energy (DOE) can help improve quality maintenance programs by supporting improved technician competency standards, FDD protocols, and service instrument standards. For utility programs in the short term, we recommend that additional field and laboratory tests and additional analyses be conducted to further research the energy saving potential of HVAC maintenance and the issues identified in this summary. The focus should be on efficiency and account for activities that may improve comfort and/or indoor air quality, but result in increased energy consumption. The program can adopt standards-based maintenance but workpapers should account for occupant comfort improvements at the expense of energy savings. Programs should focus on simple measures that can be reliably implemented and have demonstrated savings.

The evaluation also acknowledges that maintenance is a process that is unlike almost all other energy efficiency measures. This difference presents major measurement and evaluation challenges. Program workpapers assume changes lead to reduced HVAC demand and energy use. The statewide programs make those changes over a relatively long time period, while local and third party programs perform the measures as an event. The differences in program designs present different evaluation challenges. Measuring changes in unit operation over long periods associated with the state-wide program design limits the ability to provide timely feedback and introduces potential uncertainties associated with non-program issues. Estimating the impact of multiple measures installed at the same time within local programs affects the ability of evaluation to provide measure specific savings estimates. The recommendation for programs to pilot strategies also provides a framework for evaluation of specific measures or service actions in detail that are not easily accomplished in the evaluation of full scale programs.

Residential Quality Installation

The quality installation field assessments focused on residential systems because non-residential programs were not in full operation in the 2010-12 cycle. The residential quality installation workpaper assumed common practice baseline installation conditions as opposed to code minimums. The team conducted site visits at 50 program participant and 50 non-participant sites that recently installed HVAC units. Site evaluation staff followed identical data-collection protocols at participant and non-participant sites. Non-participating households were included to provide a baseline for the program evaluation. The non-participant homes spanned Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) service areas. Because SCE was the only IOU with a Residential Quality Installation program in 2010-12, program participants could only be recruited from within the

SCE service area. Differences between participant and non-participant sites were used to establish program savings.

Participant contractors with more units installed under the program had more units in the test sample. Participant units spanned single-family homes, duplexes, and apartment and condominium complexes throughout the SCE service area. Because the non-participant sample pool was more limited (they were identified from other recent studies as being homes that had recently installed HVAC units), the team recruited non-participants first and then recruited participants from similar neighborhoods where possible. The non-participant data sources included one study that collected system age with no questions about change outs which is considered unbiased. The other source asked customers about recent change outs, which may have introduced some bias away from non-permitted installations. Potential bias was mitigated to the maximum extent possible; onsite recruiting emphasized the anonymity of test results and never mentioned compliance or permitting. This study did not investigate the issue of permitting for non-participants, but a follow-on project was conducted to determine the permit frequency and differences between permitted and non-permitted installations.[9]

Data collection for all tested units included spot measurement of unit airflow and duct leakage. Building envelope characteristics informed load-calculation models for each site for non-participants. Existing load-calculation models (a program requirement) for participants were reviewed for consistency. The evaluation team calculated energy savings for participants relative to non-participants based on system sizing, correct airflow, and reduced duct leakage. The evaluation team took the data collected for participants and non-participants and re-ran the DEER prototype DOE-2 models consistent with the method reported in the residential quality installation workpaper. The evaluation notes that the workpaper was not reviewed by the ex ante review process. If the ex ante team had reviewed the workpaper then the current DEER prototypes and calculation procedures would have been required of the workpaper.

Table 4 summarizes the field findings from the evaluation compared to the workpaper assumptions. In particular, ex ante workpapers claimed higher non-participant duct leakage than found in the baseline group. Participant duct leakage results met the QI program goal of 12% total leakage, but the baseline leakage was lower (17%) than the 24% leakage value assumed in the workpaper. This more efficient baseline resulted in lower actual savings than expected. There was not a statistically significant difference in per-ton airflow between participants and non-participants. The evaluation team modeled the mean differences to develop savings estimates as the collected data represented the best information available, since the workpaper relied on assumed values. The evaluation found that the calculated average sizing ratios to be similar between participants and non-participants. There were both under and oversized non-

[9] PG&E. *HVAC Permitting: A Study to Inform IOU HVAC Programs* . August 2014(CALMAC ID: PGE0349.01),

participant units, but there were primarily right sized and a few oversized participant units. The workpaper assumed an average amount of oversizing and used the sizing ratio to represent this in simulations.

Table 4: Comparison of Field Findings and Baseline Assumptions

Measure Parameter	Non-Participant Field Observations (mean)	Workpaper Baseline Assumptions	Participant Field Observations (mean)	QI Efficient Case Workpaper Assumptions	Non-Participant Participant Significant Difference
Total System Duct Leakage	17%	24%	12%	12%	Yes
System Airflow (CFM per ton)	300	350	338	400	No
System Oversizing	13%	20%	10%	0%	No

Table 5 provides the ex ante and ex post savings for each quality installation measure category. The evaluation only modified the sizing, duct leakage, and airflow simulation inputs between ex ante and ex post results. The overall gross realization rates were 35% for electric energy savings and 38% for demand savings. These realization rates were driven by the better-than-assumed sizing and duct leakage for non-participant units, which set the baseline for savings.

Table 5: Final Gross Savings for Residential Quality Installation Measures Installed (2010-12)

Quality Installation Measure Category	Ex Ante Energy Savings (kWh)	Ex Post Energy Savings (kWh)	Energy Real. Rate (%)	Ex Ante Demand Savings (kW)	Ex Post Demand Savings (kW)	Demand Real. Rate (%)
13 SEER Air Conditioner Quality Installation	18,417	7,124	39%	6	3	53%
14 SEER Air Conditioner Quality Installation	169,180	59,898	35%	80	37	46%
14 SEER Heat Pump Quality Installation	10,081	3,229	32%	4	1	33%
15 SEER Air Conditioner Quality Installation	273,568	94,314	34%	149	55	37%
15 SEER Heat Pump Quality Installation	28,228	9,322	33%	9	3	33%
16 SEER Air Conditioner Quality Installation	411,269	144,617	35%	227	82	36%
Total	**910,743**	**318,505**	**35%**	**475**	**181**	**38%**

A note on our realization rate calculations: The team could not separate out free-ridership from presumed non-compliance in the gross (workpaper) baseline. Since the workpaper assumed non-compliance, it essentially presumes a standard practice baseline, not a code baseline. If one assumes that participants would have met code requirements in the absence of the program, we could have estimated freer-ridership, but we had no a-priori evidence of participant code compliance nor did we think we could get an unbiased estimate of compliance by asking that question directly. The evaluation team believes that net-to-gross issues may be influencing our realization rate, but we cannot determine the extent to which this is true and cannot develop a quantitative estimate that breaks out free-ridership. Hence, there is no free-ridership estimate factored into these realization rates. The team has no way of knowing or estimating the extent to which the gross realization rates include net effects that lower the reported realization rate. Permitting of non-participants is part of a PG&E follow-up study (CALMAC ID: PGE0349.01) and will be further studied in an upcoming project.

For residential quality installation, the evaluation team learned that installations in the programs exceeded Title 24 code, on average for system design attributes covered by the program, and those installations outside the program do not perform as poorly as assumed in program workpapers. The evaluation findings showed that there was a continuous spectrum of installation efficiencies, from good to bad, outside the QI program. The team also discovered that the program workpaper does not fully capture the improved fan efficiencies present in the

sampled participants, and does not model the impact on the program of applying sensible capacity standards via ACCA Manual S to system sizing.

The evaluation team has the following recommendations:

- The 2013 Title 24 code should be reviewed to determine opportunities to exceed code. The net to gross needs to be clearly defined since the gross baseline assumed is not code minimum, it is a common practice assumption below code. In the absence of the program a unit could be minimally compliant or could be at the common practice baseline. Using a common practice baseline requires specific evidence that code minimum is not appropriate and requires rethinking the use of the default net to gross value which usually applies to measures with a code baseline.
- Consider a revision to workpapers to account for the fact that baseline is comprised of a range as opposed to a point estimate. Gross savings vary by CZ and measure SEER level. In this case the net savings and baseline may also vary by code jurisdiction. Until larger studies are available the source of assumptions in workpapers should be clearly stated as well as whether baseline studies are needed to develop data to inform the inputs.
- Expand the non-participant sample to support evaluation of QI programs and 2014 "to code" pilots. Using a consistent data collection approach would allow expansion of the sample in any given climate zone, given the relatively small size of the sample in this study. The 2014 "to code" pilots will collect detailed compliance verification data. Comparing non-pilot and pilot jurisdictions may require larger samples of non-participants.
- Ultimately the programs can influence savings for actions that exceed Title 24 requirements. Participant systems did not all meet assumed performance values that were included in workpapers. Exceeding code will improve realization rates, but it is unknown if cost effective savings exist, especially relative to the new code. Common practice was worse than code in this study, but not as much as assumed in workpapers. The evaluation team recommends the IOUs explore a few areas where Title 24 can be exceeded or does not have requirements.
  - Explore more downsizing to reduce peak demand. The program sizing aligned much better with Manual J load calculations than non-participants, but did not eliminate all cases of oversizing.
  - Explore duct sealing to reach a lower target leakage, such as the 6% threshold that is set for new ducts systems.
  - Explore air handlers/furnaces, filters, and duct modifications that reduce pressure drop and improve fan system efficiency.
  - Explore whether all ANSI/ACCA 5 Quality Installation Standard elements in programs impact energy use and align with workpapers.
- Determine if there are specific locations where common practice baseline is worse than estimated in this evaluation. The non-participant sample covered large areas and many code jurisdictions. Further study could determine specific areas where common practice is worst and target program activities toward those locations. This may mean leveraging

local government partnership programs as opposed to statewide program models if it is determined that only specific areas have the greatest opportunity.

- Ensure that workpaper and evaluation modeling inputs produce HVAC energy estimates that are consistent with the Residential Appliance Saturation Study (RASS).

Commercial Upstream Program

The evaluation efforts for the upstream component of the study focused on the level of free-ridership in the Upstream HVAC program. Gross ex ante savings claims are based on workpapers that primarily use DEER estimates and were not evaluated. A participant self-report method was used for the free-ridership/net-to-gross (NTG) work, and the analysis was based on in-depth telephone interviews with 19 out of 22 participating HVAC distributors that were conducted by DNV GL in 2013. The approach took into account the program's effect on both the stocking practices and high efficiency sales of the distributors. The program offers rebates to decrease costs associated with high efficiency equipment and/or to make the price and availability equivalent to a less efficient alternative in order to steer market demand toward high efficiency equipment. One key limitation of the approach was that for distributors who did stock units, the survey did not determine if there were specific sizes or unit types that were always custom-ordered and therefore there could be little program influence on stocking.

Overall, the program is achieving a savings-weighted NTG score of 0.80, versus an unweighted NTG score of 0.58. The reason for this difference is that the distributors who account for the largest share of program savings are also the distributors who claim the highest levels of program influence. The final net to gross ratio was applied to gross energy and demand savings for 2010-12 programs. Table 6 shows the SCE program represented a majority of the statewide savings for the Upstream program.

Table 6: Upstream Net-to-Gross Ratio and Net Savings

IOU	Gross Energy Savings (kWh)	Gross Demand Savings (kW)	Net-To-Gross Ratio	Net Energy Savings (kWh)	Net Demand Savings (kW)
PG&E	17,705,130	9,100	0.80	14,164,104	7,280
SCE	64,368,795	21,952	0.80	51,495,036	17,562
SDG&E	560,854	203	0.80	448,683	162
TOTAL	82,634,780	31,255	0.80	66,107,824	25,004

Since many distributors served multiple service territories, the evaluation team developed a single net-to-gross score using the total savings from the two largest programs at SCE and

PG&E. The SDG&E program had relatively small levels of savings that were not assigned an Upstream flag in tracking data, but packaged and split system measures that mentioned Upstream in the name also received this net-to-gross adjustment.

For upstream distributor incentives, the evaluation team learned that incentives influence stocking and sales for the highest volume distributors, but have less influence on lower volume distributors. Some distributors supply units directly from manufacturers, and stocking incentives have no influence there. The team identified some opportunities beyond the efficiency incentives, given that the program does not focus on permitting and compliance, nor does it consider additional incentives for climate-appropriate systems.

The evaluation team makes the following recommendations, gleaned from the distributor interviews and analysis of program data:

- The program should consider increasing rebate levels for higher efficiency equipment to encourage more sales in the highest efficiency tiers. A 50% to 100% incentive increase could be explored for the top tier, however the evaluation team did not estimate what levels could be achieved while keeping the program cost effective. This recommendation is based on distributors indicating that the incentive is a greater percentage of the incremental cost for Tier 1 compared to the higher efficiency tiers.
- Program-provided support for how to market high efficiency equipment may be helpful to distributors, particularly those who are less successful at selling the concept of high efficiency.
- Providing a reservation system or rebate guarantee may encourage more participation, and increased high-efficiency sales, from distributors who have long sales cycles or custom build equipment. This type of rebate would only address incremental cost and would not have any influence on stocking.

Preliminary Laboratory Testing Results

The evaluation team conducted laboratory tests to evaluate economizer operation and performance and system faults for a dual compressor commercial roof top unit (RTU). Master technicians oversaw laboratory technicians who fully instrumented and tested packaged HVAC units in an Air-conditioning Heating and Refrigeration Institute (AHRI)-certified laboratory. The purpose of many tests was to evaluate systems under conditions more typical of field conditions–especially those conditions observed from pre/post evaluation sites. Findings suggest limitations with AHRI test procedures in addressing in situ efficiency; laboratory results reflect those that would be more typical of installed performance. The laboratory performed tests at a range of “outside” dry bulb and wet bulb temperature conditions to simulate temperature variations across the California coastal, inland, mountain, and desert climate zones. Additional laboratory tests continue currently and will be performed in the future on packaged units from additional manufacturers.

The laboratory tests with actual cabinet leakage and functioning economizers provided critical new findings on the diagnosis of system faults and the efficiency impacts of repairs. Based on discussions with the laboratory staff and the experience across the evaluation team, these tests appear to be the first of their kind. Critical findings from laboratory testing with an economizer include:

- The impact of economizers on system efficiency is significant and unexpected.
- The diagnosis and adjustment of charge is difficult, if not impossible, to achieve in the field since both unit total airflow and the presence of outdoor air intakes affect the reliability of fault detection diagnostics (FDD). This finding led to the field work described under Commercial Quality Maintenance that compared refrigerant charge diagnostics to a charge weigh out/weigh in procedure.
- The test results demonstrated that damper leakage in economizers likely results in over ventilation. Additionally, economizer maximum outside air rates when fully open were found to be less that is often assumed in repair measure evaluations. Leakage sources were identified and could be addressed via maintenance programs. Improving maximum outside air flow rates are not something that could be addressed in a maintenance program.

Understanding the efficiency impacts of faults presents several challenges. In reviewing the results, the team expected that the efficiency of all units would be relatively lower at higher outdoor temperature conditions and lower coil-entering wet-bulb conditions. Faults may have different impacts at different conditions, but generally should reduce efficiency relative to optimal at a given condition. Instead, we found that the effects of outdoor and indoor conditions and faults on efficiency exhibit non-linear trends and become more complex when combined and require empirical testing to derive efficiency impacts.

The following laboratory results are available based on tests of a 7.5-ton dual-compressor packaged RTU that uses a non-TXV expansion design:

- Tests with the economizer open from 10% to 30%, based on technician reported “rules of thumb,” indicated that loads and energy consumption increase 5% to 62% compared to closed dampers that deliver 15% outdoor air through damper and other sources of leakage. Assuming this leakage in unintended, then economizers impose a 5% to 62% energy penalty as a result of imperfect design.
- Outdoor airflow was 15% with closed dampers, 20% with 1-finger open, 23% with 2-fingers open, 30% with 3-fingers open, and 62% with dampers fully open. The “finger open” setting is a common installer minimum outside air setting where the width of a finger represents the width of the economizer damper opening for ventilation. Each finger width is assumed to be approximately equal to 10% of design air flow. It is

common to assume 2% outdoor airflow with closed dampers and 100% outdoor airflow with fully open dampers. The 2% closed damper setting is a required maximum damper leakage rating, while the fully open flow assumes all return air is blocked off by the return air dampers. Damper leakages (frame and actuator area leakages on the outside air damper and incomplete return duct coverage on the return air damper) make both assumptions incorrect.

1. Introduction

1.1 Program Evaluation and Overview

The 2010-12 IOU energy efficiency program portfolios include a statewide program and various third-party programs targeting commercial and residential unitary HVAC systems. The impact measures for HVAC systems are categorized into three measure groups: Upstream Equipment Incentives, Quality Maintenance, and Quality Installation. Combined, the ex-ante savings for these program claims comprise approximately 177.2 GWh across IOU portfolios adopted for the 2010-12 cycle; and more importantly, they comprise 60.2 MW of claimed electric demand savings[10].

These programs were developed for residential and small commercial facilities that use packaged and split-system air conditioning systems or heat pumps. The programs include a non-residential Upstream incentive program to HVAC distributors to encourage stocking high efficiency units, a continuation from 2004-05 and 2006-08 cycles. Quality Maintenance (QM) and Quality Installation programs are also included. Both of these promote packages of measures designed to improve the efficiency of HVAC systems by correcting faults resulting from poor installation, wear and tear, and malfunction or damage, and/or by improving system control. The commercial and residential refrigerant charge and airflow (RCA) diagnostics and residential duct sealing (DTS) measures in the QM and QI packages were included in 2006-08 programs. 2010-12 programs cover a broad range of new measures, including evaporator and condenser coil cleaning, off-hour controls, and economizer repair on commercial units. The residential QM programs claimed insignificant savings and were not evaluated. Commercial QI packages are still being developed by the IOUs and no claims were made in 2010-12 programs.

Table 7 summarizes IOU programs and ex-ante energy and demand savings claims by IOU. The Upstream programs compromise the greatest savings of the three primary program types. The Upstream program claimed the largest savings among the SCE programs, but the third party and local CQM programs claimed the greatest savings for PG&E and SDG&E programs.

[10] Based on 2010-12 final tracking data and measures evaluated

Table 7: Ex Ante Savings Claims by IOU HVAC Program

IOU	Program ID	Program Name	2010-12 Savings Claims	
			Energy Savings (kWh)	Demand Savings (kW)
PG&E	**PGE21061**	SW Upstream HVAC Equipment Incentive	17,705,130	9,100
	PGE21065	SW Commercial Quality Maintenance Development	5,504,808	5,589
	PGE2181	Air Care Plus (Commercial Maintenance)	60,556,253	11,031
	All Evaluated PG&E HVAC Programs		**83,766,192**	**25,719**
SCE	**SCE-SW-007A**	SW Upstream HVAC Equipment Incentive	64,368,795	21,952
	SCE-SW-007D	ENERGY STAR Residential Quality Installation Program	910,743	475
	SCE-SW-007E	SW Commercial Quality Maintenance Development	10,269,044	6,354
	All Evaluated SCE HVAC Programs		**75,548,583**	**28,781**
SDG&E	**SDGE3161***	SW Commercial Upstream Equipment	560,854	203
	SDGE3148	SW Quality Maintenance Program (Commercial Statewide)	0	0
	SDGE3161	Non-Res HVAC Tune-up/Quality Installation (Local)	17,947,787	5,579
	All Evaluated SDG&E HVAC Programs		**18,508,641**	**5,781**
	All Evaluated HVAC Programs		***177,823,416***	***60,282***

*Measures labeled upstream were assigned to the same program ID shown for the Non-Res HVAC Tune-up/Quality Installation Local Program

1.2 Organization of the Report

This report describes the impact evaluation results for Upstream Equipment Incentives, Quality Maintenance, and Quality Installation measures. It is organized as follows:

- **Section 2: Commercial Quality Maintenance.** Pre-post monitoring and site observations provided the basis for the impact analysis and installation rates.
- **Section 3: Residential Quality Installation.** Measurements of participant and non-participant air conditioner installations established performance relative to workpaper assumptions to inform the impact analysis.
- **Section 4: Upstream HVAC Program.** Interviews with equipment distributors established net to gross ratio.
- **Section 5: Package Unit Laboratory Testing.** Laboratory efficiency tests of dual-compressor unit with and without outside air intake across a wide variety of single and combined fault conditions.
- **Appendix A: Additional Measurement Details for Commercial Quality Maintenance**
- **Appendix B: Unit Level Observations for Commercial Quality Maintenance**
- **Appendix C: Residential Quality Installation Test Results by Site**
- **Appendix D: Laboratory Instrumentation Testing**
- **Appendix E: Upstream Survey Instrument**
- **Appendix F: Upstream Individual Responses**
- **Appendix G: Upstream Incentives Levels**
- **Appendix H:Residential Quality Installation Site Instrument**
- **Appendix I: Commercial Quality Maintenance Site Instrument**

In addition to the information provided in the Appendices, all evaluation data will be compiled as part of a CPUC data warehouse effort. The Appendices contain most, but not all data collected.

2. Commercial Quality Maintenance

The evaluation team evaluated the installation rate and gross savings associated with the IOU statewide and third-party/local Commercial Quality Maintenance (CQM) program. To accomplish this, we conducted site inspections and measurements to determine evidence of measure installation for both statewide CQM and third-party/local CQM programs. Pre- and post-metering was also conducted for the statewide programs, which were the focus of the evaluation research plan.[11] The statewide CQM program workpaper took an "expected value approach," based on an assumed frequency and combinations of measures that would be implemented, on average, across all projects. The evaluation team analyzed the final measure frequencies for all CQM programs based on implementer records separately from the site inspections to clearly differentiate between the differences in the assumed and installed measure frequency and whether claimed measures were installed and operating. Site visits focused only on inspecting the measures that were performed.

The evaluation effort presented several logistical and technical challenges. Evaluators coordinated with the statewide programs to sample and monitor units pre- and post-maintenance. We monitored units before program service technicians assessed the measures needed for each unit. The team randomly sampled units at sites enrolled in the program at the time, but the outcomes included some units receiving little or no maintenance. Sites could also be enrolled and inventoried and then later dropped from programs, which was a situation that was not originally anticipated. Three units with monitoring equipment installed were replaced with completely with new air conditioners. Program implementers and contractors participating in the monitoring provided notice of service dates for direct observations in some, but not in all cases. Since the monitoring sample presented multiple logistical challenges, the evaluation team conducted additional site observations of the contractors and technicians with the greatest volume of program work in terms of units, unit tonnage, and measures implemented. The non-monitored sites could not be used to estimate energy savings but allowed the evaluators to get a representative sample of the installation rates across all CQM programs. A majority of our non-monitored sites originated with third-party /local programs, as these were the programs with the largest volume of installed units and measures.

2.1 Background

The 2010-12 QM and QI program designs and measures were developed in response to HVAC research, ASHRAE/ANSI/ACCA standards development, Strategic Plan goals, the poor net

[11] As scoped, this evaluation was not intended and did not produce ex post savings results for third-party / local programs, although these produce the majority of HVAC maintenance savings claims.

savings realization rate[12] reported in the 2006-08 evaluation of refrigerant charge and airflow (RCA) and duct test and seal (DTS) measures; and other technical issues summarized by the 2009 HVAC Maintenance Study.[13] Previously, the HVAC program was designed around a single measure approach (either RCA or DTS) that addressed each fault independently. Each measure was implemented separately, and therefore was also evaluated independently. However, HVAC faults include other issues beyond refrigerant charge or duct leakage, are not independent of one another, and cannot be properly addressed in this manner, either by program design or evaluation. Recent lab test activities[14] indicated interactions between multiple HVAC system faults and the ability of one fault to mask the existence of another fault. The 2010-12 program designs favored a more holistic and comprehensive approach as opposed to addressing only one or two potential issues affecting HVAC operating efficiency. Due to these changes and program projections, the 2006-08 evaluation results and underlying data were not applicable to the 2010-12 statewide measures and programs. The research planning for 2010-12 focused on evaluating the new program designs based on the program implementation plans.

The 2006-08 evaluation conducted by the CPUC and the 2009 HVAC Maintenance Study conducted by SCE addressed underlying technical issues in energy efficiency programs built around HVAC maintenance and provided several recommendations and areas for further study. The IOUs used these recommendations to develop the 2010-12 HVAC QM and QI programs, and to suggest changes to evaluation approaches. Based on these recommendations, the IOUs included an element in the HVAC Technology Systems and Diagnostics Advocacy (HTSDA) program, a statewide non-resource program, to address further research needs.

The 2006-08 evaluation and HVAC Maintenance Study postulated (and additional laboratory studies confirmed) technical and training issues that may mislead technicians from the proper diagnosis and measurement of faults and measurement of performance in the field. These issues can arise from inadequate or out-of-calibration sensors, poor sensor installation, diagnostic procedures that do not provide effective multi-fault repair recommendations, and lack of technician training. The IOUs subsequently designed the HTSDA and the HVAC Workforce, Education, and Training (WET) program (another non-resource component of the statewide HVAC portfolio) to help address these issues. Finally, The Energy Division review[15] of

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[12] The savings projections for HVAC measures in 2006-08 were similar in scale to 2010-12: 2006-08 = 187 GWh vs. 2010-12 = 181 GWh, but the evaluated net realized savings were less than one third, or 53 GWh.

[13] Hunt, Marshal, Kristin Heinemeier, Marc Hoeschele, and Elizabeth Weitzel. *HVAC Energy Efficiency Maintenance Study*. Davis Energy Group and Southern California Edison, 2010. http://www.calmac.org/publications/HVAC_EE_Maintenance_Final.pdf

[14] Purdue and Chapter 5 of this report. 3

[15] CPUC Decision D.10-04-029, Ordering Paragraph 4, third bullet point, states, "Review of completed IOU workpapers regarding ex ante savings estimates are subject to Energy Division review and approval,

QM program workpapers directed the IOUs to develop justifications for ex-ante savings estimates proposed in the workpapers by June 2012. The IOUs did not provide justification, but rather relied on this study (WO32) to provide the additional data. The evaluation team provided preliminary results in a memo to the IOUs in August 2013 and addressed comments from the IOUs and Western HVAC Performance Alliance (WHPA) in September 2013.

A full comparison to previous CPUC or IOU HVAC evaluations or evaluations from other regions was not part of this study. The IOU program planners should take into account findings from all of these studies when planning for future HVAC programs.

2.1.1 Single and Packaged Measures

There were two program types for commercial quality maintenance (CQM): the statewide (SW) program that was based on the ASHRAE/ANSI/ACCA 180 standard (Standard 180), with an assumed package of measures, and the third-party/local programs that continued to implement individual measures including refrigerant charge similar to 2006-08 programs, as well as coil cleaning, economizer repair, and thermostat adjustments. Within the statewide programs there were also claims in 2010 based on the previous program models with individual measures.

The Standard 180-based SW program required a three year service agreement between the contractor and customer. Standard 180 provides a list of maintenance items to check and the frequency of those checks. Some of the maintenance activities provide energy savings while others do not. The service agreement established specific plans for units at each site. Early on in the 2010-12 programs these agreements were difficult to obtain as program processes were still being defined for detailed unit-level data collection. The impact evaluation was designed to measure energy savings resulting from maintenance activities and was not designed to study the standard, program process, or longer term market transformation or market effects. These elements could be addressed in a future study.

The three-year delivery approach presented an issue for program evaluation. The evaluation goals were stated to IOU program staff and implementers. Even if the program allows multiple years for service actions, the key actions must be taken as soon as possible to be considered first year savings. The process outlined to the evaluation team by IOU program staff and implementers was that most issues would be identified and repaired early in the process. If it was known that most actions would not be identified and addressed until the end of the three-year agreement, the evaluation team would have recommended that savings be claimed in later years and would have focused pre-post metering on later activities.

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as set forth in an Administrative Law Judge's Ruling of November 18, 2009 in Application 08-07-021, et al."

The evaluation also encountered the challenge that there is no single set of fault detection diagnostic (FDD) standards. This report references studies by others on these issues. The evaluation team agrees that Standard 180 does not provide specific guidance on evaluating maintenance issues, including refrigerant charge. Because different FDD methods produce different outcomes, the charge adjustments may produce positive savings, negligible savings, or negative savings. Some tests are outlined in Title-24 for new installation verification, but do not cover all faults. Manufacturers' recommendations in service manuals represent an independent benchmark to evaluate various FDD protocols. Fortunately for this effort, the laboratory testing included in this effort allowed an evaluation of both approaches noted above along with program-specific guidelines.

The pre- and post-monitoring approach focused on the two IOUs offering statewide CQM programs with participation in 2010-12. PG&E had limited participation in 2010-12 and was not included in the statewide program sample. In the final tracking data only SCE claimed ex ante savings for CQM measures. The evaluation team developed the research plan under guidance from Commission staff, advisory consultants, and the IOUs, to focus on the statewide programs, assuming those programs would eventually be the primary offering for CQM.

The final tracking claims established that individual measures installed via third-party / local programs dominated the total savings claims from 2010 through 2012. The team then refocused efforts on evaluating the installation rate of individual maintenance measures. The team also modified its focus in light of the new 2013-14 program workpapers for individual measures. Table 8 shows that the individual measures comprise the vast majority of 2010-12 program claims. Note individual measures shown in statewide programs are holdover claims from the 2009 bridge program year and do not reference the statewide workpaper. The ex post evaluation results from pre-post monitoring summarized in this section, however, apply only to the IOU's statewide CQM program, as directed by the CPUC in the scope of this evaluation. Installation rates were developed for individual measures, but apply only to the third-party/local program savings claims. Earlier in the 2010-12 cycle the IOU's planned to transition local programs into the statewide model, but going into 2013-14 the direction is moving back to individual measures. These continuing changes in CQM program structure and the potential of examining both state-wide and local program structures adds a significant level of difficulty to program evaluation.

Table 8: IOU Ex-ante Savings Claims for Commercial Quality Maintenance

			CQM Package		Individual Measures	
Program Type	Program ID	Program Name	Energy Savings (kWh)	Demand Savings (kW)	Energy Savings (kWh)	Demand Savings (kW)
Statewide	**PGE21065**	Commercial Quality Maintenance Development	0	0	5,504,808	5,589
	SCE-SW-007E	Commercial Quality Maintenance Development	3,582,081	676	6,686,964	5,678
	SDGE3148	Quality Maintenance Program	0	0	N/A	N/A
Local / Third Party	**PGE2181**	Air Care Plus	N/A	N/A	60,556,253	11,031
	SDGE3161	Non-Res HVAC Tune-up	0	0	17,947,787	5,579
TOTAL			**3,582,081**	**676**	**90,695,812**	**27,876**

2.2 Methodology Overview

The evaluation team installed data loggers on randomly selected units at statewide participant sites to measure time-series electricity use; weather data; refrigerant temperature and pressure[16]; and outdoor air, return air, mixed air, and supply air temperatures. The team sampled refrigerant diagnostic readings from the systems and measured supply airflow and outdoor damper airflow on each unit before and after maintenance services were performed. The team performed acid tests for non-condensables on most refrigerant circuits along with spot measurements and observations. The team collected make, model, serial numbers, digital photographs, and measurements for each unit. The team also observed educational training

[16] The analysis focused on airside measurements. Time series measurements for refrigerant temperature and pressure were originally included, but due to issue with the reliability of the pressure measurement connections these were not installed later in the study and these sensors were removed on all measurement suites.

classes, and observed technician experience, certification, tools, equipment, procedures, and diagnostic protocols.

The team used on-site field observations and interviews to evaluate the behavior of technicians participating in the program. Due to difficulties encountered conducting the pre/post data logging, and in response to issues noted during field observations, the evaluation team stepped up observation and inspection activities. In total, the number of on-site field observations and inspections completed was greater than the number of sites with data loggers. The planned and final sample design is described in Section 2.2.2.The team used observation data to identify equipment faults and assess the efficacy of the technicians in identifying and repairing faults. The evaluation team conducted the following three types of field observations:

1) Pre-maintenance observations conducted on commercial packaged air conditioning systems scheduled for service by participating technicians
2) Ride-along observations and interviews conducted while maintenance services were being performed by participating technicians
3) Post-maintenance inspections and interviews conducted after program services were performed

2.2.1 Observation Methods

The evaluation consisted of field observations, surveys of technicians performing service, and monitoring of HVAC system energy use before and after the service. The evaluation team installed data loggers on 44 units in two service areas to monitor pre- and post-load impacts. The team used data loggers and master technicians conducted conduct pre- and post-observations of program participant technicians performing maintenance on units. Considering monitored and non-monitored units, the team conducted field observations on 99 participant air conditioning circuits.

The master HVAC technicians identified issues and faults during field observations. An “issue” was defined as a problem or difficulty and a “fault” was defined as a defect. Issues are problems with tools or procedures that can impact FDD and the reliability and appropriateness of subsequent repairs. Faults impact cooling system performance and can cause failures of components such as compressors, motors, economizers, sensors or controllers. Faults refer to aspects of the HVAC system that are outside acceptable manufacturer specifications and tolerances such as superheat, suction temperature, evaporator saturation temperature, condenser saturation temperature, airflow, temperature difference across the evaporator or heat exchanger, motor/compressor amps, watts, voltage, cooling/heating capacity, outdoor air damper position, cabinet/duct leakage, coil fouling, economizer change over temperature, sensors, actuators, etc. Issues cause faults and faults impact cooling system performance.

The evaluation team established metrics and criteria for FDD based on published manufacturer installation and maintenance specifications for the specific unit being serviced. Manufacturers provide instructions, specifications, and protocols for coil cleaning, airflow adjustment (belt tension/alignment, fan-belt-drive pulley turns, CFM, static pressure), refrigerant charge (protocols, tools, specifications, targets), recovery and evacuation methods, liquid line driers, and economizer setup and operation (filters, wiring, sensors, controls, dampers, operation). The same criteria were used across all observations. These criteria were used to assess overall maintenance practices, but not installation rates for measures not included in the installation rate estimates. Many points on the data collection forms for master technicians mirrored program data collection. Detailed testing methods and criteria included:

- Industry and manufacturer requirements for installing new, properly sized liquid line driers when repairing leaks, reversing valves, thermostatic expansion valves[17] (TXV), or compressors to prevent refrigerant restrictions. If water vapor is left in the system, it can combine with oil and refrigerant to form corrosive acid and sludge and produce refrigerant restrictions in the form of ice at the expansion device or filter drier (if present).
- Master technicians evaluated the refrigerant system to determine the presence of restrictions or non-condensables. This included an acid test as an indicator of non-condensables including moisture in the system. Moisture in the system may produce a partial orifice freeze-up or improper TXV tracking. Restrictions that may occur during improper installation or as a result of non-condensables in the system may include a plugged inlet screen, foreign material in orifice, filter drier restrictions, kinked or restricted liquid or suction lines, oil logged refrigerant flooding the compressor, or wax buildup in the expansion valve from the wrong oil in system. If the restriction is at the metering device, then frost or ice will develop at this location. If the restriction is at the liquid line or filter drier, then the liquid line temperature will be colder than ambient at this location. All restrictions lead to a reduction in cooling efficiency and may reduce equipment life. Depending on severity, these issues make it difficult or impossible to assess the amount of charge while using diagnostic measurements.
- A check of the air distribution system total static pressure and supply air fan-belt-drive pulley revolutions per minute (RPM) and turns and belt tension/alignment. For fan belts, the team evaluated the measure according to manufacturers' recommendations, which includes checking alignment with a straight edge and checking tension with a tension gage. Power draw is an important measurement and the inspections included this aspect.

[17] A thermostatic expansion valve is a metering device for refrigerant flow into the evaporator of an air conditioner or heat pump. The valve is placed upstream from the evaporator inlet and is connected to a temperature sensing bulb and pressure tap that are located at the evaporator outlet. As the gaseous refrigerant leaves the evaporator the TXV senses its temperature and pressure (superheat) and adjusts the flow rate to maintain the super heat at a constant value.

- Master technicians performed a cold spray test and tested the signal from the controller back to the economizer sensor. Manufacturer economizer installation instructions recommend cold spray to test sensor functionality. It has been noted this test is not recommended for repeated use on modern economizer sensors and controllers which may have other functional testing options as specified by the manufacturer. Many of the economizers in this study were older and this test was the best available method. While minimum outside air damper position was noted as part of the evaluation, minimum outside air adjustments are considered retro-commissioning[18], not maintenance measures, and are separate from economizer functionality.
- The master technician team was not aware of an industry/manufacturer procedure to evaluate the severity of dirty coils or the need for coil cleaning. Manufacturer procedures indicate cleaning inside and outside of coils by removing panels, condenser fans, or economizers as necessary, but there is no specific method to evaluate the state of coils. Manufacturer procedures vary in terms of cleaning with a solution and rinsing with water or only using water. The evaluation process included noting technician coil cleaning processes and providing a general evaluation of coil cleanliness in post-only evaluations. While not in the scope of this study, the team recommends future work to quantify the energy savings, persistence, and cost associated with following the manufacturer-recommended procedure and any alternatives that take less time or claim to provide better savings.
- Master technicians observed technician use of refrigerant system diagnostic equipment. This included noting the use of EPA 608 requirements for low-loss fittings on refrigerant hoses and de minimis purging hoses of air and water vapor prior to attaching to Schrader valves. Incorrect connection of refrigerant diagnostic gauges can create a performance issue by introducing non-condensables[19] into the system. Additionally, master technicians evaluated the placement location and attachment processes for refrigerant system and coil entering air temperature readings.

[18] Retro-commissioning is the application of the commissioning process to existing buildings. Retro-commissioning is a process that seeks to improve how building equipment and systems function together. Depending on the age of the building, retro-commissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life. In all, retro-commissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance. http://cx.lbl.gov/definition.html

[19] Refrigerants are required to condense at the temperatures and pressures in the unit's condenser coil. Non-condensables found in refrigerant systems include nitrogen, oxygen, and carbon-dioxide which are common in the air surrounding unit service ports and can be inside refrigerant hoses if they are not purged before connection.

2.2.2 In Situ Performance Estimation Methods (Statewide Programs Only)

In addition to conducting ride-along observations and ex-post site inspections (sampled to represent the majority of participating contractors and measures), evaluation staff monitored a sample of sites before and after service in both the SDG&E and SCE QM programs. This monitoring component of the study aimed to characterize the performance changes caused by QM program activities on sampled units. The planned sample was relative to program claims, but the achieved sample relied on pre-measurement coordination and was more variable than expected. Table 9 shows the planned sampling and achieved sample. The PG&E program did not claim savings for the package of measures, thus pre-post monitoring was not conducted on PG&E sites. Coordination challenges prevented achievement of the full sample size for SCE. The desired sample was achieved for SDG&E, but the units sampled did not have savings claimed in the 2010-12 program cycle[20]. Precision levels did not meet expectations due to the smaller sample and also the high variability across the sample. The planned coefficient of variation (CV) for energy savings per ton was 0.6 but the results suggest a CV of 1.2 to 3.5 which is extremely high. Based on the coefficients of variation observed in the pre/post metering sample, sample sizes ranging from several hundred to over 1,000 units may be required to achieve 10% relative precision.

Table 9: Planned and Achieved Sample for Pre-Post Monitoring

Program Type	IOU	Sample Size Planned	Planned Relative Precision 90% Confidence Interval (±)	CQM Statewide Measure Savings (kWh)	Sample Size Fielded / Achieved	Expected Relative Precision 90% Confidence Interval (±)	Achieved Relative Precision 90% Confidence Interval (±)
Statewide	**PG&E**	**40**	16%	0	0	NA	NA
	SCE	**40**	16%	3,582,081	23/17	20%	141%
	SDG&E	**20**	22%	0	21/12	21%	61%

Prior to implementer technician service activities, evaluators connected metering equipment to sampled units, airflow tests were performed, and master technicians evaluated the initial state of the unit. The installed metering suites were then left in place for three to six weeks before program technicians began the maintenance process. Following service activities, airflow tests were performed again and metering suites were re-launched. Since QM program activities were

[20] Some units were eventually corrected after M&V and were claimed in the 2013-14 program cycle while others were never claimed.

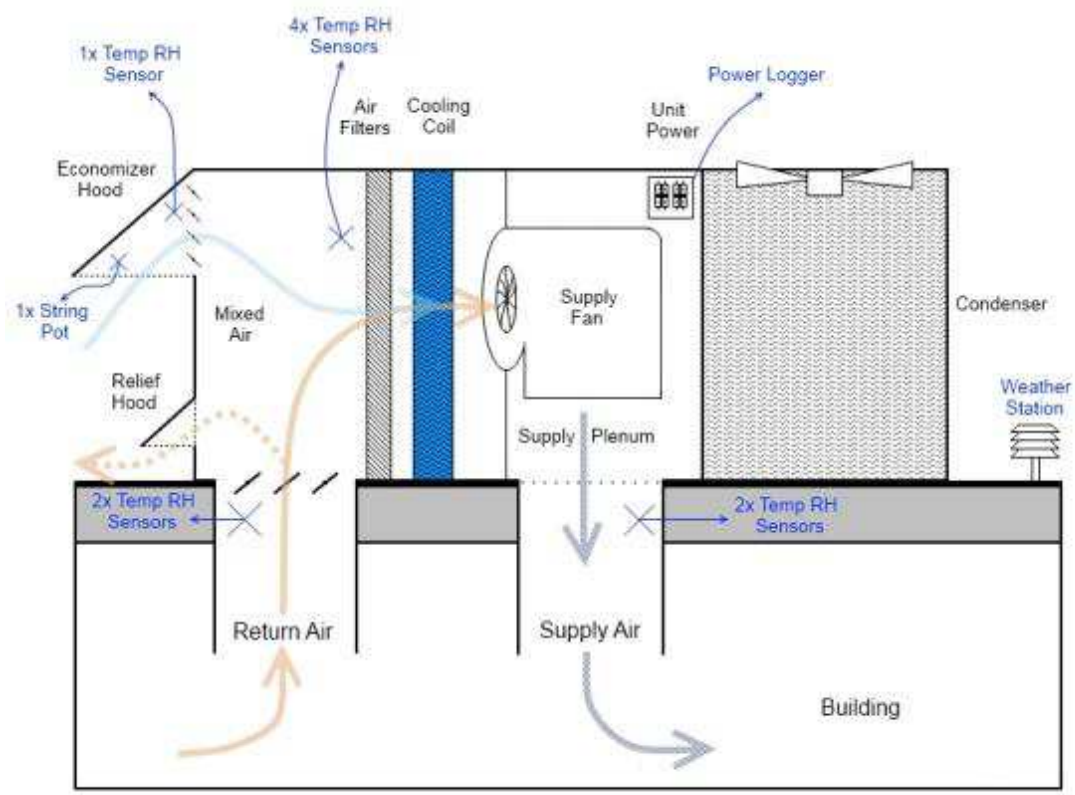
typically conducted on multiple days, often separated by months for many units, this testing and data collection process was repeated on multiple occasions for some units.

2.2.2.1 Equipment Metering

The metering suites included an array of sensors. The evaluation team installed these sensors throughout units in order to characterize airside equipment performance. Meters recorded all parameters using one (1) minute logging intervals to maximize the granularity of the recorded data.

Figure 1 provides a schematic representation of the air-side equipment measurement locations in a packaged unit. On some units we also installed refrigerant-side pressure and temperature sensors similar to the measurements taken by service technicians. These measurements were not included on all units because they used up data logger power and memory at a rapid rate, and they introduced the potential for failure resulting in refrigerant leaks, which were a safety and environmental hazard. This figure is for illustrative purposes only and does not depict an actual unit configuration. Units in the field had both economizers and fixed ventilation air intakes.

Figure 1: Packaged Unit Airside Metering Schematic



The metering suite included nine (9) temperature/relative humidity (temp/RH) sensors. In a typical installation, the evaluation team installed two (2) sensors in the return plenum just upstream of the unit's curb mount; one (1) underneath the economizer hood in an area shielded from solar radiation; four (4) in equal (as possible) quadrants inside the mixed air chamber at the face of the air filters; and two (2) in the supply air plenum just downstream of the unit curb. The team installed two sensors in the return and supply for the purposes of redundancy and four sensors in the mixed air plenum because of the stratification effects inherent to package units. Packaged units typically have little to no mixing space between the economizer hood, return air intake, and the coil face. As such, for a unit in down flow configuration (by far the most commonly observed configuration), the lower portion of the coil typically entrains return air while the upper portion entrains outdoor air. By using multiple sensors, the evaluation team aimed to capture these effects as well as possible given the limits of field instrumentation. If the multiple sensors were within the stated equipment accuracy, the values were averaged. If one sensor was consistently off, the data were reviewed to determine the correct sensor to utilize. If both sensors were close to the same but appeared erroneous, the unit was dropped from the analysis.

The metering suite also included sensors and transducers to measure power and economizer damper position. To capture unit energy use and demand, the team connected a true power pulse-count logger to the input power of each unit. The team monitored economizer damper actuation using a string-potentiometer sensor, which outputs a signal in proportion to the linear displacement of the string. The team affixed potentiometers to a static location in the economizer housing and to an economizer blade. Linear displacement registered by the potentiometer therefore translated into motion of the economizer dampers. The measurement qualitatively identified damper movement, but not actual damper position.

In addition to the monitoring equipment installed on each unit, one radiation-shielded weather station housing a temp/RH sensor was installed per site at a location removed from the immediate vicinity of the units. This logger was installed to capture ambient weather conditions to be used later in equipment performance and site load modeling.

The pre-service, post- service and sometimes "interim" service data sets were later utilized to develop DOE-2 performance maps and design conditions for each service period. The evaluation team determined that these maps were not sufficiently reliable to establish changes in capacity and efficiency. The team performed a unit-level regression analysis using sub-metered power consumption data (Section 2.2.2.2). The team also used data collected during the monitoring process to generate simplified curves that relate power draw per ton of cooling to coil and space load estimates. The team conducted an engineering assessment of the site data collected to support the planned performance map approach (Section 2.2.2.3). The engineering analysis also developed time series load profiles based on schedules and set points for the metered units and used these profiles to estimate unit-specific annualized program energy impacts. The assessments found specific reasons leading to the outcome for each unit. In some instances, the

assessments determined there were insufficient pre-maintenance data to characterize unit performance. These units were eliminated from the final analysis. .

2.2.2.2 Unit Level Regression Modeling

The evaluation conducted a regression analysis on pre-post power and schedule data to estimate savings. The team originally developed performance maps and zonal DOE-2 simulation models, which proved unreliable given the measurement uncertainties. The revised primary analysis utilized the regression model published in the Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures[21].

The analysis is based on the following equation to determine unit level hourly load estimates for the pre-maintenance and each post-maintenance period:

$$L_{dh} = \alpha + \beta_{Ch} THI_{dh} + \beta_{w(d)} w(d) + \beta_{g(h)} g(h) + \beta_{2h} H_{2d} + \beta_{3h} H_{3d} + \varepsilon_{dh} \qquad \text{[Equation 1]}$$

where for a particular HVAC unit;

L_{dh} = Load in kW on day *d* hour *h*, day= 1 to 365, hour = 1 to 8760

THI_{dh} = Temperature-humidity index on day *d* hour *h* in °F. For the purposes of this analysis, THI was defined as:

$$, THI = 0.5 \times OSA_{db} + 0.3 \times DPT + 15,$$

Where THI is the temperature-humidity index in °F,
OSA_{db} is the outside dry bulb temperature in °F, and
DPT is the outside air dew point temperature in °F.

w(d) = 0/1 dummy indicating day type of day *d* , Monday = 1, Sunday =7, Holiday = 8

g(h) = 0/1 dummy indicating hour group for hour *h*, hour group = 1 to 24

H_{2d} = 0/1 dummy indicating that hours in day *d* are the second hot day in a row

H_{3d} = 0/1 dummy indicating that hours in day *d* are the third or more hot day in a row

α, β_{Ch}, $\beta_{w(d)}$, $\beta_{g(h)}$ = coefficients determined by the regression

β_{2h}, β_{3h} = hot day adjustments, a matrix of coefficients assigned to binary variables (0/1) for hours defined for 2nd and 3rd consecutive hot days, the matrix variables are unique to each hour in each hot day

ε_{dh} = residual error

[21] National Renewables Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Chapter 4. 2013. http://energy.gov/sites/prod/files/2013/07/f2/53827_complete.pdf

The data were filtered for the hours when the unit was on, defined by kW > "fan only" and other parameters (i.e. – specific hours per operating schedule) as determined necessary by the engineer. The inputs were run in a Statistical Analysis Software (SAS) multi-variable regression for kW, THI day-type, hour-type, and consecutive hot day adjustments. The regression used onsite weather stations, or if those data appeared to have issues local weather data available closest to the unit's location, with the intent that modeling the unit this way will yield a much more accurate model that is highly sensitive to changes in temperature and humidity inputs to THI. The estimated values from the regression represent the α, β_{Ch}, $\beta_{w(d)}$, and $\beta_{g(h)}$ coefficient values in the original modeling equation as shown in Equation 1. These values were used to model the energy consumption of the unit based on THI, day type, and hour type. For the 2nd and 3rd hot days, flags were placed in the weather file to denote whether this is the 2nd or 3rd consecutive hot day. A hot day was defined as a day when the average dry bulb temperature for all 24 hours is greater than 80 °F. An adjustment is made for both 2nd and 3rd hot days in the following manner: these hot day variables represent the β_{2h} and β_{3h} terms in the original equation. Note that these terms depend on the day of the week and hour of the day for the hour in question. For each unit-level model there are 340 regression coefficients, one for each of the variables: THI, day-type, and hour-type and each consecutive hot day adjustment results in 168 coefficients for the 0/1 dummy variables.

Finally, the model values are compared to the original metered data and a statistical analysis is done to determine the mean bias error (MBE). The MBE results for the metered time frame were used to prioritize review of the unit models by senior engineers and site staff to supplement the QC. Ultimately an engineering decision was made for each unit where the model did not match the metered data to determine if poorly modeled data was a result of variability in the actual unit usage not captured by the model, or if there was a measurement or other issue requiring exclusion of the unit from the aggregate load shape analysis. Measurement error identification was assisted by examining the residual error term in the regression. The graphing procedure for quality control also automatically calculated the mean bias error for the entire profile as well as for selected time periods. Investigating the error over the various peak hours was easier in the graphical interface. The comparative statistics were calculated for coincident data values, i.e. data values for time periods which contain data values for both the measured (base) and modeled (comparison) profiles. All time periods where data were missing for either the base or comparison profile were ignored. The MBE is the mean of the error or difference between the base and comparison profiles for all pairs of coincident data points over the mean of the coincident data points of the base profile, as shown in the equation below:

$$\text{MBE} = \frac{\frac{\sum_{i=1}^{n}(b_i - c_i)}{n}}{\frac{\sum_{i=1}^{n} b_i}{n}} \qquad \text{[Equation 2]}$$

where:

b_i = data value of the base profile at time period i

c_i = data value of the comparison profile at time period i

n = number of coincident data points

The unit level model was applied to climate zone weather files (CTZ 2010)[22] to provide a weather-normalized 8760 load shape profile for the unit. This approach may introduce some spatial bias in the weather normalization, but given the relatively small sample and sites locate relatively close to the climate zone reference stations, this bias is minimal. The load predicted by the model was set to zero if the THI was less than 50°F to avoid modeling conditions where units across all samples had no compressor cooling in the meter data. This decision was made based on review of the engineering data. This restriction had no effect on summer peaks, only on off-peak and annual usage. Any information collected about when the units are activated or shut down for winter was applied when extrapolating the results. If a unit was designated as being turned on in March and off in December then no modeled usage was calculated for January and February. At this stage there is a unit level 8760 weather-normalized profile for each sample point pre and post.

2.2.2.3 Engineering Assessment

Engineers used airflow and metered unit data collected in the field to determine equipment performance before and after service activities. The team synchronized all metered data collected during a specific service interval (e.g., before service, after first service, and after second service) for a given unit, and combined this into a single data set in SAS. The team ran psychrometric calculations on parameters in the data set to determine critical engineering values for each time step. The engineers then used these values in subsequent efficiency and capacity calculations. Table 10 summarizes these critical values and notes how each was calculated.

[22] Updated Climate Zone weather available from the DEER website www.deeresources.com

Table 10: Methods of Determining Key Parameters

Calculated Parameter	Method of determination
Supply air – Average Temperature [F]	Averaged the values from the two supply air temperature sensors.
Supply air – Average Humidity Ratio [lb-water/lb-dry air]	Calculated humidity ratio for both supply air temp/RH sensors using psychrometric equations. Averaged the two values.
Supply air – Average Specific Volume [CF/lb-dry air]	Used the average supply air temperature [a], the average supply air humidity ratio [b], and psychrometric equations to determine average specific volume.
Supply air – Total Enthalpy [Btu/lb-dry air]	Used the average supply air temperature [a], the average supply air humidity ratio [b], and psychrometric equations to determine total enthalpy.
Supply air – Sensible Enthalpy [Btu/lb-dry air]	Used the average supply air temperature [a], a dry air assumption, and psychrometric equations to determine sensible enthalpy.
Mixed air – Average Temperature [F]	Averaged the values from the four mixed air temperature sensors.
Mixed air – Average Humidity Ratio [lb-water/lb-dry air]	Calculated humidity ratio for the four supply air temp/RH sensors using psychrometric equations. Averaged the four values.
Mixed air – Total Enthalpy [Btu/lb-dry air]	Used the average mixed air temperature [f], the average mixed air humidity ratio [g], and psychrometric equations to determine total enthalpy.
Mixed air – Sensible Enthalpy [Btu/lb-dry air]	Used the average mixed air temperature [f], a dry air assumption, and psychrometric equations to determine sensible enthalpy.
Return air – Average Temperature [F]	Averaged the values for the two return air temperature sensors.
Outside air mass fraction	Used the lever rule, the average supply air enthalpy [a], the average return air enthalpy [j], and the average mixed air enthalpy [f] to estimate outside air fraction as: $f_{OA} = \frac{MAh - RAh}{OAh - RAh}$
Air Mass Flow Rate – [lb-dry air/minute]	Used the supply air specific volume [c] and the spot measured volumetric flow rate [CFM] to estimate the dry air mass flow rate. Airflow measured pre and post and pre and post fan-power used to check values.

Next, engineers utilized calculated parameters to characterize two HVAC parameters: unit performance and the load imposed on the system. Unit performance refers to the mechanical cooling output and efficiency of the HVAC package, i.e., the amount of cooling provided by the cooling coil and the efficiency calculated therefrom. System load is defined by the amount of cooling provided to the space, including the building load and duct losses. To look at it another way, ***unit performance*** is calculated based on a control volume *placed around the unit* starting at the face of the coil and ending at the supply air outlet; ***system performance*** is

calculated based on a control volume *placed around the building and HVAC distribution system* starting at the unit's supply air outlet and ending at the unit's return air inlet. Outdoor air load was modeled separately to account for differences in pre/post economizer operation.

Engineering assessments used a combination of SAS for raw data processing, spreadsheets to check and post-process SAS output, and the Universal Translator 3 (UT3) software to plot and analyze data.

1. The original raw data are one-minute interval data.
2. The AC unit operations are divided into five states: OFF means the whole unit is shut down; Fan On means the unit is in ventilation mode and the compressor and condenser fan are off; AC On means the unit is in initial cooling mode (unit has been running for no more than 5 minutes) and the compressor, condenser fan, and supply fan are all on; AC STABLE means the unit is in stable running conditions (unit has been running for more than 5 min but does not stop in the next minute); and Heat ON means the unit is in heating mode and fan is on (the compressor would be on for heat pump units and the compressor would be off for gas heating units).
3. To exclude high frequency cycling data, the unit should stay in one state for more than 60 consecutive seconds for the UT3 to recognize the unit as being in that specified state.

2.3 Performance Changes and Savings Estimates from Pre- and Post-Measurement

The evaluation team estimated unit savings using the pre- and post-service load and scheduling profiles developed from the metered data sets. The performance curves, load profile data, and scheduling information utilized CTZ2010 weather data to estimate unit savings.

2.3.1 Unit Changes in Energy and Demand

The evaluation team performed the analysis described in Section 2.2.2.2 on all 44 units with a wide variety of results. In some cases, there were negative savings due to increased loads from opening economizer dampers, which diminished any potential efficiency improvement benefits from other maintenance actions. When reviewing the performance changes, the team noted in data inspections that performance pre- and post-maintenance improved and diminished for different loading conditions for the same unit. This means the curves of efficiency versus load sometimes had similar shapes pre- and post-maintenance, but more often the curves had different shapes that overlapped. The data provides no measure level analysis given the numerous combinations of measures implemented and incomplete documentation by the various QM programs of when those measures were implemented across the various units.

Table 11 shows results across 29 units with reliable pre- and post-data. The units that the evaluation team could not analyze included three units that were replaced before final service, seven units on sites that were initially in the program but were later dropped and never had maintenance attempted, and five units with insufficient pre-maintenance cooling usage. Clearly the challenge of measuring field performance was a known issue prior to fielding the sample, but a roughly equal issue was the uncertainty that a pre-monitored unit would complete service in the program cycle. Despite planning for many more sites, the coordinated approach produced very few units with acceptable data. Future study options include forcing M&V units to remain in the program or obtaining more cooperation from program staff, contractors and technicians to get enough study sites to achieve an oversample.

The average savings was positive for SCE (but not statistically significant from zero) and negative for SDG&E with significant uncertainty. SDG&E did not claim savings in 2010-12[23]. The estimated savings for the statewide program with a pooled sample across both SCE and SDG&E sites was slightly negative, but not statistically different from zero.[24] The evaluation team felt the pooled sample was the most reliable due to the higher sample size (29 vs. 17) and lower standard error (462 kWh/ton vs. 605 kWh/ton). The implementation process was quite similar for both IOUs and the key difference was that SDG&E decided not to claim savings until after all maintenance and program inspection was complete. Based on the direct field observations and post-only visits for SCE and SDG&E, we determined the issues leading to negative savings for SDG&E were present within all 2010-12 statewide programs, and the pooled sample best represents the performance of the statewide program. The engineering assessments described in the next section showed there were several cases where efficiency and capacity changed minimally, but loads increased after program service due to outside air and controls changes.

Table 11: Energy and Demand Savings Estimates for Sample Commercial Quality Maintenance Statewide Program Using Regression Analysis

IOU Statewide Program	Pre-Post Average Savings	Sample Size	Standard Error	90% Confidence Interval Error Bound	Relative Precision	Lower Bound Savings	Upper Bound Savings
	Energy Savings (kWh/ton)						
SCE	705	17	605	994	141%	-290	1699

[23] Savings claims were withdrawn from the final tracking data after interim results were provided to the IOUs.

[24] As noted previously, PG&E was excluded from the statewide program evaluation due to low participation.

SDG&E	-1486	12	551	907	61%	-2393	-580
Total	-202	29	462	760	376%	-962	558
	Demand Savings (kW/ton)						
SCE	0.06	17	0.15	0.25	409%	-0.19	0.31
SDG&E	-0.43	12	0.13	0.21	50%	-0.64	-0.21
Total	-0.14	29	0.11	0.18	132%	-0.32	0.04

2.3.2 Causes for Changes Based on Engineering Assessments

In a secondary analysis, the evaluation team investigated the energy savings using an engineering assessment that utilized all available performance data. The team undertook the analysis to corroborate the regression analysis findings, but detailed analyses were limited given the sensitivity of the engineering analysis to measurement errors of temperatures, humidity, and airflow. The data was qualitatively informative in explaining findings from the regression effort. The regression analysis relied on the power consumption data, outdoor temperature conditions and schedule variables which were not as sensitive to measurement error[25].

The engineering assessment confirmed that maintenance does have the possibility of increasing unit energy consumption as illustrated in the following section. Bringing units up to baseline can increase the capacity and energy consumption of the treated unit, adding previously unmet load through increased comfort or increased outside air. The net result is a grid impact that should be taken into account. Future evaluations should consider these issues. These assessments also confirmed new findings from laboratory testing that show significantly higher than expected measurement uncertainty for rooftop package unit performance. The primary issues noted by the pre/post monitoring and site observations were:

- The pre-post change in performance did not lead to significant energy savings. Multiple compound faults made it such that the units did not perform similar to units under assumed workpaper conditions due to circuit faults not considered in workpapers and excess outside air increased after maintenance.
- When using engineering review of reliable efficiency measurement (excluding negative impacts from increased outside air), the changes in performance are small and the estimates are not statistically significant. However, the increased energy consumption from program service appears to be statistically significant as confirmed by the time series kW analysis. This means that the combination of increased loads and marginal changes in unit performance result in negative savings in some units. The average was negative for the SDG&E units and the combined sample.

[25] Note that measurement error in this case is that associated with issues such as incomplete mixing of air streams and/or spatial variation of important data, not sensor error.

- All of the economizers with time series metering data were not responding to conditions measured by temperature or CO2 sensors, meaning the dampers were essentially fixed in one position prior to maintenance. The fixed position was often increased after maintenance but the economizer still did not respond to temperature signals that would indicate proper operation, and were deemed inoperable. The findings are supported by direct observations that economizers were often not tested or repaired, but damper positions were adjusted by program maintenance technicians. According to the workpaper assumptions all non-working economizers should be repaired and minimum outside air would not change through maintenance.

2.3.3 Examples of Program Changes in Efficiency, Usage, and Outside Air

The evaluation team selected example engineering assessments of units with high, low, and negative savings to illustrate the reasons for the negative savings result. Detailed reports for each unit assessment are contained in Appendix B. More detailed reports with data plots will be made available through the CPUC data warehouse[26]. The following series focuses on three units, one of which has negative savings.

2.3.3.1 Example 1: Negative Saver (Site CC Unit 1)

Measurements indicated the OA damper position was increased by about 15% after the service. The assessment was determined by measuring return minus mixed air enthalpy compared to return minus outside air enthalpy (RAh-MAh vs. RAh-OAh) when in AC ON or AC STABLE operation. Economizer was observed to be inoperable before and after service. This and the change in unit operation schedule dominated the change in energy consumption. The unit was cycling on and off continuously during the baseline period. There were runs of 15 to 30 minutes with no continuous ventilation between cycles. During the post period, the unit was scheduled off from 10:00 pm to 4:00 am during weekdays and all-day weekends and the unit fan ran continuously between cycles. This meant that additional load was being brought in through the added ventilation. The base system efficiency (kw/ton) based on space cooling load was very close to the post kw/ton. The kw/ton values seem to be in the reasonable range of 1 to 2 kW/ton. This indicates the unit performance did not change significantly after the service. Master technician observations confirmed the most significant changes to the unit were opening of dampers with no repair to economizer functionality and changing the schedule.

2.3.3.2 Example 2: Near Zero Saver

The unit operation schedule and outside air fraction did not change significantly after program service. The damper was almost 60% open during the base and post periods with no response to temperature indicating the economizer did not function before or after service. The unit was

[26] File size limitations prevented including all site reports in this document.

cycling on and off during the baseline and post periods except for the period from 2:00 am to 6:00 am. There was no obvious operating schedule change. The base unit kW/ton is slightly better (more efficient) than the post kw/ton at the same cooling coil load. However, there was also a slight increase in space load in the post-period, but it is unclear what the source was of this slight increase. The small improvement in efficiency led to near zero positive savings for the unit. Master technician observations confirmed the most significant change to the unit was a refrigerant charge adjustment.

2.3.3.3 Example 3: Positive Saver (Site BP Unit 13)

Measurements indicated the OA damper position was decreased by about 60% after the service. The assessment was determined by measuring return minus mixed air enthalpy compared to return minus outside air enthalpy (RAh-MAh vs. RAh-OAh) when in AC ON or AC STABLE operation. Economizer was observed to be inoperable before and after service. The post-performance is close to the base-performance at the same coil load and the unit was off from 12:00 am to 6:00 am during the baseline and post periods. The weather-normalized post power was lower than the baseline power due to changes in ventilation air quantities noted. Master technician observations confirmed the most significant changes to the unit were closing dampers with no repair to economizer functionality.

2.3.4 Energy and Demand Savings Estimates

Across all sampled units for both IOUs, the average energy savings per-ton associated with running the individual pre- and post-regression models was negative (Table 11). The analysis focused on 29 units with the most accurate data available. Units were not weighted by program savings, but rather the specific results were turned into an average savings per ton and then extrapolated to the program tonnage claimed. The measured ex post energy savings estimates from the statewide pooled sample was applied to the savings claims for the SCE CQM program as shown in

Table 12. This table was developed as a result of establishing a unit energy savings (slightly negative UES) value for the pooled sample with upper and lower confidence intervals as shown in Table 11. The UES was applied to all program tonnage to get the final estimate for the upper and lower bounds. The results show a range using the measured uncertainty to illustrate the variability in savings was much larger than assumed in evaluation planning. Given the limited sample and the large degree of variability, the point UES estimate was not statistically different from zero, thus the realization rate for the SCE program was zero. SDG&E removed their claims from the final tracking data, thus the realization rate for the SDG&E program is not defined. Given the wide range of uncertainty and limited sample, the results are considered indicative of program performance, but not definitive based on the calculated uncertainty in the measured savings.

Table 12: Energy Savings Estimates for Commercial Quality Maintenance Statewide Program—Measured Ex Post

Program Type	IOU	Ex Ante Energy Savings (kWh)	Ex Post Energy Savings Range (kWh)	Energy Realization Rate (%)	Ex Ante Demand Savings (kW)	Ex Post Demand Savings (kW)	Demand Realization Rate (%)
Statewide	**SCE**	3,582,081	-11,197,680 to 6,495,120	0	676	-3,725 to 466	0
	SDG&E	0	0	N/A	0	0	N/A
	Total	**3,582,081**	-11,197,680 to 6,495,120	0	**676**	-3,725 to 466	0

2.3.5 Additional Observations for Statewide Programs

Additional contractor observations and ex-post inspections were made for the Statewide programs, but these results were not applied to energy savings claims. The goal of presenting this information in Table 13 is to illustrate specific measures that did or did not pass ex-post inspections. Some of the results presented include early 2013-14 program sites and include both data logger and non-data logger sites for SCE and SDG&E. The findings from post-only inspections seem relevant given that program workpapers assume an average frequency of pre-maintenance deficiencies and a post-maintenance condition of no deficiency for each measure. The pass and fail criteria were based on unit-specific manufacturer protocols. Some additional criteria were required for specific measures.

- Coil cleaning was assumed to pass unless the cleaning method was directly observed since use of water versus manufacturer specified methods could not be determined in post-only observations.
- The refrigerant charge pass/fail has issues as this pass rate does not account for the partial pass outcomes. This issue is discussed in greater detail relative to developing installation rates in Section 2.3.6.
- Airflow adjustment was not a program workpaper measure, but documentation existed that issues were identified by service technicians and the uncorrected deficiencies do affect assessment of charge and unit performance.

Table 13: Observation and Inspection Results for Measures Included in 2010-12 Statewide Programs

	SCE Statewide (Data Logger and Additional Observations)		SDG&E Statewide (Data Logger and Additional Observations)		PG&E Statewide (2013 Observations)	
Fault / Measure	Sample	Diagnostic Pass Rate	Sample	Diagnostic Pass Rate	Sample	Diagnostic Pass Rate
Coil Cleaning	94	96%	38	97%	41	12%
Adjust Airflow	6	17%	0	N/A	14	0%
Refrigerant System Service	17	24%	21	19%	22	23%
Economizer Functional Test	71	0%	38	13%	40	10%
Integrate Economizer Wiring	0	N/A	0	N/A	14	0%
Replace Damper Motor	0	N/A	0	N/A	18	0%
Replace Controller/Sensor	0	N/A	0	N/A	29	0%
Renovate Linkage & other components	0	N/A	0	N/A	23	0%
Replace T-stat	0	N/A	0	N/A	18	39%
Notched V-Belt Upgrade	3	100%	2	0%	0	N/A

2.4 Installation Rate Based on Ex-Post Observations

The team directly observed technicians performing maintenance for units with data loggers. The program design allowed measures to be installed over the course of the three-year service agreement, so it was not always possible to observe all maintenance as planned. The statewide programs did not record the amount of refrigerant charge added or removed or specific adjustments made to the system such as economizer minimum position, so the observations were quite valuable.

In most cases the team was not notified when additional maintenance occurred outside of the site observations; therefore direct observation of all measures was not possible. The 2010-12 SCE program team approached the M&V sampling as voluntary and recruited contractors and technicians with a relatively low volume of program jobs for pre-post monitoring. SDG&E and PG&E each had two primary participating contractors. The SDG&E program team obtained full participation in the sample but ultimately claimed no savings for CQM, while both PG&E contractors dropped from the program prior to sampling. Given these situations, the data logger

sample did not include some of the top SCE contractors in the statewide programs and did not include the PG&E and SDG&E local programs.

The EM&V team concentrated new efforts in 2013 to observe and inspect work performed by the contractors accounting for the most claimed savings for the 2010-12 program cycle. The team coordinated with program implementers to perform additional contractor observations and post maintenance inspections for the statewide programs and for the local programs to supplement the initial sampling. Due to the size of the program savings claims, most of these additional observations and inspections occurred within the third-party / local programs. Since the local programs used the individual measures design, the team only performed post maintenance inspections within these programs. The refrigerant charge and economizer measures were a primary focus given the difficulty in assessing the coil cleaning measures, since coils may have gotten dirtier or have been cleaned since initial service and prior to evaluation inspections.

Details for each unit assessed are provided in Appendix B. These details are extremely important since the measures varied across the programs. Manufacturer's recommended maintenance procedures, including manufacturer's refrigerant charge diagnostic protocols were used as the basis of comparison across all sites sampled. The EM&V team determined late in the process, after the last round of laboratory testing, that the most reliable method for assessing refrigerant charge was complete removal and weigh-in to factory charge. This process was completed on a select number of units since the process is more expensive than indirect diagnostics and impact evaluation did not have budget and time to re-assess a larger sample. The master technicians described the details of the results compared to manufacturer and Title-24 diagnostics in the Appendix B. Lab testing indicated that manufacturer refrigerant charge protocols provided the best set of diagnostics for all possible faults, but still provided false diagnostics in some cases.

2.4.1 Fault Detection Diagnostics Role in Installation Rate

Correct FDD and repair are important for HVAC maintenance. If technicians cannot correctly perform FDD and repairs, then HVAC maintenance programs will not realize ex ante savings. In addition to the laboratory findings presented later in this report, another set of recent reports indicate problems correctly identifying faults using various RCA protocols. Yuill and Braun indicated that the Title 24 RCA protocol identifies faults in 46% of cases without faults, misdiagnoses in 25% of cases with faults, and does not detect faults in 32-55% of cases with faults. [27,28]

[27] Braun, Jim, David Yuill, and Howard Cheung. *A Method for Evaluating Diagnostic Protocols for Packaged Air Conditioning Equipment*. Purdue University and the California Energy Commission, 2012.

[28] Braun, Jim, and David Yuill. Evaluation of the Effectiveness of Currently Utilized Diagnostic Protocols. Purdue University. 2014.

Are technicians correctly following a poor protocol or are errors compounded due to incorrectly implementing a poor protocol? The evaluation found problems with both protocols and implementation of those protocols. Additionally, the team found a lack of awareness and training regarding manufacturer protocols that are provided in installation manuals.[29] Manufacturers provide unit specific service procedures in the installation manuals with trouble-shooting information on many but not all faults. The current Title 24 RCA protocol is based on superheat measurement, subcooling measurement, and airflow diagnostic protocols from at least three different manufacturers that have been available for decades.[30] These protocols have been applied in previous program cycles and were still used in some 2010-12 cycle programs. The Title 24 protocols help technicians evaluate proper RCA when no other faults are present. The Title 24 and at least some manufacturer protocols are not designed to account for or diagnose other faults and were developed under conditions with no combinations of faults.

In addition, many protocols depend on accurate measurement of the temperature and humidity of air entering the evaporator coil. Unlike residential systems, common rooftop packaged units have outside air intakes that bring in ambient air that does not fully mix with the return air. The coil entering temperature is only equal to the return air temperature with the outdoor air intakes are completely sealed. Service technicians measuring only the return air or a single point measurement near the coil produce inaccurate coil entering temperature measurements leading to misdiagnoses of system faults. Protocols that do not require direct measurement of coil-entering temperature and humidity are also affected by outside air because these conditions change the unit loading that changes the target values for the diagnostics.

The instrumentation used for FDD can introduce significant measurement uncertainty, thus confounding the ability of the FDD protocol to accurately diagnose faults. The measurements include air temperatures and the pressure and pipe surface temperatures of the refrigerant circuit. The 2006-08 HVAC Evaluation and previous studies show that the target tolerances cannot be reliably achieved without an accurate and relatively expensive combination of instrumentation.

Program technicians do not evaluate FDD of outdoor airflow through economizer or make-up air dampers. Additionally, outdoor airflow is not included in efficiency tests used to develop diagnostics for packaged units. The database used by the Yuill and Braun study did not include

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[29] Carrier 2005. 48HJD/HJE008-014, 48HJF008-012 Single-Package Rooftop Gas Heating/Electric Cooling Units. Installation, Start-up, and Service Instructions. Form 48HJ-32SI. Fig. 57 – Cooling Charging Charts. http://www.docs.hvacpartners.com/idc/groups/public/documents/techlit/48hj-32si.pdf

[30] Carrier 1986. R22 Superheat, Subcooling, and Airflow Calculator. GT24-01 020-434

Carrier 1998. R410A Superheat, Subcooling, and Airflow Calculator. GT58-01A 020-517

Trane 1996. Air Conditioning Charging Calculator. Pub. No. 22-8065-07

York 1991. Superheat, Subcooling, and Airflow Calculator. Form 501.00-PM5Y (5/91).

units with fixed outdoor air intakes or economizers. This critical gap was filled by laboratory testing conducted by the evaluation team, where units were tested with economizers, as described in Section 5 of this report.

2.4.2 Results for Recovery and Re-Charge

The team evaluated refrigerant charge in the field by measuring ex-post performance on units where technicians made adjustments. The evaluation selected a random sample of packaged rooftop air conditioners towards the end of the evaluation as new information from laboratory testing was released on the uncertainty in the accuracy of charge diagnostics. The detailed charge assessment sample included five single-compressor and two dual-compressor units for a total of nine refrigerant circuits. For each circuit, the EM&V master technicians recovered and weighed out charge, evacuated to 500 microns, held at or below 500 microns for 20 minutes, weighed in factory charge, and measured performance with factory charge. The average refrigerant charge adjustment reported by the local program for the units evaluated was 19.4 ± 5.7%. This indicates that, on average, units had a significant amount of charge added. Recovery and weigh-out of these units indicated cases of both over and undercharge after service. Units that were still undercharged after the program-added charge realized benefits, but additional potential remained. Units that had charge added and ended up overcharged had multiple potential outcomes including positive, zero, or slightly negative benefits.

The team looked at the refrigerant charge benefits using the efficiency estimate at various charge conditions in the 2009 PG&E workpaper, which the ex ante team recommended based on the available data. The workpaper provided estimated EER at various charge conditions for TXV and non-TXV units. The team calculated program assumed EER's based on claimed initial charge, actual initial charge and final charge state. From this the team calculated claimed, actual and correct savings percentages based on average EER's. Installation rates were then calculated as the actual benefits divided by the claimed benefits since these rates were developed and applied to the third-party and local programs. Results are summarized in Table 14. Note that the change in EER values in this table show both TXV and non-TXV, but for the installation rate calculation, program level total tonnage of TXV and non-TXV units were used given the frequency of metering devices in the sample was not likely to be representative. Total tonnage associated with TXV units was 16% for the AirCare Plus program and 46% for the SDG&E local program.

Table 14: Installation Rate Based on Recovery and Re-charge Method

Unit #	Circuit #	Program Charge Adjustment	Unit Weighed Charge Compared to Factory Charge after Program Service	Disposition - Did Program Adjustment Have a Benefit based on direction and amount	Claimed Change in EER (TXV/Non-TXV)	Actual Change in EER (TXV/Non-TXV)

Unit 1	Circuit 1	Added 7.1%	Charge within -2.6%	Partial benefit, high discharge pressure due to failed condenser fan reduced efficiency by 27%. Undercharge had 5% impact.	0.06	0.33	0.08	0.42
Unit 1	Circuit 2	Added 6.5%	Charge within -1.1%	Partial benefit, also see above	0.05	0.29	0.06	0.33
Unit 2	Circuit 3	Added 14%	Overcharged 6.5%	Partial benefit (negative for TXV), Overshot	0.18	0.87	-0.09	0.17
Unit 2	Circuit 4	Added 13%	Overcharged 18.3%	Negative benefit	0.16	0.78	-0.32	-0.38
Unit 3	Circuit 5	Removed 17%	Undercharged 31.4%	Negative benefit	0.41	0.50	-0.62	-2.30
Unit 4	Circuit 6	Added 33%	Undercharged 9.4%	Increased benefit exceeds range of DEER charge adjustment assumptions, representing additional opportunity	0.89	3.49	1.20	4.39
Unit 5	Circuit 7	Added 19.1%	Undercharged 17%	Increased benefit exceeds range of DEER charge adjustment assumptions, additional opportunity if condenser kept clean.	0.32	1.42	0.80	2.90
Unit 6	Circuit 8	Added 16.8%	Undercharged 15.8%	Benefit consistent with DEER, additional opportunity	0.26	1.16	0.65	2.37
Unit 7	Circuit 9	Added 48%	Overcharged 6.1%	Increased benefit exceeds DEER, over by 6.1%	1.29	4.87	1.14	4.69
Unit 8	Circuit 10	Added 13%	Overcharged 13%	Negative benefit	0.16	0.78	-0.32	-0.38
Installation Rate - Combined based on program savings								**79%**
Installation Rate – PG&E AirCarePlus (14% TXV)								**81%**
Installation Rate – SDG&E Local (46% TXV)								**77%**

If only diagnostics are used after program service then most units would be indicated as not passing, and the resulting installation rate would be very low. However, as shown above the program adjustments did have benefits. The outcome would be much different if the installation rate was based on pass/fail diagnostics as indicated in Table 15.

Table 15: Comparison of FDD Methods for Recovery and Recharge Sample – As Found Conditions

		Diagnostic outcome after program service (as found condition)		
Unit #	Compressor #	2008 Title-24 / 06-08 Program (SH or SC)	Generic Program FDD (SH, SC, COA, EST)	Manufacturer FDD (DP, SP, AT, LT, ST, SH. SC)
Unit 1	Circuit 1	Fault	Fault	Fault
Unit 1	Circuit 2	Fault	Fault	Fault
Unit 2	Circuit 3	Fault	Fault	Fault
Unit 2	Circuit 4	Fault	Fault	Fault
Unit 3	Circuit 5	False Pos.	Fault	Fault
Unit 4	Circuit 6	Fault	Fault	Fault
Unit 5	Circuit 7	Fault	Fault	Fault
Unit 6	Circuit 8	False Pos.	Fault	Fault
Unit 7	Circuit 9	Fault	False Pos.	Fault
Unit 8	Circuit 10	False Pos.	Fault	Fault
		Fault	**Fault**	**Fault**
		7 of 10	**8 of 10**	**10 of 10**

Finally, the team assessed diagnostics after charge additions brought units back to factory conditions. Results are shown in Table 16. This analysis illustrates that diagnostics can cause technicians to add or remove charge for units already properly charged. It also indicates that technicians will have difficulty knowing when to stop adjusting charge for units with deficiencies. The false alarm rate was lowest for manufacture protocols and the manufacturer and generic program protocols provide valuable information on other faults besides charge amount.

Table 16: Comparison of FDD Methods for Recovery and Recharge Sample – Factory Charge Conditions

		Diagnostic indicates False Alarm (FA) at Factory Charge (Diagnostic Failed) - Partial means diagnostic indicates other issues		
Unit #	Compressor #	2008 Title-24 / 06-08 Program (SH or SC)	Generic Program FDD (SH, SC, COA, EST)	Manufacturer FDD (DP, SP, AT, LT, ST, SH. SC)
Unit 1	Circuit 1	False Alarm	Partial Pass	Partial Pass
Unit 1	Circuit 2	False Alarm	Partial Pass	Partial Pass
Unit 2	Circuit 3	False Alarm	False Alarm	Partial Pass
Unit 2	Circuit 4	False Alarm	False Alarm	Partial Pass
Unit 3	Circuit 5	False Alarm	False Alarm	False Alarm
Unit 4	Circuit 6	Pass	Pass	Pass
Unit 5	Circuit 7	Pass	Pass	Pass
Unit 6	Circuit 8	NA	NA	NA
Unit 7	Circuit 9	False Alarm	Partial Pass	Pass
Unit 8	Circuit 10	Pass	Pass	Pass
		False Alarm %	**False Alarm %**	**False Alarm %**
		67%	**44%**	**11%**
		Pass %	**Pass %**	**Pass %**
		33%	**22%**	**44%**
		Partial Pass %	**Partial Pass %**	**Partial Pass %**
		0%	**33%**	**44%**

The evaluation team found problems both with the recommended refrigerant charge (RCA) fault detection procedures and with incorrect implementation of the procedure, which led to a large number of undiagnosed faults. Refrigerant charge FDD methods seek to assess the amount of refrigerant in the system indirectly through measurements of operating pressures and temperatures. The Title-24 approach could not be guaranteed to determine correct refrigerant charge faults under ideal conditions (Braun[31,32]) and were more problematic when applied to commercial field conditions. In the sample examined as part of this effort, the Title-24 approach correctly assessed charge in only 1/3 of the cases. Additional common faults, which also affect

[31] Braun, Jim, David Yuill, and Howard Cheung. *A Method for Evaluating Diagnostic Protocols for Packaged Air Conditioning Equipment*. Purdue University and the California Energy Commission, 2012.

[32] Braun, Jim, and David Yuill. Evaluation of the Effectiveness of Currently Utilized Diagnostic Protocols. Purdue University. 2014.

the pressures and temperatures measured (e.g., contaminants, especially non-condensables and line restrictions), are not addressed by the Title-24 methodology and lead to incorrect charge adjustment when not identified. This section focuses on the third-party and local programs. Similar issues existed in the statewide programs, but separate installation rates were not developed.

After third-party and local program service and evaluation, the team determined that:

- Program refrigerant charge service achieved full benefits, partial benefits, and negative benefits based on the weighed-out charge and reported adjustments.
- Linking FDD values to benefits is difficult. This means program and typical verification FDD methods frequently fail in assessing potential savings or achievement of factory charge. FDD protocols are inherently pass/fail, making it difficult to quantify the benefits of incremental but suboptimal improvements.
- Manufacturer protocols perform better than the Title 24 or generic program FDD protocols in determining whether a unit has achieved factory charge
- Linking results of weigh-out/weigh in charge testing to benefits is plausible if correct charge adjustment is known. However, correctly adjusting charge based on common protocols remains challenging.
- The Title-24 protocol only looks at superheat for non-TXV units and subcooling for TXV units and cannot diagnose faults with high/low heat transfer, pressure, restrictions, or non-condensables

2.4.3 Installation Rates for Third-Party and Local Programs

The CPUC defines installation rate as measures being installed and capable of saving energy as intended. Initially, the study estimated installation rates by sampling units completed by the contractors in each IOU third-party and local program that comprised 70% or more of combined savings. The samples were relatively small compared to the size of the programs since they were not the initial focus of the evaluation. The evaluation team did not use the diagnostic assessment to evaluate the installation rate of refrigerant charge measures based on the discussion in Section 2.4.2. The installation rate for economizers is based on the diagnostic tests presented in this section. Other measures are included in the report tables below but no installation rate adjustments were made for non-economizer measures.

The evaluation team found that a majority of economizers were not functional after servicing, and that a number of other issues were not addressed by the maintenance effort. The evaluation team also considered that some economizer repair measures had an effective useful life (EUL) claimed of three years and inspections for some sites occurred close to that timeframe. The expectation would still be that half of the economizers would still be working based on the EUL definition. Table 17 and Table 18 show the results for all observed measures for PG&E AirCare

Plus and SDG&E local programs. Overall, only 5% of economizer measures in the PG&E AirCare Plus sample and none in the SDG&E Local Program sample passed the post diagnostic assessment. Considering the EUL of the measures and timing of inspections the final economizer installation rate assumes that an average of 20% of the measures would have failed at the time of the inspection. Therefore the installation rate was estimated to be 25% for AirCarePlus and 20% for SDG&E Local program. The pass and fail criteria were based on unit-specific manufacturer protocols. Some additional criteria were required for specific measures.

- Coil cleaning was assumed to pass unless the cleaning method was directly observed since use of water versus manufacturer specified methods could not be determined in post-only inspections.
- The refrigerant charge pass/fail has issues as this pass rate does not account for the partial pass outcomes. This issue is discussed in greater detail relative to developing installation rates in Section 2.3.6.

The majority of economizers with reported repairs were not found to be performing their primary function of changing damper position in response to temperature. In some cases, the program technicians opened the position of the dampers, but did not observe other changes to sensors, linkages, or control settings. In one program, new sensors and new controllers were installed by the program technicians but were not set up such that the controller or sensor actually changed the damper position. Additionally, although most systems required economizer repairs, none of the technicians performed them in direct observations, and they were the most common fault found in post-maintenance visits. In addition to the limitations of the fault detection diagnostics (FDD) applied in the CQM programs, the evaluation team believes that un-diagnosed economizer faults and inherent leakage of economizers present an additional challenge and future opportunity.

Table 17: PG&E AirCare Plus Measure Observations

Measure	Sample	Diagnostic Pass Rate
Basic Package	33	100%
Refrigerant Charge and Airflow Service	27	52%
Functional Economizer Test and Repair	33	6%
Economizer Adjustment	33	0%
Economizer Control Package	19	11%
Programmable T-stat Replacement	11	100%
Programmable T-stat Adjustment	25	44%

Table 18: SDG&E Local Program Measure Observations

Measure	Sample	Diagnostic Pass Rate
Condenser Coil Clean	39	100%
Refrigerant Test	39	100%
Refrigerant Service	37	35%
Economizer Repair	8	0%
Replace Economizer Controller/Sensor	2	0%
Evaporator Coil Clean	23	100%
Comb Condenser Coil Fins	2	100%

Further study is ongoing on whether the program criteria and other methods can reliably be used to diagnosis and adjust refrigerant charge as described in the preceding section. See Section Appendix B for detailed summaries of all units observed.

The evaluation team applied the installation rates for refrigerant charge and economizer measures to the ex ante savings reported by the local programs. Similar data were collected for statewide programs but an additional adjustment was not made to those estimates which were based on pre/post measurements across a package of measures. Table 19 shows the adjusted gross savings for refrigerant charge after applying the installation rates developed in Table 14. It should be emphasized that the savings result occurred somewhat randomly given the poor performance of the diagnostics in assessing factory charge. Determining the installation rate for charge required program tracking of charge adjustment amounts and the recovery and re-charge method of EM&V. Both programs used proprietary refrigerant system analyzers. Individual units were found to be above and below factory charge after service in the weighed charge sample. The installation rate may change dramatically in future evaluations given the wide variation in estimated actual benefits from charge adjustment. The evaluation team recommends using a more conservative installation rate for future programs if the recovery and recharge cannot be performed due to budget constraints. Additional EM&V using this method is strongly recommended for 2013-14 evaluation given the small sample available to date.

Table 19: Final Installation Rate and Adjusted Gross Savings for Refrigerant Charge Measures (2010-12)

IOU	Program Name	Ex Ante Energy Savings (kWh)	Ex Ante Demand Savings (kW)	Install Rate	Installed Energy Savings (kWh)	Installed Demand Savings (kW)
PG&E	Air Care Plus	2,339,072	0	81%	1,894,648	0
SDG&E	Non-Res HVAC Tune-up/Quality Installation	2,390,079	1	77%	1,840,361	1
TOTAL		4,729,151	1	79%	3,735,009	1

Table 20 shows the installation rate applied to economizer repair measures. The criterion for the installation rates was basic functionality of the economizer and the short EUL for some economizer repairs was considered.

Table 20: Final Installation Rate and Adjusted Gross Savings for Economizer Measures (2010-12)

IOU	Program Name	Ex Ante Energy Savings (kWh)	Ex Ante Demand Savings (kW)	Install Rate	Installed Energy Savings (kWh)	Installed Demand Savings (kW)
PG&E	Air Care Plus	6,938,405	3,488	25%	1,734,601	872
SDG&E	Non-Res HVAC Tune-up	3,884,115	2,571	20%	776,823	514
TOTAL		10,822,520	6,059	23%	2,511,424	1,386

2.5 Additional Observations

The following additional observations were not used in determining energy savings or installation rates, but these findings are presented to suggest possible causes for the high uncertainty in savings and relatively low installation rate for economizer repairs. Observations of training sessions, review of training materials, and review of QC procedures was performed by master technicians who also performed direct observations of program service as well as post-maintenance inspections. Note that review and observations were not conducted of all trainings within all programs.

2.5.1 Technical Training Issues

In the post measure assessments, the evaluation team found a number of issues with systems related to program measures, especially systems where the economizer minimum outdoor air position was systematically increased, as well as lack of economizer functionality. The program workpapers intended to repair non-functioning economizers, but in the direct observations process, service technicians also opened economizers beyond their previous minimum positions. An SCE training video obtained through a data request directed contractors to increase minimum outdoor air position; this behavior was confirmed by field observations and in the pre-post data logger analysis.

Master technicians attended additional program training and reviewed training material and observed that the training for programs in 2010-12 did not include functional testing of economizers or repair processes. This is a likely root cause of the observed low installation rate for economizer repairs in the third-party and local programs. These findings on economizer repair issues are similar to other evaluation studies.[33]

Observations of training classes indicate that the 2010-12 statewide and local programs consistently provided training on how to enter data into the program database, but there was variation in procedures and information for technicians to diagnose and repair faults that lead to improved energy efficiency. Given that the program training observed varied, it is not surprising that the observed procedures used varied across technicians. In late 2013 and early

[33] Wang W, S Katipamula, Y Huang, and MR Brambley. 2013. "Energy savings and economics of advanced control strategies for packaged air conditioners with gas heat." Energy and Buildings 65:497-507. doi:10.1016/j.enbuild.2013.06.033

Katipamula S, and MR Brambley. 2005. "Methods for Fault Detection, Diagnostics and Prognostics for Building Systems - A Review Part I." HVAC & R Research 11(1):3-25.

California Energy Commission (CEC). 2003. Small HVAC Problems and Potential Savings Reports. 500-03-082-A-25. http://www.energy.ca.gov/2003publications/CEC-500-2003-082

2014, program contractors were contending that repairs of faults are not covered under their maintenance contracts, and need to be bid and implemented separately as "retro-commissioning." This interpretation is not consistent with workpaper assumptions for the statewide programs.

2.5.2 Technical Tool Issues

Approximately 92% of program technicians had issues with tools or procedures. None had proper tools to evaluate economizers or outdoor air damper position. Approximately 50% did not have EPA low-loss fittings on their refrigerant hoses. Those that did have low-loss fittings often did not purge hoses of air and water vapor prior to attaching to the system. Lack of low loss fittings and failure to purge hoses causes non-condensables or contaminants to enter the system when adding refrigerant or attaching hoses. The weight of non-condensables introduced through the use of non-EPA fittings was not measured in the field. Field tests indicated the presence of non-condensables, but it was not possible to quantify the amount. Current lab tests are attempting to quantify the impact of non-condensables introduced by attaching typical service equipment, but quantification may be difficult, even under laboratory conditions.

In almost all direct observations, program technicians did not use proper tools or procedures to measure relative humidity, economizer operation, or damper position. Manufacturer recommendations for coil cleaning were only followed in one direct observation. Most technicians did not install fan belts with proper tension or alignment, which led to reduced airflow, efficiency, and premature failure.

2.6 Conclusions and Recommendations

2.6.1 Conclusions

Ultimately, we determined that the overall results were zero but highly uncertain realization rates and total program savings for 2010-12 statewide CQM program. This result is applicable to SCE claims only, since SDG&E withdrew claims from the final tracking data and PG&E sites were not included in the study sample.[34] The evaluation team reviewed all of the detailed data and observations and concluded that the underlying reasons for the result were that the current program has various inherent challenges, many of which were likely unknown until the field and laboratory research under this study became available. The reasons center on the program

[34] PG&E claims under the statewide program were measure-based holdover claims from a previous cycle.

implementers changing economizer minimum outside air positions without fixing their functionality. There were negligible changes in unit and system efficiency from RCA measures, but significant improvement in unit operation was noted for thermostat and fan control measures. The lack of efficiency improvement likely stems from the program providing incentives for adding or removing refrigerant charge without diagnosing other faults such as low airflow and refrigerant restrictions or non-condensables.

Multiple HVAC faults can present the same diagnostic readings depending on the combination of faults and operating conditions. This reality means that it can be unknown which of the faults or which combination is present for a given diagnostic result, leading to mis-diagnosis and incorrect remediation when a service technician focuses on a single fault. The programs also assumed economizers would be repaired, but these repairs were often considered non-maintenance repairs or retro-commissioning measures by the program contractors and, as such, outside the scope of program services. Statewide program training for SCE in 2012 guided technicians to increase minimum damper positions rather than making non-functional economizers functional. The increase of minimum outside air may be the largest driver of increased energy consumption for the monitored units. For all programs, outdoor air intake at the unit makes diagnosing other faults such as airflow and refrigerant charge difficult, if not impossible through FDD.

The team also found very few economizer repairs working which led to a conservative estimate of 23% mean installation rates. For refrigerant charge, estimating installation was much more complicated than originally expected and only a small sample could be conducted which showed issues with FDD and a wide range of positive and negative benefits. The installation rates present the same underlying issues as discussed above. Laboratory tests results, which are presented in Section 5, indicate challenges associated with relying on refrigerant charge adjustments to improve efficiency. For economizers, the programs focus on installation of sensors or changing outside air minimum position instead of testing and repairing economizer functionality. Logically, reducing minimum damper position to code levels instead of increasing minimum position based on rules-of-thumb identified in program training might be a reliable measure to reduce energy consumption (i.e., easier to diagnose and repair).

These issues demonstrate some of the reasons why commercial HVAC maintenance programs have failed to achieve potential savings as documented in this and previous evaluations.[35]

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[35] KEMA. 2010. Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group Programs, 2006-2008 Program Year, Volume 1 and Volume 2. California Public Utilities Commission (CPUC). http://www.calmac.org/publications/Vol_1_HVAC_Spec_Comm_Report_02-10-10.pdf

Footnote 13 - Hunt et al. 2010

2.6.2 Economizer Findings Relative to CQM Programs

In 2010-12, the programs did not provide consistent training or incentives regarding economizer minimum outdoor air damper position to improve energy efficiency. Maintenance programs require retro-commissioning or test and balance (TAB) service prior to other repairs to address minimum outside air regardless of the whether new sensors or controllers are added. The primary functional components such as linkages and dampers need to be working as a prerequisite to adding or improving sensors and controllers. While programs provide incentives for repairing non-functional economizers, none of the technicians performed economizer repairs while being observed. If contractors view repairs as "retro-commissioning" not maintenance, then these measures could be replaced by others to reduce unnecessary outside air, such as sealing the junctions of economizers to units, or expanding the program to include both retro-commissioning and maintenance items.

Participating technicians in one program received incentives for 1,136 economizer tests in 2010-12. The IOUs paid a total of 438 repair incentives for wiring, damper motor, sensor/controller, and linkage repairs. Although it is not indicated in the tracking data, an individual unit likely required multiple repairs. Assuming all repaired units received new sensors, we estimate repairs were made on 148 units or 13% of those tested. In another program, 11 out of 16 economizers at one site were reported as repaired, but only 5 were still working one year later while 11 were not. These finding indicate that there are significant economizer savings available.

Replacement parts for old economizers with analog sensors and controllers are no longer manufactured or available from local distributors.[36] It can be more expensive to repair a broken economizer than to install a new one, and many repairs don't work. Field observations of one program found more than 70% of economizer repairs were not working one year later. These findings are similar to other evaluation studies.[37] New economizers have improved digital sensors and controllers with on-board diagnostics and are relatively easy to install.[38] However, a past study of newly constructed buildings in California with new economizers reported 64% failures after 2 to 3 years of operation.[39]

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[36] The programs provide incentives of $1,125 to $1,485 to repair broken economizers.

[37] Pacific Northwest National Laboratory study found 62.5% of economizers not working at a university laboratory building and 100% not working at a hotel in San Francisco (EDR 2011). An evaluation in New England found 44% of economizers failed within 2 years (HEC 1993).

[38] See http://www.micrometl.com/economizers.aspx and http://beyondinnovation.honeywell.com/products/jade.

[39] California Energy Commission (CEC). 2003. Small HVAC Problems and Potential Savings Reports. 500-03-082-A-25. http://www.energy.ca.gov/2003publications/CEC-500-2003-082

The primary issue occurs when new controllers are installed on older economizers that have mechanical issues. The new sensors and control algorithms send signals to components that cannot function and respond. The 2010-12 programs offered incentives to decommission non-functional economizers. If economizer dampers are closed when units are decommissioned, laboratory tests summarized in chapter 5 indicate cooling efficiency can be improved by 5% to 140%, depending on the pre-existing damper position, while maintaining Title 24-required outdoor ventilation air quantities for many occupancies.

2.6.3 Recommendations

The recommendations provided in this report do not cover all of the changes between the 2010-12 and 2013-14 programs. These recommendations have not been tested for cost effectiveness and they are intended as areas that should be considered and if feasible, developed further, piloted, and tested for cost effectiveness.

To address these findings, we recommend that IOU programs coordinate to clearly define measures and ensure program workpaper assumptions match the implementation process of the measures. The terminology (maintenance, repair, retro-commissioning) is less important than defining the specific actions that take place and how those actions lead to energy savings. The IOU programs should focus on activities that will lead to energy and peak demand savings, rather than trying to address all repairs and actions recommended in Standard 180. A focus should also be placed on the one-time and ongoing maintenance activities that lead to more persistent savings. Other repairs and maintenance activities that improve comfort, indoor air quality, or unit reliability may increase energy consumption or peak demand, and should be accounted for if performed.

We recommend piloting approaches that have demonstrated measurable savings. For each approach with measureable savings, the program should provide a definition and examples of the effective energy efficiency measures. In 2010-12 some programs provided lists of tools that were acceptable while others did not, but these reference documents did not list the acceptable tool for each procedure. The measure definitions should include specific training requirements, approved tools based on accuracy requirements, protocols to perform and inspect the measure, and data collection requirements. We also recommend that incentives be provided for measures with the highest probable applicability, FDD repair rate, and savings. Measure recommendations include:

- **Seal Unit Leaks.** Sealing the junctions between economizers and unit cabinets may have large opportunities as they are not part of routine maintenance. Pilot efforts should measure the change in performance in the field and use reliable sealing methods such as properly rated metal taping and mastic. This recommendation requires coordination with certified test and balance (TAB) technicians to ensure minimum requirements for ventilation are met. It is not likely that economizer perimeter leakage is intended to help

meet ventilation requirements. Economizer perimeter leakage will be further studied in the 2013-14 laboratory tests. The evaluation recognizes that any recommendation regarding reductions in outdoor air quantity raises liability concerns, but over-ventilation does waste energy. Some units are operated with fans that cycle on with compressors and may not meet ventilation requirements even when accounting for leakage. Outside air rates need to be evaluated and the leakage must be taken into account such that it is known and part of calculations.

- **Reconsider Generic Diagnostic-Based Refrigerant Charge Measures.** Identifying and adjusting units with incorrect charge proves to be extremely difficult on commercial units with outdoor air intakes and more difficult if multiple faults are present. A key issue becomes determining appropriate coil-entering sensor placement due to unmixed and temperature-stratified air on the inlet side of the coil, since the ideal placement changes with damper position. Evacuation and recharge is recommended as the best method to assess exact charge level. The evaluation team understands that this method may not be cost-feasible for program implementation, and thus the program recommendation is to follow unit specific manufacturer diagnostic procedures (see next bullet). We recommend that programs implementing this measure perform quality control verifications on a sample of completed jobs using recovery, weigh-out and re-charge.
- **Use Manufacturer Maintenance and Diagnostic Protocols or Compare Program Methods to them for Reference.** Manufacturer protocols provide important instructions on troubleshooting multiple faults for units including refrigerant charge, restrictions and non-condensables. These methods were found in field and laboratory testing to be more reliable than generic FDD protocols. Manufacturer protocols also may provide new methods for adjusting airflow based on static pressure measurements. Manufacturer protocols provide instructions on proper tensioning and alignment of fan belts. This recommendation does not preclude future FDD protocol development that provides better energy efficiency optimization. Any new methods should be compared to manufacturer methods to demonstrate they are better at achieving optimal unit performance. The accuracy of manufacturer and other FDD methods across ranges of airflow conditions and other faults continues to be a subject of laboratory testing.
- **Develop Criteria to Replace Rather than Repair Economizer**s. Repairing old economizers can be expensive and difficult due to limited availability of parts and the need to address old design issues. Economizer replacement offers an option that may overcome some of the fundamental economizer repair issues and should be explored. De-commissioning is not an energy efficiency measure and this recommendation calls for a replacement measure which would also entail installing Title 24 compliant controls with FDD. Unit age should also be considered in determining whether to repair or replace an economizer. Also note that integrating new economizer controls with older unit controls and motors presents an issue. It should be considered whether this

measure also requires changes to settings, upgrades to unit controls (thermostat or energy management systems), and/or upgrades to motors.

In the long term, HVAC manufacturers, industry associations, state licensing boards, and the U.S. Department of Energy (DOE) can help improve quality maintenance programs by supporting improved technician competency standards, FDD protocols, and service instrument standards. For utility programs in the short term, we recommend that additional field and laboratory tests and additional analyses be conducted to further research the energy saving potential of HVAC maintenance and the issues identified in this summary. The focus should be on efficiency and account for activities that may improve comfort and/or indoor air quality, but result in increased energy consumption. The program can adopt standards-based maintenance but workpapers should account for occupant comfort improvements at the expense of energy savings. Programs should focus on simple measures that can be reliably implemented and have demonstrated savings.

The evaluation also acknowledges that maintenance is a process that is unlike almost all other energy efficiency measures. This difference presents major measurement and evaluation challenges. Program workpapers assume changes lead to reduced HVAC demand and energy use. The statewide programs make those changes over a relatively long time period, while local and third part programs perform the measures as an event. The differences in program designs present different evaluation challenges. Measuring changes in unit operation over long periods associated with the state-wide program design limits the ability to provide timely feedback and introduces potential uncertainties associated with non-program issues. Estimating the impact of multiple measures installed at the same time within local programs affects the ability of evaluation to provide measure specific savings estimates. The recommendation for programs to pilot strategies also provides a framework for evaluation of specific measures or service actions in detail that are not easily accomplished in the evaluation of full scale programs.

The IOUs have made changes for 2013-14 programs and continue to receive input from the WHPA to further improve the programs. Feedback on drafts of this report has included stakeholder recommendations for the future programs and evaluations. Additional program strategies and EM&V Recommendations may include, but are not limited to the following:

- Continue ACCA 180 efforts as non-resource market transformation effort. Focus on measures and providing savings in resource programs to maximize savings. Measures that are part of routine maintenance such as changing air filters and cleaning coils with water could be part of non-resource training efforts to ensure they are done.
- Do more process evaluation. The project was designed as an impact evaluation and did not include a process evaluation. Some process work was done for the SCE program based on interim findings of WO32. This recommendation will be raised within the HVAC EM&V Project Coordination Group.

- Study new economizers and controllers that meet current standards to assess whether technicians are able to better understand the operation and setup. This effort would help to assess the previous recommendation of replacing entire economizer assemblies given efforts made to add automated fault detection in new economizer controllers and new written and hands on certification processes for technicians.
- Track and support industry-wide efforts. The Consortium for Energy Efficiency is currently supporting a combined system efficiency laboratory testing approach for these packaged units and economizers as an improved energy rating. AHRI has formed a committee to work on a combined test standard. This would provide a test method and metrics to fully evaluate the RTU with Economizer.
- There are plans for both field and laboratory efforts in the 2013-14 evaluation cycle. Given the uncertainties in field measurements, laboratory measurements are critical to providing empirical evidence of the potential benefits. Lab tests should be coordinated between the CPUC and IOUs and coordinated with field tests to establish realistic test conditions. Field measurements are also made to establish in-situ efficiency changes within the limitations of field measurement accuracy. Field limitations may limit some measurements to being acceptable for qualitative assessment, but not reliable enough for quantitative analysis.

3. Residential Quality Installation

This section presents the methodology and results of the residential quality installation program evaluation. The evaluation approach relied on field measurements of key parameters for a sample of participants and non-participants, focusing on HVAC system oversizing, airflow, and duct leakage. Field results were run through a DOE-2 prototype simulation model to develop annual estimates of energy use, and participant use was compared against non-participant use to determine savings.

The overall gross realization rates were 35% for electric energy savings and 38% for demand savings. These realization rates were driven by the finding that non-participant baselines for system sizing and duct leakage were better than those assumed in ex ante program calculations.

3.1 IOU Workpaper Assumptions for Quality Installation

Energy savings in the program workpaper are usage reductions from quality installation (QI) practices that exceed Title 24 requirements or common installation practices for attributes not addressed by code. The savings from the system replacement with a higher efficiency unit are relatively simple to determine and are documented in the DEER database. However, the savings from quality installation practices present unique challenges. Interactive effects between QI practices and installation of high-efficiency equipment further complicate the issue.

The IOU workpaper identified the basis for quality installation savings as:

- **Reduction in HVAC system oversizing**. The workpaper reflects the understanding that HVAC units are typically oversized by 20%. This is excessive and can lead to lowered efficiency and shortened useful life. Participants are assumed to be sized to the load while installations outside the program are assumed to be oversized 20%. The workpaper did not specify if the target size is determined via Manual J load calculations or Manual S system sizing calculations.
- **Airflow Correction**. The workpaper reflects the belief that fan settings are typically incorrect, resulting in airflow of only 350 CFM/ton assumed for units outside the program compared with the workpaper-recommended 400 CFM/ton assumed to be achieved by participants.
- **Duct leakage sealing**. Ducts are often not properly sealed (DEER 2005 Measure D03-458 was used as the basis for savings). Participants are assumed to have 12% leakage; with an assumed baseline leakage of 24% for installations outside the program.

3.2 Methodology Overview

The quality installation field assessments focused on residential systems since non-residential QI programs were not in operation in 2010-12. Onsite visits were conducted at non-participating homes identified using known installations from other general population studies such as the CLASS (California Lighting and Appliance Saturation Study) conducted under WO21. These non-participants were recruited from PG&E, SCE, and SDG&E service areas to provide a common-practice baseline. Because SCE was the only IOU with a residential quality installation (RQI) program, program participants could only be recruited from within the SCE service area. The team conducted site visits at 50 program participant and 50 non-participant sites, all of which were located in climate zones (CZs) 8 through 16. The significance of climate zones is explained in Section 3.3.1. Identical data-collection protocols were followed at participant and non-participant sites.

The program workpaper established aspects of energy code that, on average, are presumed to not be fully met outside the program. The aspects affect installed performance and included duct leakage, airflow, and sizing. The baseline for unit efficiency was a new minimum efficiency unit, not the existing system since the program assumed a replacement upon burnout of the existing system. The pre and post energy consumption is not equivalent to the savings from quality installation since the savings claims were not early replacements.

3.2.1 Participant Selection

The evaluation team sampled QI participant sites for extrapolation of the results to the program population. The evaluation team recruited participants proportional to contractor participation in the RQI program. The evaluation sampled the participant population at the site level; if more than one new unit existed at a given site; one new unit was randomly selected within the site for metering.

This program is subject to self-selection effects at two different levels, and at each level it is more likely that the self-selection effects will lead to increasing bias in the savings results. The two levels of potential self-selection effects leading to greater bias are: (1) participants seeking out contractors with good installation practices; and (2) contractors who already have good installation practices tending to self-select into the program. It is not certain that self-selection exists or that it operates in this particular manner, but the nature of the program is such that it has a degree of potential for self-selection, and that there is an unusually strong potential for self-selection to lead to more bias in the results given the particular quasi-experimental design used here. The results should be interpreted as most likely being an upper bound for net savings rather than a point estimate.

This study acknowledges that it may be difficult to compare participants with general non-participants since the customers and contractors differ. We think this is bias within the

program, not within the evaluation. The question of what the customer would have done without the program is mitigated by selecting non-participants from similar geographic and socio-economic areas. This approach is good for program evaluation and not so good for estimating statewide compliance rates. The non-participant customers represent baseline conditions for 2010-12 participants, but likely do not represent statewide average conditions.

3.2.2 Non-Participant Selection

Non-participant installations were identified through WO54 and CLASS and characterized by climate zone, with 18 out of 50 installations coming from SCE service territory CZs 8-16. In WO54, a market assessment study, telephone surveys asked about recent HVAC system change-outs. The study approach was vulnerable to self-selection bias. The evaluation team could not quantify the extent of this bias and there were no other means to identify additional recent non-participant installations within the evaluation budget. CLASS, a random site survey that did not ask about HVAC change-outs during recruiting, had no similar self-selection bias. All available contacts were exhausted so there was no subsampling. Recruiters offered a $200 incentive and made up to seven attempts until acceptance or refusal. Non-participants were recruited to allow DNV GL field staff to perform onsite diagnostic measurements and observations to establish a common-practice baseline performance. The field team used the same tests, test protocols, and observations as site visits for QI participants. The aggregate non-participant performance was used as the baseline for each participant unit level analysis.

3.2.3 Onsite Data Collection

Residential QI programs seek to provide savings through right-sizing systems, testing and sealing ducts, adjusting fan airflow, and optimizing fan wattage draw. The evaluation team established data collection protocols to determine the effects of these measures. Data collection protocols were identical for program participants and non-participants. Data collection forms can be found in Appendix G and site level data can be found in Appendix C.

3.2.3.1 Demographic and Usage Data

Upon arrival at the site, the DNV GL staff interviewed the resident to gather information about the number of permanent residents, thermostat setpoints, hours of use (if not using a programmable thermostat), and the age of the residence. If a programmable thermostat was used, setpoints and hours were taken directly from the thermostat.

3.2.3.2 Temperature and Relative Humidity Measurements

Rather than waiting for the unit to reach steady state to take spot measurements, the strategy was to collect time series data that could be cleaned and averaged off-site with data loggers. Hobo Micro Stations were installed onsite to measure outdoor air, supply air and return air

temperature and relative humidity. The outdoor measurements were made near the air conditioner condensing unit. The loggers were set up to record measurements at one-minute intervals throughout the test period. They were removed before the team left the site.

3.2.3.3 Airflow Testing

A unit's airflow was measured in cooling mode using The Energy Conservatory (TEC) TrueFlow meter kits. Whenever possible the TrueFlow plate was placed at the air handler to eliminate the effect of return duct leakage. There is a standard adjustment for return duct leakage of 4% when remote return grills are the only access point. When time permitted, after measuring the air flow in cooling mode, the team switched the unit to either fan only or heating mode depending on the effect on residents' comfort, allowed it to stabilize, and measured airflow again. The evaluation made additional measurements in each mode to assess whether cooling airflow was set differently in other modes, meaning there would be potential to easily increase flow through changes in fan settings. Static pressure was also measured.

3.2.3.4 Refrigerant Charge

The refrigerant liquid line and suction line temperatures and pressures were measured with the unit in cooling mode[40]. Superheat and subcooling were estimated, but this element was not included in the final analysis.

3.2.3.5 Power Measurements

For split systems, the cooling mode power and power factor for the entire condensing unit and the entire air-handler unit were measured with Fluke 345 clamp-on true RMS power meters. For package units, the cooling mode power and power factor for the entire unit were measured, and where possible, the supply fan alone.

3.2.3.6 Infiltration

TEC Minneapolis Blower Door kits were used to depressurize the houses. Where possible, the house was depressurized to 25 Pa and 50 Pa below ambient pressure. Some houses could not be depressurized to 50 Pa below ambient; in these cases the team used lower pairs of values such as 30 Pa and 15 Pa, or 24 Pa and 12 Pa, and used flow correction factors to obtain the infiltration in cubic feet per minute that would have resulted from the CFM25 and CFM50 test. CFM testing at two pressures allowed calculation of a proper flow exponent to better model the impact of infiltration on building loads.

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[40] Similar high grade instrumentation as was used in 2006-08 evaluation, including industrial grade Crystal pressure gauges and platinum thermistor temperature sensors. CALMAC ID: CPU0028.01;

3.2.3.7 Duct Leakage

TEC Duct Blasters were used to measure duct leakage to outside (LTO), which is leakage outside the conditioned envelope, and total duct leakage. First, all supply air registers and all but one of the return air registers were taped off and sealed. Next, the Duct Blaster fan was then attached to the untaped return register and used to pressurize the conditioned space to 25 Pa above ambient pressure. Then the Duct Blaster fan was used to pressurize the duct system to 0 Pa relative to the conditioned space. With the conditioned space and duct system at equal pressure, there should be zero net flow between them; that is, there should be no leakage between ducts and conditioned space, thus, any air moving through the Duct Blaster was leaking outside the conditioned space. After noting the LTO at 25 Pa, the team repeated the test at 50Pa. As with infiltration testing, there were cases where the team used 30 Pa and 15 Pa or 24 Pa and 12 Pa because they were unable to pressurize the space to 50 Pa. For total leakage, the blower door was removed and the duct system was tested at 25 Pa and 50 Pa with respect to the conditioned space.

3.2.3.8 Building Shell Characteristics

Site and building information sufficient to allow calculation of heating and cooling loads was gathered. This included creating floor plan sketches; determining wall, floor, and ceiling construction types and dimensions; recording attic and crawlspace insulation types and thicknesses; observing window types and sizes; and building orientation.

3.2.3.9 Notes on Data Collection

Other than the data the team collected onsite, there was no consistent information about what scope of installation work was done or how equipment was selected for non-participant sites. It was unknown if the installations included other changes to duct systems or if furnaces were included in air conditioning replacements.

3.3 Results

3.3.1 Title 24 Testing Requirements

HVAC replacements within California must comply with relevant sections of Title 24, Part 6, which define the baseline regulatory codes for the program.[41] However, due to low code

[41] California Energy Commission, *2008 Building Energy Efficiency Standards: Residential Compliance Manual,* August 2009. Section 8.4

compliance rates observed in other studies[42], the IOU workpaper established a "common practice" baseline for this study. In addition, baseline assumptions used in the QI program workpapers submitted by IOUs were compared with field results of non-participants from this study. Participants and non-participants alike are required to meet Title 24 requirements for replacements, which are described in the following section.

3.3.1.1 Requirements

Units located in climate zones in hotter areas of the state (CZ 2 and 8 through 16) need more cooling than units located elsewhere. Since HVAC systems in these zones operate more of the time and use more electricity to provide more cooling, it is important that these units operate as efficiently as possible. As a result, Title 24 imposes more stringent requirements on systems operating within these zones. The individual requirements impose specific climate zone restrictions. These include duct testing and sealing, duct insulation, and refrigerant charge verification. However, for new systems serving newly constructed homes or additions to existing homes, 2008 Title 24 duct sealing requirements apply to homes in all zones. Per *§151(f)10* such new construction must be shown by a HERS rater to leak less than 6% of system fan airflow.[43]

Per *§152(b)1E*, in zones 2 and 9 through 16, if a major component of the HVAC system (air handler, outdoor condensing unit, cooling or heating coil, or furnace heat exchanger) is replaced or installed, the duct system must meet 2008 insulation and air distribution requirements.[44] Per *§152(b)1D,*[45] if this replacement or installation requires the replacement or addition of more than 40 feet of ductwork in unconditioned space, the ducts must also be tested and sealed so that leakage is no more than 15% of nominal system airflow.[46] Because this is an evaluation of QI measures, every site included installation or replacement of at least one major component and is subject to this requirement. However, if the entire duct system is replaced, it must meet the same 6% leakage requirement as new construction.

In zones 2 and 8-16, refrigerant charge testing is required for new systems and when any major component of the HVAC system is replaced. The QI program workpaper further describe aspects

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[42] G. William Pennington, *"Underground Economy: Contractors Failure to Pull Permits for Residential HVAC Replacements"* Testimony to the Little Hoover Commission, 27 March 2014 pg.1-17

[43] Op. cit.

[44] Op. cit.

[45] Op. cit.

[46] If the rater or installing contractor tries but is unable to reduce leakage to 15%, then any of these options can be used: (1) contractor or HERS rater must verify that leakage to the outside is less than 10% of system fan airflow; (2) contractor or HERS rater must verify that leakage is reduced by more than 60% compared to before the alteration and a smoke test shows that all accessible leaks have been sealed; or (3) HERS rater must verify that all accessible leaks have been sealed.

where participants exceed Title 24 minimums and assumptions are made about non-participant systems. These assumptions are described in Section 3.1.

Load calculations are required for all replacements, but evidence of the calculations was not available for non-participants.

3.3.2 Field Findings on System Sizing

Data collected onsite informed the development of an ACCA Manual J-based system-sizing model for all participants and non-participants.[47] The primary analysis compared the calculated size to the installed tonnage to determine the amount of over- or under-sizing. Residential-sized units are typically available in half-ton increments, so the analysis looked at distributions of units sized within half ton increments higher or lower than calculated. Units sized at 4.5 tons are rare, but the actual sizing ratio was used in the analysis and the bins were created for display purposes. The QI programs require the use of both Manual J and Manual S[48] for equipment sizing; therefore participants' project folders contained a calculation in accordance with Manual J and Manual S. Participant sampled sites averaged 1,880 square feet of the floor area served by the tested unit. Non-participants averaged 1,770 square feet of the floor area served by the tested unit.

The data in Table 21 show oversized and undersized units in both the participant and non-participant samples. Both groups tended to have oversized units with a small difference in mean sizing ratio, but non-participants had a wide distribution with more cases of significant oversizing. The evaluation used program approved Manual J software in the analysis.[49]

[47] ACCA Manual J is a standard for producing air conditioning and heating load calculations for single-family homes, small multi-unit residential structures, condominiums, town houses, and manufactured homes. More information is available from the Air Conditioning Contractors Association (www.acca.org)

[48] ACCA Manual S provides sizing requirements for cooling and heating equipment, allowing the selection of equipment based on sensible and latent loads and ensuring the selected equipment will be properly matched to the local climate.

[49] The team used Rhavc from Elite Software for the Manual J calculations.

Table 21: Preliminary System Sizing based on Manual J Calculations

Bin	Participants	Non-Participants
Oversized > 1 ton	2	15
Oversized 0.5-0.9 ton	13	12
Sized within 0.5 ton	33	15
Undersized 0.5-0.9 ton	2	3
Undersized > 1 ton	0	5
Average Manual J tons	3.31	3.09
Average Installed tons	3.64	3.54
Average Manual J / Installed	0.91	0.87
Percent of sample sized within 0.5 ton	66%	30%

The evaluation team applied Manual S site-specific calculations provided by the participants' contractors. The distribution of participant sizing ratios varied, but participant and non-participant sizing ratios were fairly similar. Consequently, the non-participant sizing ratio remained at 0.87 while participants, taking advantage of Manual S sizing, had ratio of 0.90 (Table 22). The average target capacity using Manual S changed slightly from 3.31 tons for participant Manual J to 3.28 tons for participant Manual S. The difference between participants and non-participants is not statistically significant using Manual J or Manual S as the program sizing target.

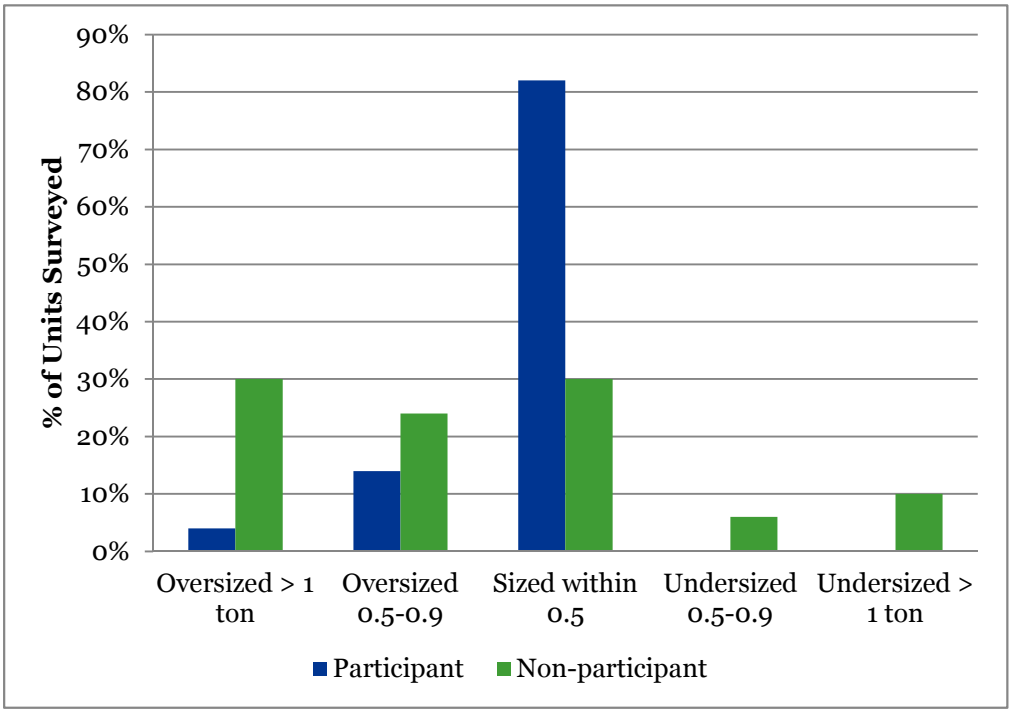
Table 22: System Sizing based on Manual S Total Capacity Calculations

Bin	Participants	Non-Participants
Oversized > 1 ton	2	15
Oversized 0.5-0.9 ton	7	12
Sized within 0.5 ton	41	15
Undersized 0.5-0.9 ton	0	3
Undersized > 1 ton	0	5
Average Target Size -Manual S or Manual J, tons	3.28	3.09
Average Installed, tons	3.64	3.54
Average Manual S/Installed	0.90	0.87
Percent of sample sized within 0.5 ton	82%	30%

Non-participant results indicate that the oversizing ratio observed in the sample was 13% compared with the 20% workpaper assumption. It should also be noted that about 30% of non-participant systems were oversized by one ton or more and 10% were undersized by one ton or

more. The QI program appears to eliminate extreme cases of improper sizing because achieving increased savings requires participant oversizing to be eliminated and undersizing to be allowed where possible. Figure 2 provides the sizing distribution of units surveyed.

Figure 2: System Sizing based on Manual S Total Capacity Calculations



3.3.3 Field Findings on Duct Leakage

All participants were required to undergo duct testing and sealing, and most of the non-participant systems were located in climate zones where Title 24 requires duct testing and sealing for system replacements. Five non-participants were in climate zones where duct testing and sealing were not required; these sites were excluded from the duct leakage findings. Both participant and non-participant duct leakage could be compared with Title 24 requirements and the workpaper assumptions on duct leakage. Data for the excluded sites is included in Appendix C.

If the workpaper assumptions were correct, non-participants would have an average of 24% total leakage relative to nominal airflow and participants would have 12%. Most of the systems sampled did not significantly extend or replace ducts, so the 15% leakage requirement from Title 24 generally applied; however, some systems had new or significantly renovated ducts and were required to meet the 6% duct leakage requirement. Table 23 shows that the mean duct leakage

of participant units was 11.5% and non-participant units were 16.6%. The difference in total duct leakage between the two groups was statistically significant at the 90% confidence interval.[50]

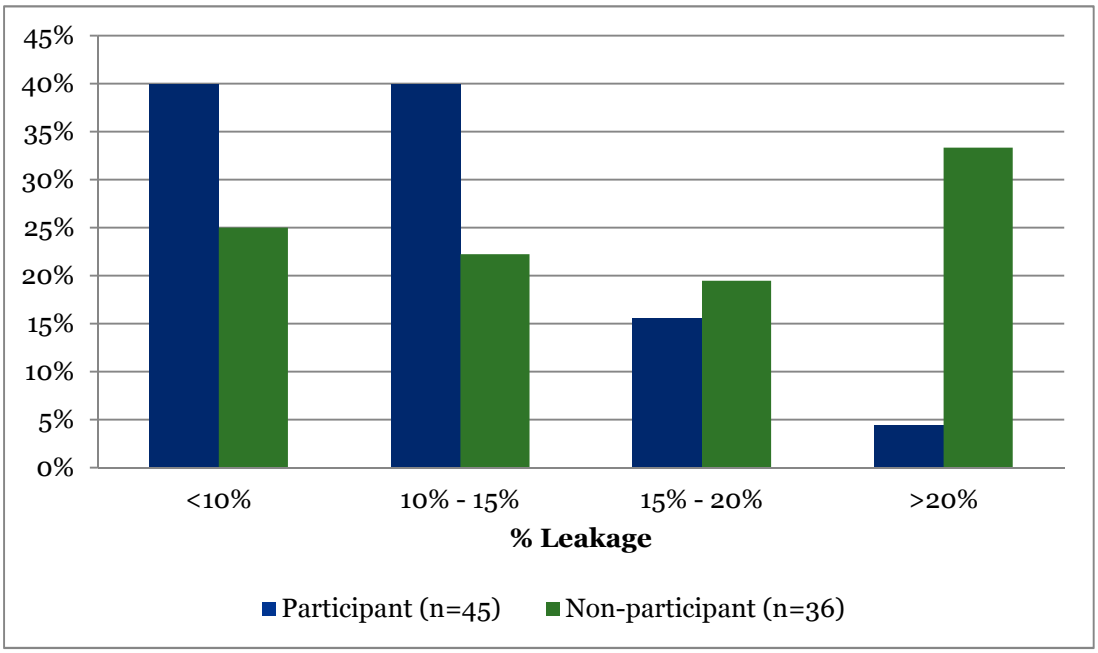
Table 23: Total Duct Leakage for Recent Residential Installations

Group	Sample Size	Mean Duct Leakage	Standard Deviation	90% CI Error Bound	Relative Precision
Participants	45	11.5%	0.045	± 0.011	± 9%
Non-Participants	36	16.6%	0.085	± 0.023	± 14%

Figure 3 illustrates the percentage of total duct leakage for recent participant and non-participant installations. The distribution shows that there were participant systems that had leakage greater than 15% which exceeds program requirements. While the average shown in Table 23 meets the workpaper assumption, eliminating cases of leakage greater than program requirements will increase savings. The workpaper assumed non-participant ducts would be twice as leaky on average at 24%, but the average was 16.6%. More importantly almost half of the tested systems had leakage meeting program requirements of 15% or less. Also note that the non-participant test results were limited to locations where Title 24 required duct leakage less than 15%.

[50] Given the research design and the use of standard practice (rather than Title 24 energy code) as baseline in the workpaper, the evaluation team was not able to separate gross and net savings; that is, the team was unable to separate free-ridership from presumed non-compliance in the gross workpaper baseline. If we assumed that participants would meet code requirements in the absence of the program we could estimate free-ridership, but we have no evidence that was the case nor could we get an unbiased estimate by asking that question directly because of participant self-selection bias.

Figure 3: Participant and Non-participant Total Duct Leakage



The total leakage above fed all additional calculations. The evaluation also measured the leakage outside the conditioned space (LTO-leakage to outside) relative to nominal unit airflow. Total duct leakage is the sum of leakage into conditioned spaces and leakage to outside of conditioned spaces. For example leaky ducts in an attic or crawlspace will experience leakage outside the conditioned space, while leaky ducts in a conditioned mechanical closet will not. Leakage to outside of conditioned space is wasted cooling. These LTO measurements reflect the actual delivered cooling and amount of leakage, which has a direct impact of energy lost. The LTO results provide additional information since the correlation between total leakage and leakage to outside is a fixed assumption in the prototype simulations.

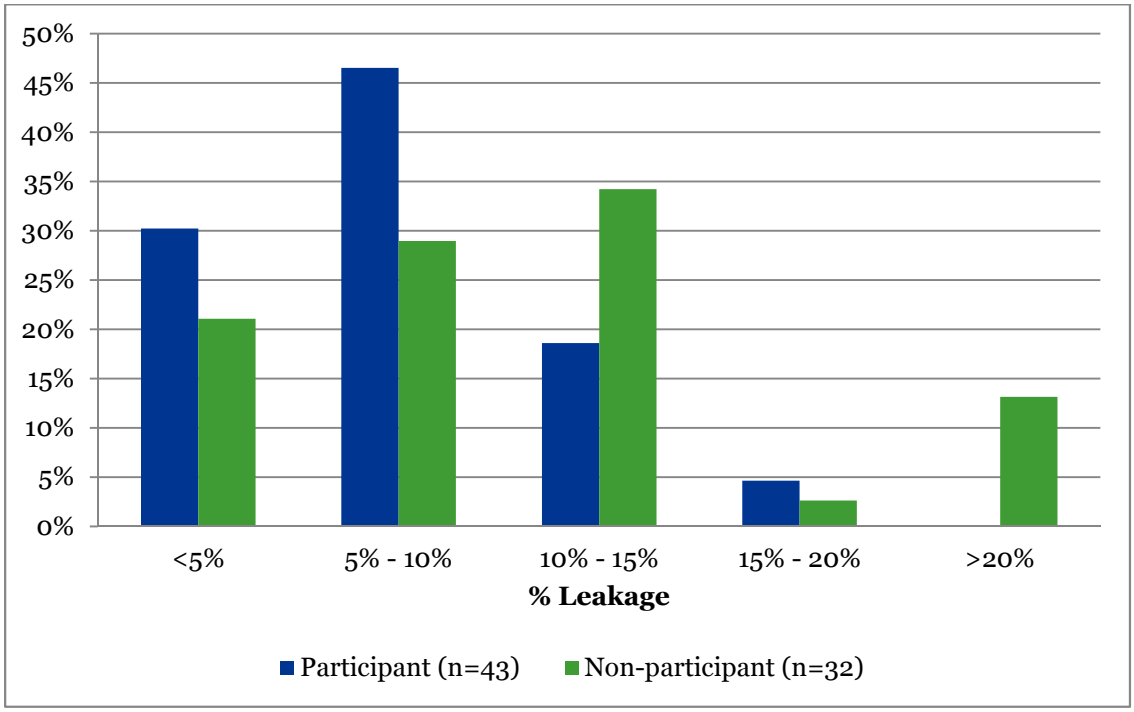
Table 24 shows program participants averaged 7.4% LTO, while non-participants averaged 10.7% LTO. Qualitatively, some non-participant sites had extremely leaky ducts while the spread in the amount of duct leakage for participants was much tighter, indicating the influence of the program on reducing duct leakage. The evaluation team found that the difference in LTO between the two groups is statistically significant at the 90% confidence interval.

Table 24: Duct Leakage to Outside for Recent Residential Installations

Group	Sample Size	Mean LTO	Standard Deviation	90% CI Error Bound	Relative Precision
Participants	43	7.42%	0.037	± 0.009	± 13%
Non-Participants	32	10.73%	0.067	± 0.019	± 18%

Figure 4 shows the distribution of LTO for participants and non-participants. LTO of 10% is a Title 24 threshold that can substitute for total leakage of 15%. The distribution of participant and non-participant units above and below 10% LTO were similar to the total leakage results.

Figure 4: Duct Leakage to Outside for Recent Residential Installations



3.3.4 Field Findings on Fan Airflow

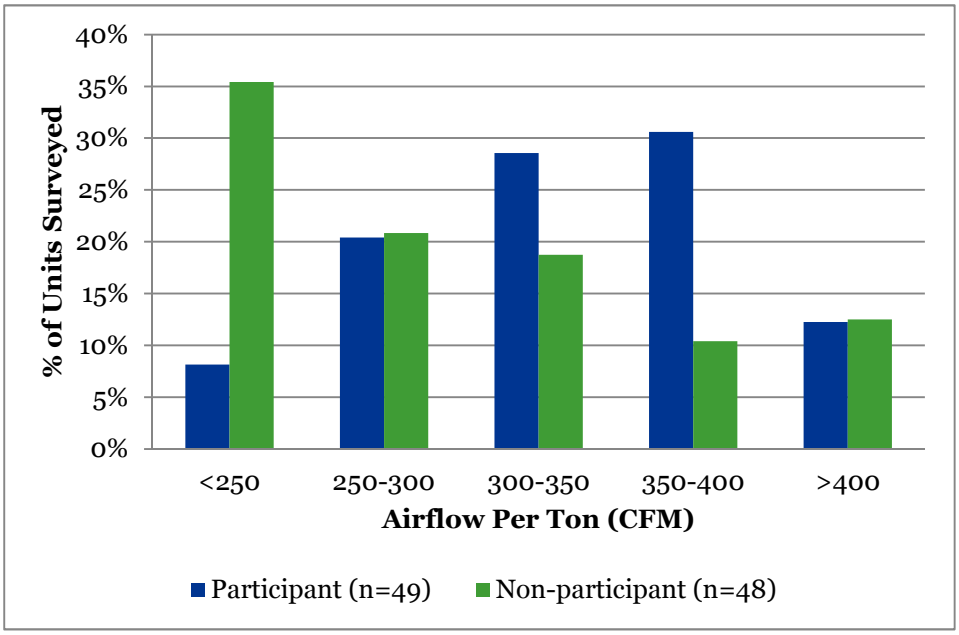
The QI workpapers assumed that non-participant units provide airflow of 350 CFM per ton and participant units provide 400 CFM per ton, which resulted in the claimed benefits. The evaluation used nominal cooling tons established by AHRI ratings for each unit. The collected data showed that the averages were closer to 300 CFM per ton for non-participants and 338 CFM per ton for participants. These values are within the 300–350 CFM/ton range for Title 24 compliance. The 10% difference between participant and non-participant airflow was similar to the workpaper assumptions. The participant units mean CFM/ton was 337.5 and the nonparticipant units' was 299.7 (Table 25). This difference is not statistically significant at the 90% confidence interval.

Table 25: Airflow per Installed Ton

Group	Sample Size	Mean CFM per Ton	Standard Deviation	90% CI Error Bound	Relative Precision
Participants	49	337.5	68.37	± 16.07	± 5%
Non-Participants	48	299.7	85.74	± 20.36	± 7%

Figure 5 shows the distribution of participant and nonparticipant unit airflows. The most important finding was that just over a third of non-participant systems had very low airflow under 250 CFM/ton. There were participant systems with low airflow as well and improving the airflow of those systems would increase program savings.

Figure 5: Airflow per Installed Ton



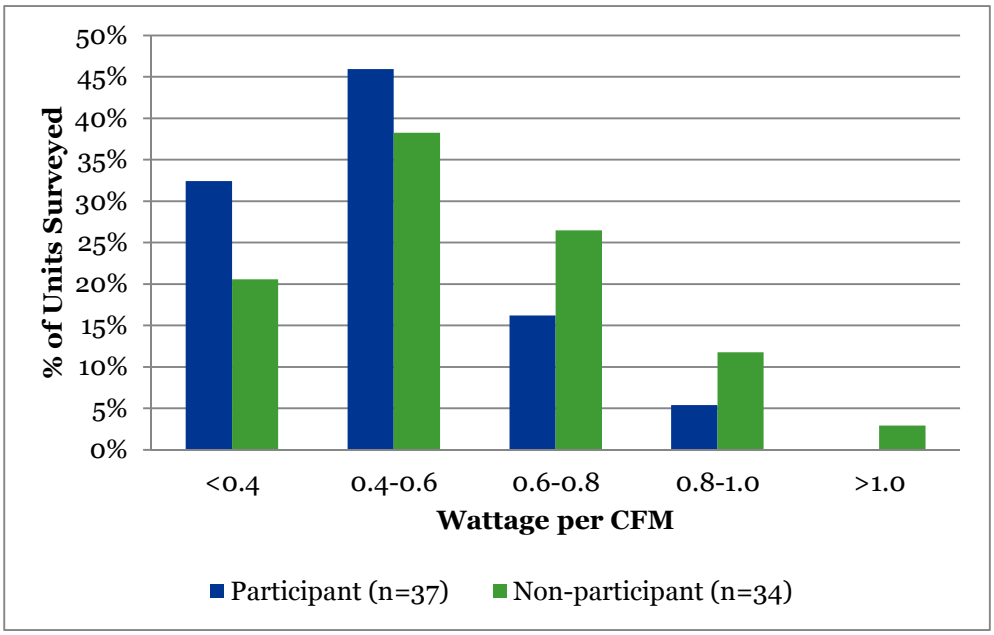
Perhaps even more important than airflow is the difference in the total fan power between participants and non-participants. If the high airflow associated with participant sites requires additional fan power then energy savings will be reduced or eliminated. Wherever possible, the field teams measured fan power in cooling and either heating or fan-only modes. Table 26 shows the mean power consumption per ton was lower for participants (0.486 W/CFM) than for non-participants 0.569 W/CFM); the difference is not statistically significant at the 90% confidence interval. Note that this difference may be partially due to the fact that QI participants also installed high efficiency units with more efficient fans, but this aspect was not studied as the focus was on the QI aspects not the unit efficiency and fan motor efficiency. Additional information on static pressure, fan settings, and design airflow were not part of the analysis, but these data were collected may be useful for additional future analyses (Appendix C). Table 26 lists the average watts per CFM for participants and non-participants.

Table 26: Fan Watt Draw Relative to Measured Airflow

Group	Sample Size	Mean Watts per CFM	Standard Deviation	90% CI Error Bound	Relative Precision
Participants	37	0.486	0.171	± 0.046	± 10%
Non-Participants	34	0.569	0.211	± 0.060	± 10%

The fan watt draw relative to airflow for both groups is shown in Figure 6. The distribution of fan power relative to airflow was influenced by the lower measured airflows for non-participants.

Figure 6: Fan Watt Draw Relative to Measured Airflow



3.4 Measure Level Analysis (UES)

The gross unit energy savings estimates for RQI measures were developed through simulations to extrapolate and normalize observed savings to first year annual savings. The evaluation focused on data collection using participant and non-participant studies for RQI that focused on the efficacy of the program measures. Onsite data collection activities were combined with calibrated simulation modeling to estimate impacts. This approach supports the evaluation and measurement of residential HVAC systems in the current cycle; it also provides field data to improve ex-ante estimates used in future program cycles.

3.4.1 Simulation

As described in detail below in Section 3.5, the analysis team used the test results and building characteristics gathered from each non-participant site to generate building heating and cooling load calculations at the level of the space served by that system. These test results included spot measurements of HVAC unit input power; supply, return, and outdoor temperatures; airflow rates; and duct leakage rates. The results were then input into the same single-family DEER eQuest prototypes used in the program workpaper, and results were developed for all measure categories, climate zones, and vintages and then re-applied to tracking data that listed the square footage served by each unit in the program population[51]. We note the DEER simulation models used for both the 2010-12 workpaper and this evaluation were outdated[52], but properly re-running the analyses with an updated prototype was not within the scope of the evaluation.

3.5 Rhvac Sizing Calculations for Non-Participants

3.5.1 Software

For non-participant sites, design cooling loads were calculated with Rhvac Version 9.01.129.[53] For participant sites, the QI program required contractors to submit models in their choice of Rhvac or Right-Suite.[54] The analysis team reviewed each of the participant models and confirmed that the input values were consistent with the data the evaluation collected at that site and the non-participant modeling process.

3.5.2 General Project Data Section

The General Project section of Rhvac stores information on the ambient design conditions as well as certain ductwork characteristics. Ambient conditions were modeled by selecting a reference city based on geographic proximity to the site or, in the absence of a nearby reference city, on the most climatically similar reference city[55] available. Within the General Project Data Section, modelers selected duct roughness factors based on the observed predominant duct material (e.g., aluminum, fiberglass, steel), as well as minimum and maximum air velocity based

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[51] Documentation of DEER models and assumptions as well as non-DEER workpapers are available at www.deersources.com

[52] Simulated residential energy consumption exceeded current RASS estimates.

[53] Rhvac is a Manual J residential heating/cooling load calculation application from Elite Software Development (www.elitesoft.com).

[54] Right-Suite is a Manual J residential heating/cooling load calculation application from WrightSoft (www.wrightsoft.com).

[55] The reference cities are taken from Table 1A, ACCA Manual J, 8th edition, version 2 and aligned with Title 24 reference cities in Table J2. A comparison of altitude deviations was not conducted

on the observed predominant duct type (rigid or flexible). . Specifying the duct material was done for completeness and does not affect the final results.

3.5.3 System Data Section

The System Data section of the Rhvac program contains information on the HVAC system as well as information on system design conditions. Data include thermostat setpoints for heating and cooling, supply air temperature in heating and cooling modes, and the building shell infiltration rate.

The winter (heating) and summer (cooling) thermostat set-points were entered from the observed heating and cooling schedule.[56] Where schedule information was not available, default-modeling setpoints were utilized: 68°F for winter and 80°F for summer.

The difference between the air entering the rooms and the inside design temperature of the system is the winter or summer leaving coil-room delta T value (in degrees). The inputs for these modeled values were taken from the difference in supply and return temperature logger readings during the cooling and heating mode operations. In two cases the supply and return temperature information were unavailable for the heating or cooling modes, the default values of 70°F for winter and 20°F for summer were used.

The building shell infiltration data were entered into the Rhvac single-point blower door method section. For this method, modelers input the wind shielding class[57], the number of stories in the building being modeled as well as a calculated flow exponent "n," and recorded flow rate for the blower door test at 50 Pa. The flow exponent was calculated using the results of the two blower door tests and the following equation:

$$n = \frac{\ln\left(\frac{CFM_{50}}{CFM_{25}}\right)}{\ln\left(\frac{Pa_{50}}{Pa_{25}}\right)} \qquad \text{[Equation 3]}$$

In cases where insufficient data were collected to calculate the value of n, a default value of 0.65 was used. Using the input flow exponent, flow rate, and pressure differential for the blower door test at 50 Pa, Rhvac calculated an equivalent leakage area in square inches. For the four sites where blower door testing was not possible, the Manual J Air Changes per Hour (ACH) method

[56] The field teams often observed that the thermostat was being used as off/on switches ("I turn it on when I get hot and I turn it off when I cool down.") For those sites we used 68°F/80°F after confirming with the residents that these were reasonable values. For sites using thermostats as intended, there was little variation; these sites used 78°F -82°F setpoints for cooling.

[57] The default selection was "4 – substantial obstruction," unless there was a compelling case to use "3-more obstructions," or "5 – surrounded by structures."

was used as an alternative to model infiltration. For this method, the ACH rate was determined by selecting a wind shielding class range, conditioned floor area range, qualitative construction tightness, and quantity of fireplaces.

Input data for Rhvac's HVAC System Design section include airflow rates and detailed ductwork characteristics. When TrueFlow data on system air flow in cooling or heating modes were available, the modeler changed the default system air type from "auto" to "fixed" and entered the average recorded airflow rate for the cooling or heating mode. When TrueFlow data were not available, the default 'auto' system air type was used, and Rhvac calculated the required airflow rates. For ductwork characteristics, modelers selected the inclusion of sensible and latent cooling duct gains.

For the calculation of duct load factors, modelers input information on duct location, insulation R-values, duct surface area, and leakage rates. For both supply and return ducting, modelers entered the observed duct location, such as attic, crawlspace, garage, or conditioned space. The observed duct insulation R-values were entered into the duct load factor calculation window. When duct insulation was observed but the R-value was unknown, a default R-value of 4.2 was used. Duct surface area was modeled using the Rhvac duct surface area calculator, which employs the ASHRAE Standard 152 duct surface calculation method. This method calculated supply duct area as the conditioned floor area (in ft^2) multiplied by a factor of 0.27, and return duct area as the conditioned floor area (in ft^2) multiplied by the number of returns and factor of 0.05[58].

The duct leakage rate was calculated as the quotient of the flow rate (in CFM) result from the DuctBlaster duct leakage to the outside at 25 Pa and the Rhvac calculated total duct surface area to produce an overall ductwork leakage rate in CFM/ft^2. For one case when the calculation produced overall leakage rates that exceeded 0.35 CFM/ft^2, the highest Rhvac default leakage rates of 0.35 CFM/ft^2 supply and 0.7 CFM ft^2 return were input in place of the calculated leakage rate.

3.5.4 Room Data Section

The Room Data section of Rhvac covers information on the building dimensions, materials, insulation levels, fenestration, and internal loads. When possible, sites were modeled as one large rectangular room with representative length, width and height dimensions that create a

[58] If there were no remote returns (instrument showed return duct is 0% of total ducting): return count was 0 but modelers input a "Return Duct Surface Area" 20 ft2.

If airflow was tested at the returns, modelers input the number of test locations from the instrument.

If airflow was tested at the unit, modelers assumed 2 returns for a two-story home or a unit with capacity >= 4 tons; modelers assumed 1 return for a single-story building or a unit with capacity < 4 tons.

simplified building shell. Heat transfer surfaces such as floors, walls, and roofs/ceilings were modeled by selecting the appropriate types, materials, and insulation levels.

When modeling slab flooring, modelers selected the passive heat, heavy dry or light moist soil type.[59] If modeling a floor above a garage, modelers selected the appropriate material type and assumed R-13 insulation level.

For modeling of roofs and ceilings, modelers selected a vented attic (unless otherwise noted in the site observations) with the appropriate roofing material type and color. Modelers selected attic insulation R-values corresponding to the type and amount of insulation observed onsite. If the attic R-value was unknown, the modelers selected insulation values based on the vintage of the home and the historical Title 24 attic insulation R-value code requirements[60], which are presented in Table 27 below:

Table 27: Title 24 Attic Insulation R Values

Period	R-value
<1978	11
1978-1992	30
1992-Present	38

When modeling 2x4 framed walls, an R-13 insulation value was entered, while an R-19 insulation value was used for 2x6 framed walls. For shaded heat transfer surfaces such as partitions or garage walls, modelers entered -1 for the summer temperature difference, which calculates the appropriate temperature difference between a shaded exterior wall exposed to ambient air and the indoor conditioned space.

For modeling of fenestration, modelers selected the appropriate number of glass panes, frame material, and glazing treatment (low-E/ no low-E[61]). The following window characteristics were used for modeling all window fenestration except skylights: internal shading blinds 45 degree light color and 50% drawn, insect screens outside with 50% coverage, ground coefficient = 0.23 (green grass), and no overhangs or projection included in models.

For the modeling of doors, the appropriate door material (wood or metal) and type (solid or hallow core, polystyrene, etc.) were used. For doors recorded as metal insulated, modelers assumed polystyrene insulation.

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[59] This option was the middle-of-the-road choice and refers to soil under the slab. No thickness info was available for concrete slabs at non-participant sites and floor-covering data were not captured.

[60] The team sourced historical attic insulation R-value code requirements from the California Energy Commission website: http://www.energy.ca.gov/title24/standards_archive/

[61] The presence of low-e treatment was determined using ETEKT + (AE1600) low-e detectors.

Internal equipment and occupant loads were also input into the room data section of Rhvac. For all modeled sites, internal equipment loads of 2,400 Btuh sensible heat and 350 Btuh latent heat[62] were used. Internal occupant loads were accounted for by entering the reported year-round occupancy into Rhvac, which then calculated occupant loads based on 230 Btuh of sensible heat and 200 Btuh of latent heat per occupant. The evaluation reviewed program assumptions in models which did include site variation as well as variation in detail based on which of the two approved software packages were used. The site collected data was used to develop assumptions for non-participants that were consistent with the level of detail and assumptions in program models.

3.6 Savings Based on Participant and Non-Participant Comparison

The savings per square foot from the program workpaper were applied to the square footage of sites in the program population to get ex ante savings in the tracking data. Table 28 shows the distribution of savings and units by measure category which indicates the efficiency level and equipment type. The methodology used to develop the inputs and savings results were described in previous sections.

Table 28: Ex Ante Savings for Quality Installation Measures Installed 2010-12

Quality Installation Measure Category	Ex Ante Energy Savings (kWh)	Ex Ante Demand Savings (kW)	Number of Units
13 SEER Air Conditioner Quality Installation DX Equipment	18,417	6	137
14 SEER Air Conditioner Quality Installation DX Equipment	169,180	80	1,045
14 SEER Heat Pump Quality Installation DX Equipment	10,081	4	39
15 SEER Air Conditioner Quality Installation DX Equipment	273,568	149	1,401
15 SEER Heat Pump Quality Installation DX Equipment	28,228	9	110
16 SEER Air Conditioner Quality Installation DX Equipment	411,269	227	2,152
Grand Total	**910,743**	**475**	**4,884**

[62] Lighting loads are entered separately from equipment loads in Rhvac. 2,400 Btuh was the default recommendation for appliance loads in the Manual J "speed sheet". Rhvac accounts for latent heat from human occupants; we included 350 Btuh to account for houseplants that were typically present.

The evaluation team took the HVAC test results collected for participants and non-participants and re-ran the DEER single-family residential prototypes consistent with the method used in the program workpaper.[63] The evaluation noted that the workpaper was not reviewed by the ex ante review process. During the simulation process it was clear that within workpaper calculations the total cooling capacity was adjusted in the DEER prototypes based on the 20% oversizing assumption.

Across measure categories the gross realization rates were reviewed at the zone level per square foot, consistent with the workpaper. The duct leakage, airflow, and sizing inputs modified in the workpaper were the only variables modified in the ex post analysis. The evaluation team reapplied the results by measure and climate zone. The table below describes the realization rates of each climate zone and is followed by ex post savings by measure category, which varied based on the climate zone mix of each measure. The precision of the input values are reported previously in this section while the energy savings after extrapolation through the prototype simulations would be difficult to assign a precision estimate. The results in Table 29 present only the comparison between ex ante and ex post means. The climate zone results follow the workpaper assumed mix of building vintages, which varies by climate zone. Another set of drivers of variation by climate zone are the effects of the sizing, airflow, and duct leakage inputs on the simulation models.

Table 29: Gross Realization Rates by Climate Zone

Climate Zone	Energy Savings Realization Rate (kWh)	Demand Savings Realization Rate (kW)
6	23%	61%
8	33%	23%
9	41%	77%
10	32%	27%
13	30%	58%
14	11%	24%
15	43%	54%
16	9%	35%

Table 30 shows the energy and demand savings for each measure description from the program tracking data. The workpaper used the same measure descriptions and the results reported are

[63] Energy savings due to system "right sizing" were calculated by modifying "right sized" measure runs of the single family DEER prototypes. The total cooling capacities (COOLING-CAPACITY) were multiplied by the ratio of the observed average installed system size to the average calculated Manual J system size for participants and non-participants (see Table 22). The non-participant ratio was applied to the "baseline" run while the participant ratio was applied to the "measure" run.

based on the volume of measures claimed and the realization rates were applied by measure and climate zone combination. The results show that many installations in the program were of high SEER units.

Table 30: Ex Post Electric Savings for Quality Installation Measures Installed 2010-12

Quality Installation Measure Category	Ex Ante Energy Savings (kWh)	Ex Post Energy Savings (kWh)	Ex Ante Demand Savings (kW)	Ex Post Demand Savings (kW)
13 SEER Air Conditioner Quality Installation DX Equipment	18,417	7,124	6	3.2
14 SEER Air Conditioner Quality Installation DX Equipment	169,180	59,898	80	37.0
14 SEER Heat Pump Quality Installation DX Equipment	10,081	3,229	4	1.3
15 SEER Air Conditioner Quality Installation DX Equipment	273,568	94,314	149	55.0
15 SEER Heat Pump Quality Installation DX Equipment	28,228	9,322	9	3.0
16 SEER Air Conditioner Quality Installation DX Equipment	411,269	144,617	227	81.9
Grand Total	**910,743**	**318,505**	**475**	**181**

The overall gross realization rates were 35% for electric energy savings and 38% for demand savings. The final realization rates are based on the final savings and similar to a weighted average of the realization rates by climate zone. These realization rates were driven by the better than assumed sizing and duct leakage for non-participant units.

The evaluation determined that the ex-ante estimates need to better define how the gross savings and the net to gross ratio work together. The evaluation focused on measuring the primary gross savings assumptions in the workpaper for participants and non-participants. The final ex-post savings result is likely a combination of a realization rate and a net-to-gross factor.[64] The evaluation did not estimate a net to gross ratio, but the workpaper value of 0.7 should be reviewed. It is important to note that it was not possible to identify free-ridership from presumed non-compliance in the gross workpaper baseline. Since the workpaper assumed non-compliance, it essentially presumed a standard practice baseline, not a code baseline. If it

[64] 2010-12 net implies net of freeriders – spillover is important for 2013-14 and the spillover effect of utility and CEC trainings on code compliance is an interesting topic to research in the future.

was assumed that participants would have met code requirements in the absence of the program it would have been possible to estimate free-ridership. The evaluation team believes that net-to-gross issues may be influencing the realization rate though it is not possible to determine the extent to which this is true.

3.7 Conclusions and Recommendations

The QI program did result in energy savings, but the realization rates were generally low. Table 31 summarizes the field findings compared to the workpaper assumptions.

Table 31: Comparison of Field Findings and Baseline Assumptions

Workpaper Assumption	Non-Participant Field Observations (mean)	Baseline Assumptions	Participant Field Observations (mean)	QI Efficient Case Assumptions	Non-Participant Participant Significant Difference
Total System Duct Leakage	17%	24%	12%	12%	Yes
System Airflow (CFM per ton)	300	350	338	400	No
System Oversizing	13%	20%	10%	0%	No

In particular, ex ante workpapers claimed higher duct leakage than found in the baseline group. Duct leakage—a major source of HVAC energy loss—was lower in participating households than in non-participating households by a statistically significant amount, with a mean total leakage of 11.5% of nominal airflow for participants versus 16.6% for non-participating homes.[65] While this meets the QI program goal of 12% total leakage, the average baseline leakage was lower than the 24% leakage value assumed in the workpaper, although some non-participants had very high duct leakage. This resulted in lower actual savings than expected.

There was not a statistically significant difference in per-ton airflow between participants and non-participants, nor was there a significant difference in per-CFM power draw between the two groups. The evaluation team modeled the mean differences to develop savings estimates as the collected data represented the best information available, since the workpaper relied on assumed values. The evaluation team measured greater airflow for participants, but the non-participant results had high variation contributing to the lack of statistical significance of the difference. Some non-participants had very low airflow. Power draw (in watts per CFM of

[65] This includes sampled non-participants only in those CZs where duct sealing is required (2 and 9-16).

measured airflow) was below the recommended maximum of 0.58W/CFM for participants and non-participants alike.

The evaluation team found that the QI program resulted in the majority of systems (41 out of 49) sized within one-half ton of the size recommended by Manual S calculations. This compares to only 15 out of 50 non-participant systems being "right-sized." However, the average sizing ratios were calculated to be similar as there were both under and oversized non-participant units, but there were primarily right sized and a few oversized participant units. The workpaper assumed an average amount of oversizing and used the sizing ratio to represent this effect in simulations. The evaluation team reports the number of over and undersized cases, but did not separate the effects of under and oversizing in the ex post calculations. Future studies could be conducted to separately assess the effects and impacts of under and oversizing.

The evaluation team has the following recommendations:

- The 2013 Title 24 code should be reviewed to determine opportunities to exceed code. The net to gross needs to be clearly defined since the gross baseline assumed is not code minimum, it is a common practice assumption below code. In the absence of the program a unit could be minimally compliant or could be at the common practice baseline. Using a common practice baseline requires specific evidence that code minimum is not appropriate and requires rethinking the use of the default net to gross value which usually applies to measures with code baseline.
- Consider revisions to workpapers to account for the fact that baseline are comprised of a range as opposed to a point estimate. Gross savings vary by climate zone and measure SEER level. In this case the net savings and baseline may also vary by code jurisdiction. This includes under and oversizing and a range of duct leakage and airflow after installation. The findings suggest that about half of the installations outside the program perform similar to the program participants and the other half perform poorly. Until larger studies are available the source of assumptions in workpapers should be clearly stated as well as whether baseline studies are needed to develop data to inform the inputs.
- Baseline system oversizing was closer to 13% than the assumed 20%. Manual S allows up to 140% sizing relative to Manual J which leads to participant systems that don't meet the workpaper assumption that all participant systems are sized to the load. Increasing savings due to sizing requires that participant oversizing be eliminated and undersizing be allowed where possible to create a significant difference with common practice and recommended code.
- Revise workpaper assumptions to reflect the findings with respect to baseline values in addition to reconsidering the meaning of the assumed net-to-gross ratio.
  - Baseline total duct leakage was around 16.6% rather than the assumed 24%. Participant total duct leakage was near the claimed 12%.

  - We found that, directionally, the non-participant airflow per ton of cooling was about 300 CFM, lower than the baseline value of 350 CFM assumed in the workpaper. The difference between participants and non-participants was not statistically significant, but since both groups had lower airflow than assumed there may be additional opportunity to capture airflow savings.
- Investigate program overlaps between Quality Install and the Energy Upgrade California Home Upgrade Program. Highest available efficiency installations made up a large portion of QI program participants and some of these installations may be appropriate to include in Energy Upgrade California Home Upgrade Advanced path jobs. The strategy could capture pre-retrofit deficiency savings and load reduction leading to smaller installed QI units.
- Expand non-participant sample to support evaluation of QI programs and "to code" pilots. Using a consistent data collection approach would allow expansion of the sample in any given climate zone, given the relatively small size of the sample in this study. The "to code" pilots will collect detailed compliance verification data. Comparing non-pilot and pilot jurisdictions may require larger samples of non-participants.
- Ultimately the programs can influence savings for actions that exceed Title 24 requirements if they exist. Participant systems did not all meet assumed values which could be improved by program inspections. Exceeding code will improve realization rates, but it is unknown if cost effective saving remain, especially relative to the new code. Common practice was worse than code in this study, but not as much as assumed in workpapers. The evaluation team recommends the IOUs explore a few areas where Title 24 can be exceeded or does not have requirements:
  - Explore downsizing to reduce peak demand. The program sizing aligned much better with Manual J load calculations than non-participants, but did not eliminate all cases of oversizing. Non-participants did not systematically oversize, but rather there was a wide range of sizing relative to load calculations. A focus on reducing the installed size compared to the unit that is being replaced would have peak demand benefits if the reduction in size can be documented.
  - Explore duct sealing to reach a lower target leakage, such as the 6% threshold that is set for new ducts systems.
  - Explore air handlers/furnaces, filters, and duct modifications that reduce pressure drop and improve fan system efficiency.
  - Explore whether all ANSI/ACCA 5 Quality Installation Standard elements in programs impact energy use and align with workpapers. The standard does not call out items specific to energy efficiency so the program workpapers should reference which items in the standard are tied to energy savings and assess whether some elements may have non-energy benefits and determine if they are energy neutral or add additional load.

- Determine if there are specific locations where common practice baseline is worse than estimated in this evaluation, potentially using AMI or other data[66]. The non-participant sample covered large areas and many code jurisdictions. Further study could determine specific areas where common practice is worst and target program activities toward those locations. This may mean leveraging local government partnership programs as opposed to statewide program models if it is determined that only specific areas have the greatest opportunity.
- Ensure that workpaper and evaluation modeling inputs produce HVAC energy estimates that are consistent with Residential Appliance Saturation Study (RASS)

[66] Comparative Use programs, such as Opower, should be able to define regions to focus on without violating confidentiality – maybe targeting specific counties, cities, or even ZIP codes

4. Upstream HVAC Program

4.1 Summary

The evaluation efforts for the upstream component of the study focused on the level of free-ridership in the Upstream HVAC program. Gross ex ante savings claims are based on DEER estimates and were not evaluated. A participant self-report method was used for the free-ridership/net-to-gross (NTG) work, and the analysis was based on in-depth telephone interviews with 19 out of 22 participating HVAC distributors that were conducted by DNV GL in 2013. The approach took into account the program's effect on both the stocking practices and sales practices of the distributors.

Overall, the program is achieving a savings-weighted NTG score of 0.80, versus an unweighted NTG score of 0.58. The reason for this difference is that the distributors who account for the largest share of program savings are also the distributors who claim the highest levels of program influence.

The evaluation team makes the following recommendations[67], gleaned from the distributor interviews and analysis of program data:

- The program should consider increasing rebate levels for higher efficiency equipment to encourage more sales in the highest efficiency tiers.
- Program-provided support for how to market high efficiency equipment support may be helpful to distributors, particularly those who are less successful at selling the concept of high efficiency.
- Providing a reservation system or rebate guarantee would encourage more participation, and increased high-efficiency sales, from distributors who have long sales cycles or custom build equipment.
- Future evaluation should consider data from the Market Effects and Commercial Market Share Tracking studies in addition to self-reported distributor information. The parallel 2010-12 studies did not include such an overarching analysis, but this is recommended for 2013-14.

In the remainder of this section, we describe the upstream program, report on the distributor surveys, present the NTG analysis and results, and provide conclusions and recommendations for the upstream program.

[67] The recommendations were not tested for cost effectiveness

4.2 The Upstream Program

From program years (PY) 2010 through 2012, the California IOUs funded an Upstream HVAC non-residential rebate program. The program implementation contractor is Energy Solutions and the California utility program partners include PG&E, SCE, SDG&E, and SMUD. The Upstream program has been in operation since 1998. More information can be found on Energy Solution's website http://energy-solution.com/index.php/case-studies/upstream-hvac.

The program has three primary goals:

- Encourage participants (distributors) to increase their stock of high-efficiency non-residential equipment in order to be readily available to customers (contractors).
- Encourage participants to up-sell equipment to customers (e.g., explaining to customers the technical benefits of the efficient option and calculating the payback or net present value when possible).
- Encourage the purchase and installation of the most efficient equipment available.

The Upstream HVAC program enlists HVAC distributors who are willing to participate under the program's terms and conditions to sell high efficient heating and cooling equipment for non-residential (commercial) use. Rebate amounts paid to distributors are based on performance tiers.[68] Tiers vary based on equipment type, capacity, and efficiency (SEER, EER, or IEER ratings). Distributors' customers are typically licensed HVAC contractors (C-20) or mechanical design engineers.

Equipment eligible for rebates must be installed in non-residential buildings within the sponsoring IOU's service territory and must meet program-specified efficiency requirements; distributors must provide information on the location of the installation. The most common rebated equipment includes:

- Three-phase package and split equipment (air-cooled and water-sourced heat pumps, water and evaporative-cooled AC)
- Single-phase equipment (air cooled)
- Single-phase ductless equipment (mini and multi-split equipment)

Distributors are also entitled to receive rebates for these less common equipment types:

- Three-phase air-cooled chiller equipment
- Three-phase water-cooled chiller equipment
- Three-phase variable-refrigerant-flow equipment (VRF heat pumps and heat recovery)

[68] See Appendix E for 2010-2012 SCE Qualifying Minimum Equipment Efficiencies & Incentive Levels for Commercial Air Conditioners

4.2.1 Utility Level Claimed Savings for 2010-12

PY 2010-12 energy savings claims for each IOU are detailed in

Table 32. The SDG&E savings were not classified in the original program ID associated with upstream incentives, but some measures in their Non-Res HVAC program were clearly labeled as a part of the Upstream HVAC program.

Table 32: Ex Ante Savings for Upstream Programs

Program ID	Program Name	2010-12 Savings Claims	
		Energy Savings (kWh)	Demand Savings (kW)
PGE21061	Upstream HVAC Equipment Incentive	17,705,130	9,100
SCE-SW-007A	Upstream HVAC Equipment Incentive	64,368,795	21,952
SDGE3147	Commercial Upstream Equipment	0	0
SDGE3161	Non-Res HVAC	560,854	203
TOTAL		82,634,780	31,255

4.3 Survey with Participating Distributors

During the two-year program cycle, 22 HVAC distributors received rebates for the sale of high-efficiency equipment, and DNV GL was able to interview 19 of these participating distributors. The distributor interview length was, on average, slightly longer than one hour.

The distributor survey was designed to address these objectives:

- **Characterize participating distributors** including distributor geographic territories, exclusive rights to serve in a region, number of manufacturers represented per distributor, quantity of equipment maintained in stock, equipment stock turnover rates (i.e., period of time before needing to replenish stock) and distributor market shares.
- **Estimate program free-ridership** for high-efficiency equipment sold and/or stocked by distributors.
- **Identify sales volume** by type, amount, and efficiency levels of equipment currently being sold.
- **Identify availability of a tracking database** for company sales and willingness to share data on non-program-qualified HVAC units.

The last two survey objectives (sales volume and tracking database) were part of a joint effort with the CPUC Market Effects Report (Work Order 54).

4.3.1 Characteristics of Participating Upstream Distributors

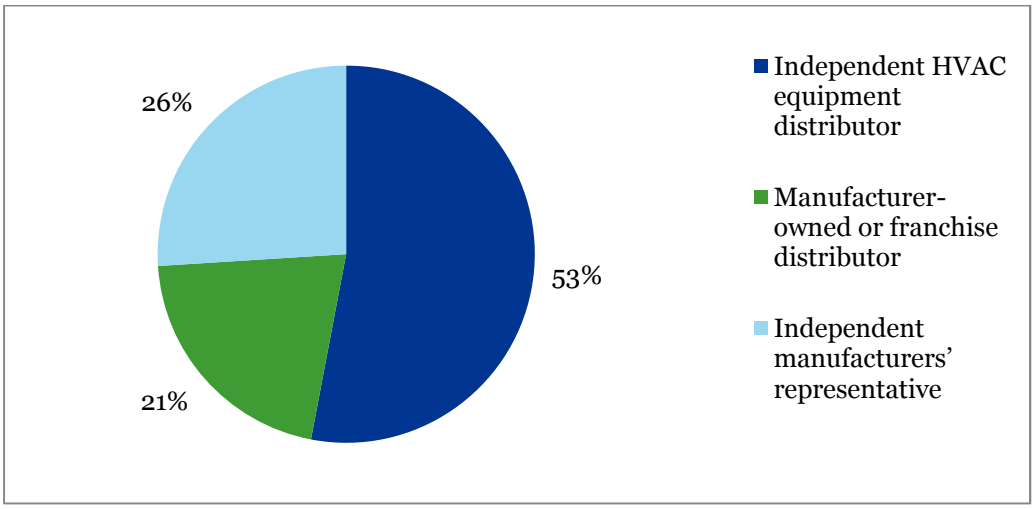
Evaluators asked distributors a battery of survey questions to better understand their business practices, the products and services they offer, and their use of rebates. The evaluators presented distributors with three distinct distribution business models and asked them to identify which model most closely relates to their practice. The models presented are as follows:

- **Independent HVAC equipment distributors** are distributors who and buy and sell equipment from various HVAC manufacturers and are not linked to a single manufacturer.
- **Manufacturer-owned or franchise distributors** are distributors that are-manufacturer-owned or franchised by a manufacturer. These distributors sell equipment directly from the manufacturer; they generally do not represent more than one manufacturer unless the manufacturer has multiple brands.
- **Independent manufacturer's representatives** are distributors who are independent sales agents that have exclusive rights to sell equipment for a specific manufacturer. Manufacturer representatives generally represent more than one manufacturer. Often, the products offered are complementary and do not compete with each other.

The evaluation team found it was fairly common for distributors to have more than one business model. For example, a distributor may be a manufacturer's representative for certain product lines and an independent HVAC equipment distributor for other product lines; or the distributor may be manufacturer-owned but sell other equipment as an independent distributor for product lines the manufacturer does not produce. We found such hybrid business models for about 25% of the distributors interviewed.

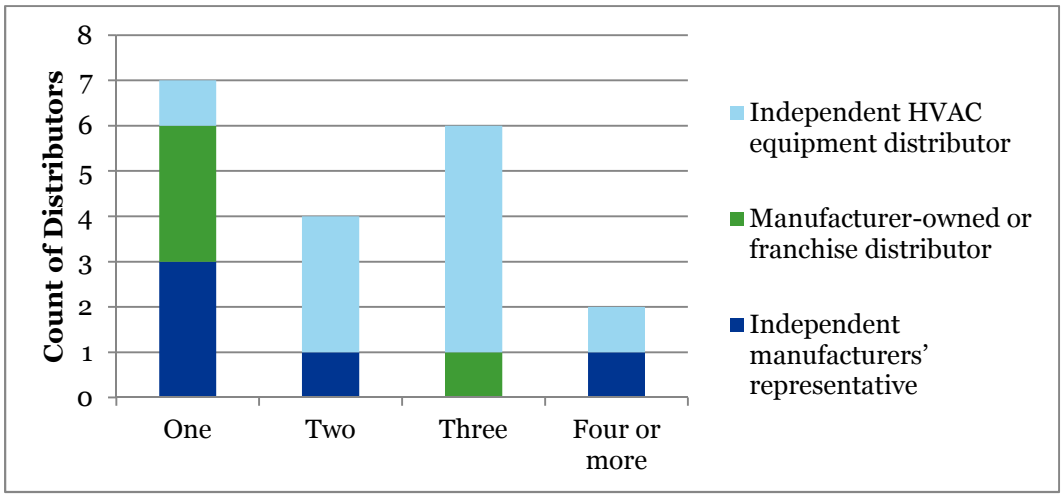
Distributors were asked which model best represented their practice. The majority (53%, as illustrated in Figure 7) stated they were independent HVAC equipment distributors, 26% were independent HVAC equipment distributors, and the remaining 21% were independent manufacturers' representatives.

Figure 7: Business Models of Upstream Distributors (n=19)



Distributors were also asked how many different packaged and split system manufacturers their company carries. As illustrated in Figure 8, independent distributors carry units from more manufacturers (most offer two or three) while manufacturer-owned/franchise distributors and independent manufacturers' representatives typically offer units from a single manufacturer.

Figure 8: Number of Unique Manufacturers Distributors Represent (n=19)



Another characteristic captured in the survey was the concentration of distributors in the state's major metropolitan areas. As shown in Table 33, the San Francisco bay area and the Central Valley had the highest concentration of distributors covering a geographic area, while the lowest concentration was in the southern part of the state: Los Angeles (LA) Inland Empire, LA Coastal, and San Diego. The "other areas" were most often cited as coastal cities throughout the state. Approximately three quarters of distributors also serve markets in states other than California. None were aware of nationwide Upstream programs and few were aware of mid- or downstream programs at the national level.

Table 33: Distribution Areas Served by Participant Distributors*

Geographic Areas	n=19	%
San Francisco Bay Area	15	88%
Central Valley (Modesto, Fresno, Bakersfield)	13	76%
Northern Valley (Redding	12	71%
Sacramento Area	12	71%
Desert (Palm Springs, Imperial Valley)	7	41%
LA-Coastal (LA, Orange County)	6	35%
LA-Inland Empire	6	35%
San Diego	5	29%
Other Areas	8	47%

*(multiple-response)

Distributors were also asked if they were knowledgeable about market and sale trends outside of California, and eleven of the 19 respondents said they were knowledgeable or somewhat knowledgeable. They were then asked how demand for high efficiency equipment in California compared to other states. Most respondents said demand in other states was lower due to electricity costs being cheaper (with Hawaii noted as an expectation[69]); lower due to California having Title 24, and some also mentioned the IOUs incentive programs.[70] [71] One distributor cited CA as having lower demand for high efficiency cooling than other states and extreme efficiency demands occur in: "Minnesota and Wisconsin, and less so in Oregon and Washington and to a degree Iowa."

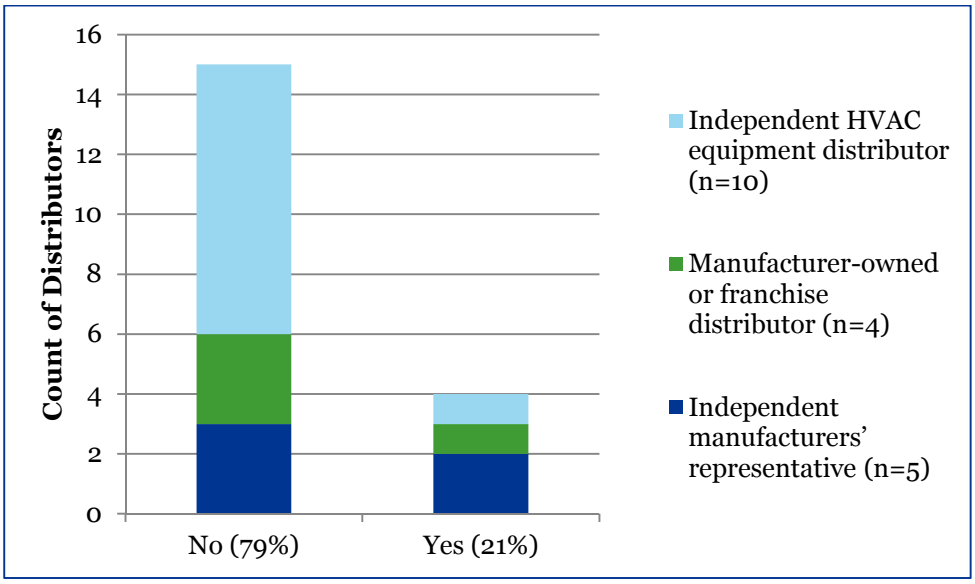
The target participants of the Upstream program are HVAC equipment distributors that sell commercial HVAC equipment, not HVAC companies that mainly install HVAC equipment and only do some distribution. To identify whether the program was engaging the right mix of distributors, we asked respondents if their company installed equipment. For this question, we anticipated few companies offering installation services. We found this to be the case. As illustrated in Figure 9, the majority of distributors (79%) do not offer installation services.

69 "High efficiency cooling equipment is proportional to the electric rates of in those areas. So Hawaii for example has some of the highest rates in the country and so there is a large demand there".

70 "Higher for CA because we have more emphasis on energy-efficiency. I wish the other states were as high as CA we specifically target the western states but nothing compares with your program".

71 "Demand is lower (in other states), my sense is based on Title-24, energy costs in California, and we sell more high efficiency equipment in the state of CA. The incentives are also factors you have to include that are driven through these utility programs (SCE, SMUD & PG&E) and incentives. There are localized programs, Oncor has a program in Dallas, and it's regional and local. I don't know that there are other states that have as good of a quality of as CA when it comes to rebates."

Figure 9: Does Distributor Install Equipment? (n=19)

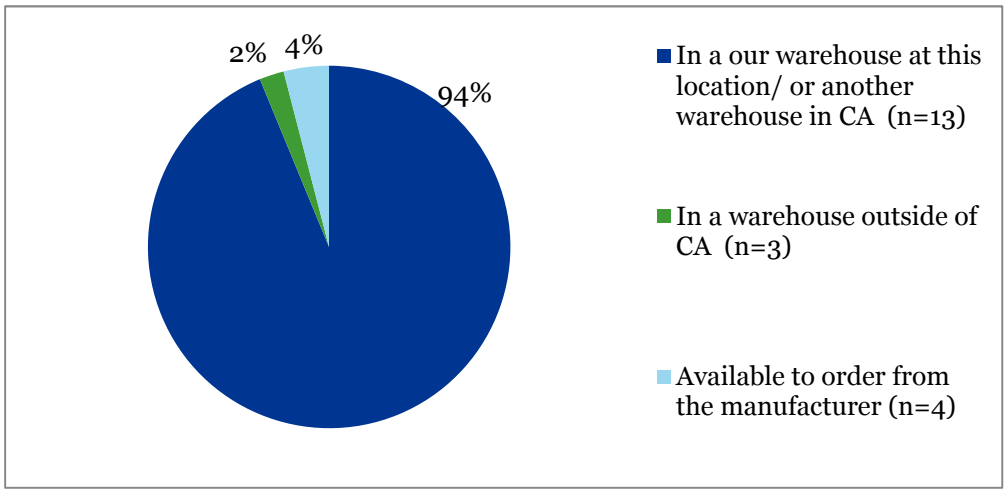


Also as shown in Figure 9, the majority (90%) of independent distributors do not install equipment; installations are more evenly divided among the other two types of distributors with slightly more independent manufacturers installing equipment. DNV GL found that manufacturer representatives often engage in sales of custom equipment (such as ultra-large-tonnage units), which appear to require installation by distributors.

If the respondent stated they distribute and install HVAC equipment, we then asked if they were more of a distributor, more of an installer, or if their activities were evenly divided. Among the 21% of respondents stating their business included both distribution and installation, only one distributor responded their activities were "evenly divided" while the remaining indicated they mainly engaged in distribution.

Distributors were asked where they source their shipments from. Evaluators applied distributor's share of program savings to their responses of where shipments come from. As illustrated in Figure 10, 94% of program saving shipments come from a warehouse in California, 2% come from warehouses outside of CA, and 4% are available to order from the manufacturer.

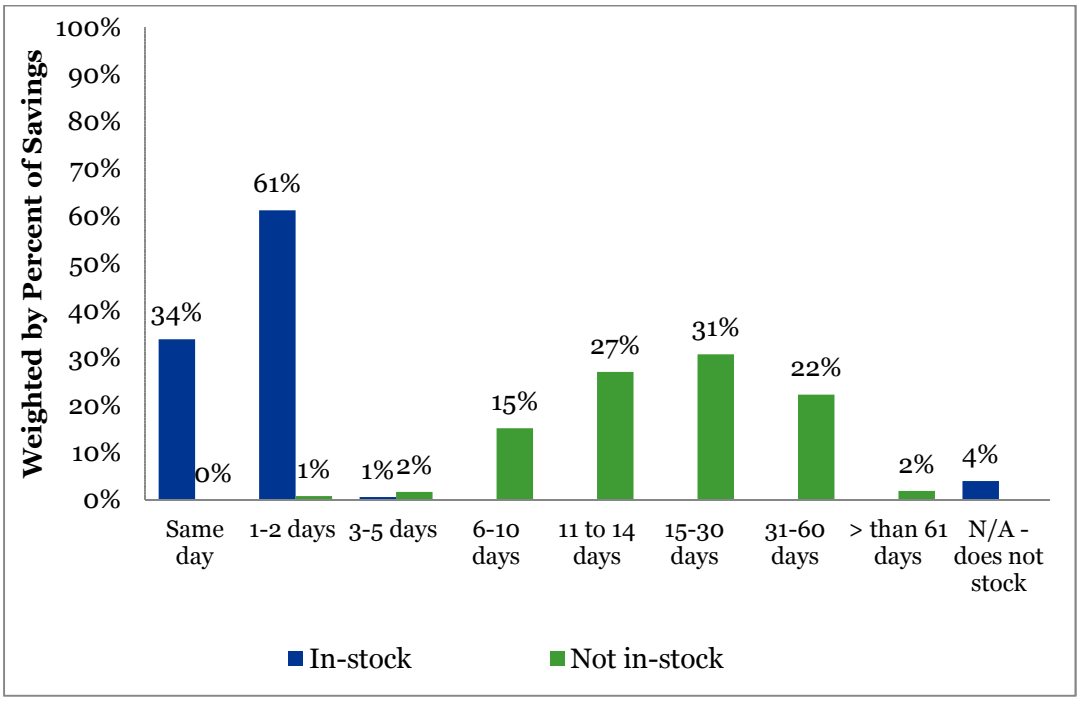
Figure 10: Shipment Sources for HVAC Equipment by Program Savings (n=19)



One of the program's theories is if high efficiency equipment is not readily available, a purchaser will select a lower efficiency unit, especially for units serving the emergency replacement market. In a few cases we found distributors citing this factor. In their cases, they made the decision to stock higher inventories of high efficiency equipment to differentiate themselves from competitors. Their theory is, by retaining a larger stock of high efficiency units, they can upsell to the next best model, but if the high efficiency models are out of stock then they don't have anything to sell.

Figure 11 compares the average length of time to receive a shipment for in-stock and out-of-stock equipment. The results were then weighted by distributors' shares of program savings. As illustrated, 95% of the shares are readily available and can be sold/received within 2 days or less. And 95% of out-of-stock equipment can be received within one week to two months. Without program intervention driving high efficiency, and following the theory that most distributors would have limited inventories of high efficiency, one would expect high efficiency delivery timeline would follow the out-of-stock timeline. According to the distributor's, the market is highly competitive. As such, the distributors experience a constant sense of urgency to deliver products quickly, if not immediately. Having what consumers want, when they want it, is relatively important as compared to other factors such as price and service.

Figure 11: Average Length of Time to Receive Equipment (n=19)



Balancing equipment supply and demand is a challenge for distributors; unless there is consistent demand, a distributor may only carry a very limited supply of a particular efficiency level or may only offer the equipment as a special order.

Distributors describe this assessment of supply and demand as their "turns rate," or how many times does a piece of equipment sell (turn over) in a given time period (e.g., one year, one month). The turnover rate is constantly re-evaluated and is of significant importance to distributors.

As one distributor indicated:

> *"The number one factor is the turns, (the number of times you sell that product per year). If you only sell it once a year there is no reason to keep it in stock; but if you can sell what you have in stock multiple times per year then it's a product you want to have in stock. We look at what people are buying and we also look at what rebates are out there that help us pay for the additional stock."*

The pressure to stock equipment that has a high turnover rate is a major barrier for the program, since higher efficiency units still have less demand than standard units.

4.3.2 Upstream Program Participation

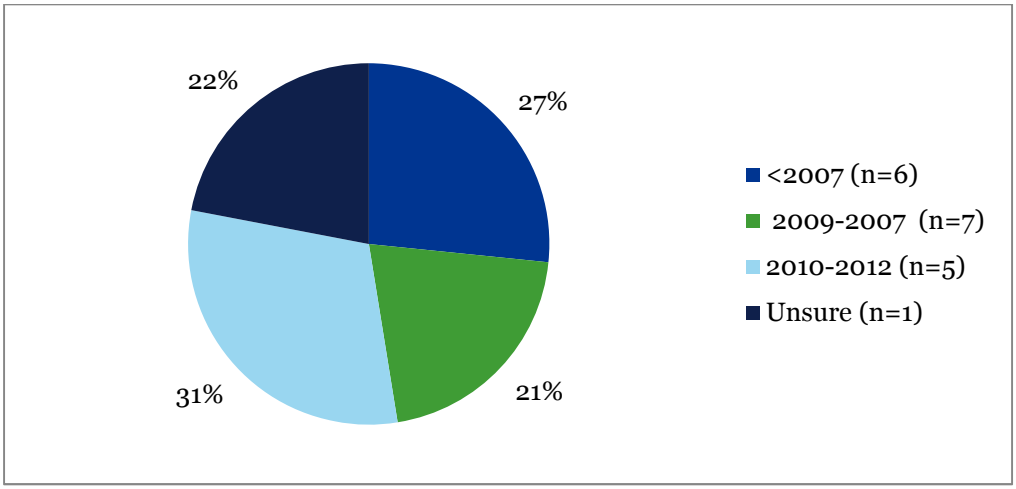
We solicited survey responses from high-level company decision-makers, most of whom were company presidents, vice presidents, or commercial sales managers. The role respondents had at their company enhanced the reliability of the survey results as they were likely to be more knowledgeable of the direct effects of the program and could provide the company's historical perspective on their participation. As illustrated in Table 34, the majority of respondents interviewed were personally involved in the decision to participate in the program. One respondent stated he/she was not personally involved in the decision to participate but oversaw the program implementation.

Table 34: Was Respondent Personally Involved in the Decision to Participate in the Upstream Program? (n=19)

Response	n=19	%
Yes	14	74%
No	5	26%

Figure 12 illustrates distributors' share of program savings, for the 2010-12 period, by the year they first enrolled in the program. Participation has grown steadily, with new enrollments peaking in the year 2010. During that year, six distributors joined the program, the most significant year of growth in the program's history. On average, the program has grown by a measure of two new distributors each year since 2006.

Figure 12: Program Share of Savings by Year Distributors Engaged in Upstream Program (n=19)



Unfortunately, one distributor could not recall when the year the company enrolled. Its share of program savings accounts for slightly more than 1/5 of the total share. The lack of this

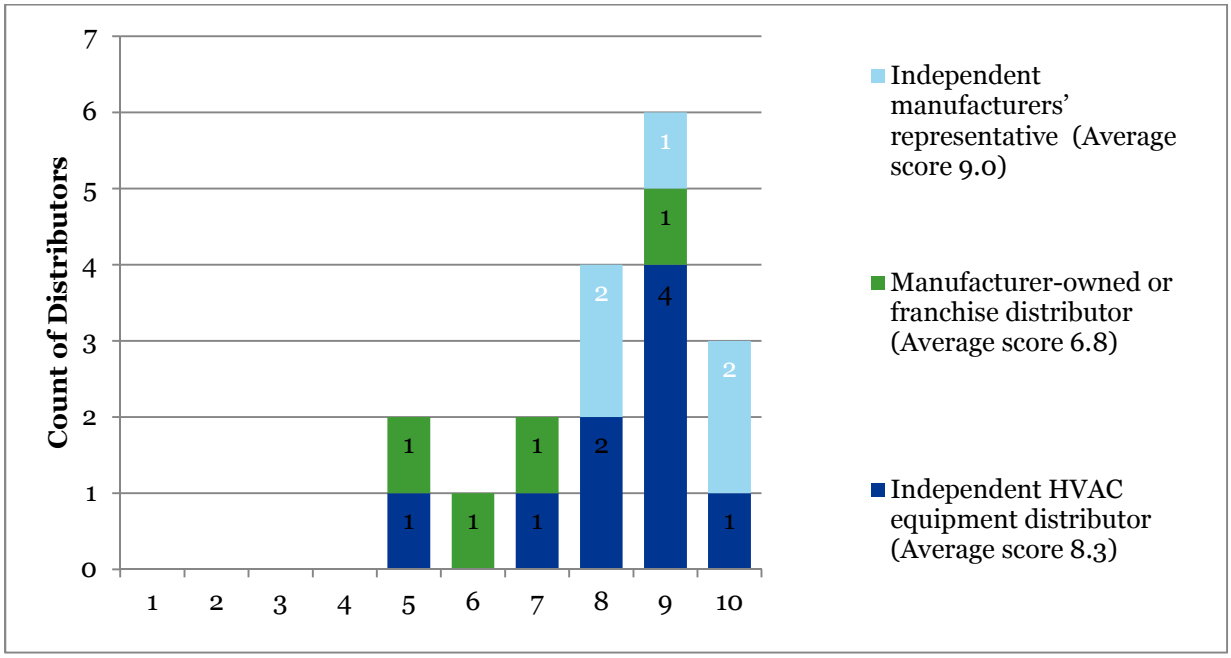
information does impact our peak savings by year of enrollment. This information would have likely informed us on the program cycle where savings reached its peak. As illustrated, the savings peak at 31%, (absent that distributor) occurred in the same program cycle as the enrollment-peak occurred.

4.3.3 Importance of Energy Efficiency

To identify whether distributors prioritize energy-efficient products in their marketing efforts, the evaluation team asked if energy-efficient HVAC is a particular focus of their marketing efforts or product offerings. The overwhelming response was "yes" with 18 of the 19 respondents agreeing. Additionally, 18 of the 19 respondents indicated their company tries to upsell higher efficiency product lines.

Interviewers asked distributors who rated energy efficiency as important just how important efficiency is in their marketing efforts and product offerings. Eighteen distributors rated importance on a Likert scale of 0 to 10 where 0 is not at all important and 10 is the most important. Figure 13 shows, independent manufacturer representatives rated energy efficiency the highest, with an average score of 9.0. Independent equipment distributors rated importance of energy efficiency slightly lower, with an average score of 8.3, and manufacturer- owned distributors rated it the least important with an average 6.8 score.

Figure 13: Importance of Energy Efficiency Rated 0-10 (n=18)



Independent manufacturer representatives rated efficiency the highest with an average score of 9. To the follow-up question of why energy efficiency is important, these distributors, with specialty products, reported that they market their brand as very efficient and often work

directly with design engineers to customize their equipment. Below is a sample of comments to the follow-up question, "In what ways does your company focus on the sale of energy-efficient HVAC equipment?"

> *"Well by the products that we represent, we are an exclusive [manufacturer's] representative, we tend to be leaders in the industry as far as efficiency is concerned."*
>
> *"We generally get mechanical engineers on projects they are designing that an owner and architect have brought to them. They call us requesting a certain type of equipment we always push them into the highest efficiency and not just efficiency but also pushing the operation, the sequences, the controls to make those things happen, a lot of our work, 70% of our orders, are from engineers."*
>
> *"By the design of the project and working with the engineering firm, laying out the job, evaluating our equipment making sure it's meeting the mark."*

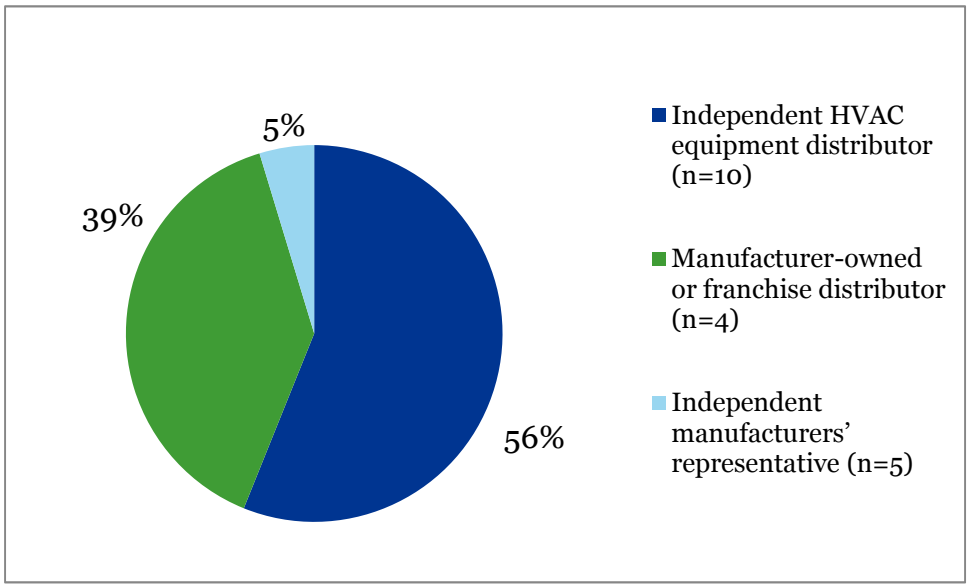
Manufacturer Owned/Franchise distributors rated efficiency the lowest, just slightly lower than independent distributors. These distributors promoted energy efficiency by giving consumer and dealer incentives, by working with design consultants to promote lifecycle costs vs. first cost, and through product design and development.

Independent Equipment Distributors: These distributors promoted energy efficiency by: upselling when the order is placed, marketing and advertising, training, guaranteeing or maintaining inventory for high efficiency stock, promoting return on investment or lifecycle, knowledge sharing via annual meetings with dealers, instant rebates (Upstream dollars), and selling the high efficiency unit for the low efficiency price.

4.3.4 Claimed Savings by Distributor Model Type

As illustrated in Figure 14, during the 2010-12 cycle 10 independent HVAC equipment distributors accounted for 56% of the program savings. Four manufacturer-owned or franchise distributors accounted for 39% of the program savings, and independent manufacturers' representatives accounted for 5%. Evaluators were unable to interview three distributors. These non-respondents claimed less than 1% of the total claimed rebates during the 2010-12 cycle, a minimal share of program savings.

Figure 14: Distributors Percent of Claimed Savings



4.4 Measuring Program Influence on Upstream Distributors to Develop Net to Gross

4.4.1 Program Theory and Distributor Practice

Historically, distributors believed that to compete in the marketplace they had to stock the least efficient equipment in order to offer the lowest-priced products to the market, while higher-efficiency equipment theoretically sold less often due to higher cost (for both the distributor and customer) and therefore was not stocked and required a special order. Upstream rebates were designed to influence sales and stocking practices towards higher efficiency. So one might ask, how can the program influence stocking such that high efficiency equipment is readily available? The method that appears to have the greatest impact is for the program to provide funding to allow distributors to discount units or to offer a higher-efficiency unit at the same price as a lower-efficiency unit. As one distributor articulately stated: *"When you eliminate the price differential between a high efficiency and a standard efficiency unit you eliminate the only real objection to buy a high efficiency unit."* Some distributors also attempt to influence the market through knowledge sharing: *"We have nine people that specialize in that line alone and their sole job is to support contractor sales and engineering sales department in that line of product. There is a cost associated with training contractors and engineers on that type of product."*

Influencing stocking is a complex issue because stocking inventory is ultimately a demand-based decision or as distributors call it their "turns-rate," the number of times a product sells in a given time period. The turns-rate is of great importance, as reported by distributors: *"How*

often you can turn over the inventory, the "turns-rate", looks like cash so you need to turn it over a lot, you need to move it;" and "*If we sit on inventory for more than one year there is a penalty; you never want to be penalized by headquarters; if you sit on a unit for more than a year, it's a write off."* If a product has few turns (little demand) then there is no reason to keep an item in stock, and as the above comments illustrate, having the right mix is critical to business operations. Stocking decisions are tactical and evidence based; products must have a sufficient demand to warrant storage at a local warehouse.

To fully embrace the program offerings, distributors must be willing to take risks by stocking equipment that doesn't have significant demand. *"People thought it might be risky; there was a little push back… Everyone is a bit change-averse… We found very quickly that any resistance or risk was made up for; that we were moving high efficiency faster than we could keep them in the factory."*

However some distributors may not be willing to take the risk and some may find they are ineffective at creating demand even after they took the risk. *"There will be no changes now or in the future because we don't plan on doing the promotions again since they were not successful;" and "The fact that we were flat using our skills or lack of, however you want to look at it, we were not able to change the marketplace."*

Ultimately, to be successful the program distributors must find a way to create demand: *"We supply and try and create demand;"* and *"The market has to be developed, in other words there is no market demand for high efficiency equipment; we have to bring that message to our customers."*

Therefore, it appears participant distributors must be willing to take risks and stock more high efficiency units than the market is currently requesting with the expectation they can direct demand toward high efficiency units. To change the market, the unit cost and availability need adjusting. The expectation is rebates will create market demand by increasing availability and making higher-efficiency units cost-competitive alternatives.

This outcome may be facilitated by defraying distributors' cost of carrying higher-efficiency units. This in turn will allow for distributors to reduce their equipment and/or storage cost for high efficiency systems, and any remaining rebates can be used to drive market demand towards the high efficiency equipment by reducing the purchase price.

According to some distributors, rebates are also used to fund knowledge sharing or for compensating commission-based sales staff when they effectively sell the benefits of high-efficiency equipment. Under this application it is difficult to be sure whether the rebates are actually improving a service offering or if the rebates are simply increasing a distributor's profit on the sale of a high-efficiency product that would otherwise sell without a rebate. If there are no service-enhancement offerings (such as spending more time with customers, increased

staffing, and utilizing tools such as energy-savings models) or offerings are actually reduced, the rebate could simply be padding the pockets of distributors or paying for employees' wages. According to an article published by HARDI that referenced this particular program, distributors will "come up with creative ways to motivate sales staff rather than just lowering the price of the equipment."[72]

The evaluation found that rebate handling by individual distributors was discretionary and managed in a myriad of ways, such as: compensating commission-based sales staff for selling higher-efficiency equipment, covering equipment carrying costs, or passing on a portion of the rebate to the customer to drive sales. While the program model may appeal to many distributors because they are seeing the benefits through increased staffing levels and selling high efficiency equipment, the lack of transparency emphasizes the potential for misuse.

The industry-accepted definition of a free rider is a program participant who would have implemented the program measure or practice in the absence of the program[73]. If we attempt to frame the Upstream Program into this standard free-ridership paradigm, one could point to examples of free ridership. A distributor could be considered a free rider when they have made no changes to their practice and naturally-occurring market demand is the only driver to account for high-efficiency equipment sales.

Some quotes from surveyed distributors highlight cases where the program has been both ineffective and effective.

Skepticism of the Upstream Model:

- Distributor B: *"I think because the simple fact is the rebate is not finding its way to the person who is spending the money on the product."*

Examples of handling of the rebate in line with program theory:

- Distributor K: *"The incentive program does drive our decision, to a certain extent. It allows us to have carrying cost and sale price cost with a reasonable delta vs. standard efficient equipment. It flattens the playing field and drives the market in that direction."*
- Distributor M: *"When we don't have the inventory costs we 'pass it through' to the buyer."*
- Distributor O: *"As I said the rebate is what helps us with manpower to promote this product and without that it makes it very difficult."*

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[72] Angela D. Harris, "Distributors Play Key Role in Efficiency Programs" HARDI Net, 15 March 2012, http://www.hardinet.org/distribution-center,

[73] The TecMarket Works Team, *California Energy Efficiency Evaluation Protocols,* April 2006, pg. 226

- Distributor S: *"The element of the rebate pass through, in order to remain competitive the Upstream programs have become apparent and public knowledge."*

4.4.2 NTG Score Algorithm

As previously mentioned the NTG algorithm relied on a self-reported approach. The evaluation team developed a self-reported scoring methodology that quantifies program influence to sales and stocking, given these are two factors that the program aims to effect. In a two-part[74] question, distributors quantified program influence. The two-part questions were repeated for sales and stocking. The evaluation team assigned influence-weights for the program influence on stocking and influence-weights for the program influence on sales to reflect the direct overall influence of the program. In order for the program to increase the efficiency of systems being installed, there needed to be a strong influence on the sale of high-efficiency systems. The team determined that sales were of primary importance; therefore sales were given a higher influence-weight of 70%, while stocking was assigned a lower influence-weight of 30%. Each distributor received an individual score ranging from 0-100% based on the scoring algorithm.

To obtain full program credit in the scoring, the distributor must state that the rebate was influential to both sales and stocking and they must state the rebate was highly influential relative to other factors affecting high efficiency equipment sales. All influential factors where rated on a Likert 0-10 scale, where is zero is not influential and ten is very influential; the distributor's assigned 0-10 ratings determined the quantified program influence.

To avoid leading respondents during the interview process, the evaluation interviewers did not directly ask the question "did the rebate influence your equipment sales and stocking practice" but rather asked "what are the primary factors that influence sales and stocking for high-efficiency equipment?" Asking respondents directly if the rebates were an influence could introduce bias and respondents may want to give the "right" answer even if no influence exists; for this reason the survey asked for the top influential factors. By asking for the primary factors of influence, the respondents must state on their own that the program was influential, and furthermore they must rate the importance of the rebate in addition to other factors that may have also influenced their sales and stocking practices.

Figure 15 and Figure 16 present the NTG questioning sequence and scoring approach that address both stocking and sales influences of the program, and subsequent text further describes the process.

[74] NTG Stocking question: "What specific factors influence your company's decision to stock a certain efficiency level for packaged and split system units? Please cite as many factors as you think are relevant. And for each of the factors you cited [in Q1] could you rate on a 0 to 10 scale how influential each individual factor is in your stocking decision? Where 0 means not at all influential and 10 means extremely influential.

Figure 15: Flow Diagram for Upstream NTG Scoring on Stocking

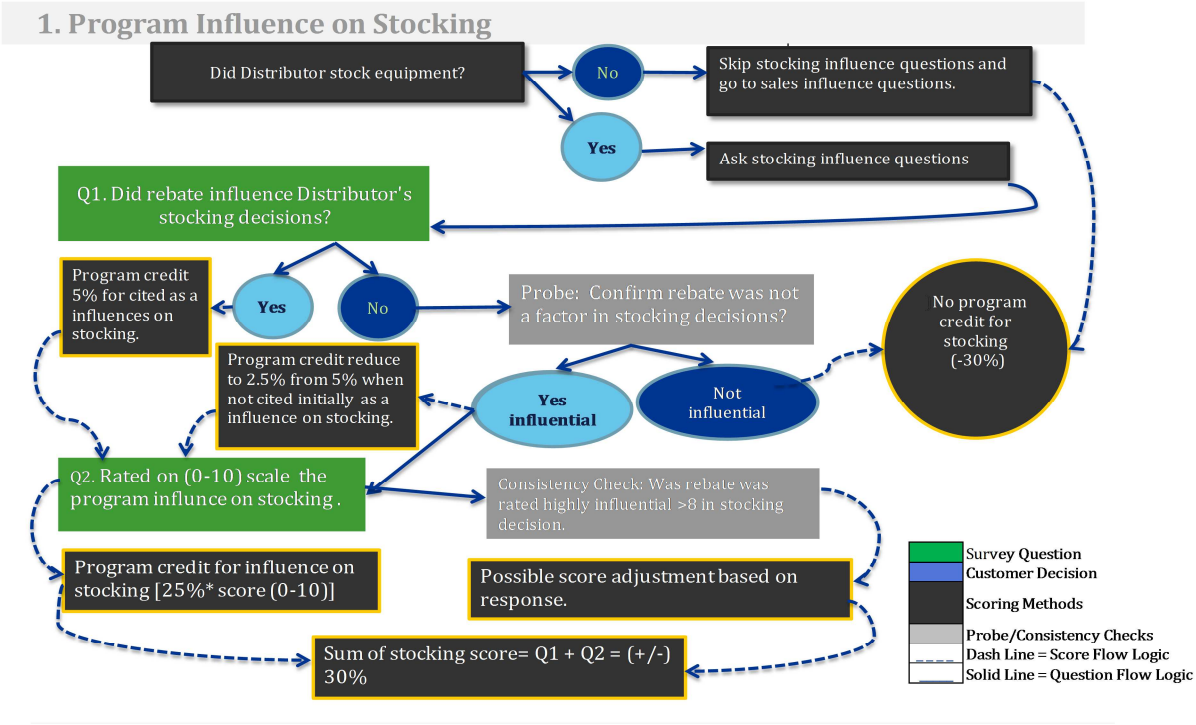
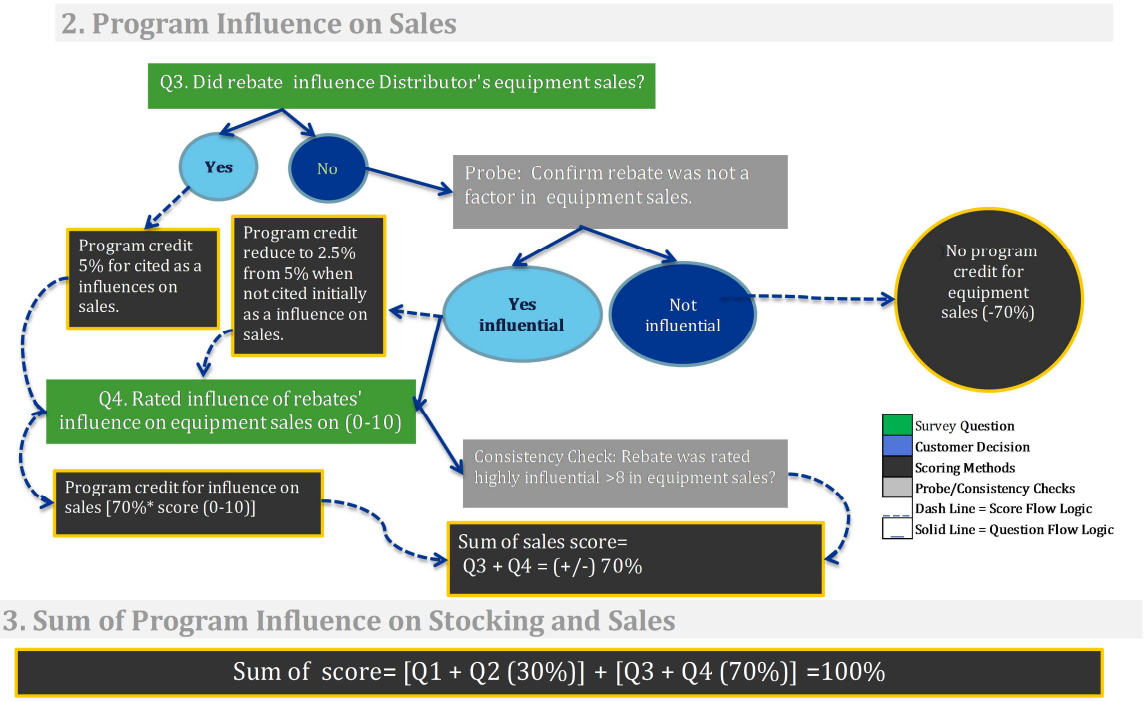


Figure 16: Flow Diagram for Upstream NTG Scoring on Sales



The program received full credit (net-to-gross ratio of 1.0) when all of the following conditions are met:

- **Stocking**—when the distributor claimed that the rebate influenced their stocking practices, the program received 5% credit in the scoring algorithm. The evaluation team thought it was appropriate to give nominal credit when respondents cited on their own, unprompted, that the program was one of the factors that influenced stocking. Had the questions been designed to lead or directly ask if the rebate was a factor then the degree of importance would have been the only consideration for weighting program influence. In this survey, the team combined the citation (or acknowledgement that the program was an influence) and degree of importance to generate the stocking score. The respondent was then asked to rate the degree of importance *for all factors* on a Likert 0-10 scale. If the rebate was cited as a factor, the score assigned to the rebate was then multiplied by 25%. The sums of these scores resulted in the following equation for program influence on stocking (under maximum credit):

  [5% + (0-10*0.25)% =30%].

  If the respondent stated that they did not stock equipment, the team skipped the questions on stocking and reduced the score by 30%. The team based the decision to automatically reduce a respondent's score based on the program theory component that in order to increase sales the equipment must be readily available or in-stock.

- **Sales**—the evaluation team repeated the same set of questions to address program influence on sales. The methodology was the same; the rebate was given nominal credit (5%) if cited since the respondent was not prompted to address the rebate. The team then asked the respondent to rate the degree of importance for all factors mentioned. If the rebate was one of the influential factors cited, the degree of importance (rated 0-10) assigned to the rebate was multiplied by 65%. The sum of those two scores resulted in the following equation for program influence on sales (under maximum credit):

  [5% + (0-10*0.65)% =70%].

- **The full equation** was, then:

  stocking [5% + (0-10*0.25)%] + sales [5% + (0-10*0.65)%] =100%

Partial Credit— To make sure the evaluation team explicitly accounted for how the rebate may or may not have influenced their decisions and practices and to clear up any misinterpretation the respondent may have had about the questions, the team also prompted the respondent with an aided question about the rebate, to confirm whether it was a factor or not. This prompt occurred after importance of all other factors was rated and *only* if the respondent did not previously cite the program as an influential factor.

If the respondent did not cite the rebate as a factor that influenced stocking and/or sales, the team asked them to confirm that the rebate was not an influence. If the evaluation team needed to prompt the respondent to confirm or deny the rebate influence, the team reduced their score slightly. The team asked the question: "In the previous questions you did not cite the rebate program as a factor that influenced in your stocking decisions; I'd like to confirm, did the rebate have an influence you're stocking decisions?" If yes, then, "Could you rate on a 0 to 10 scale how influential the rebate was?" If the evaluation team aided the respondent on either stocking or sales, the team reduced the score overall by just 2.5%. If the evaluation team aided the respondent on both stocking and sales the team reduced the overall score by 5%.

No Credit—the program received no credit if the respondent did not cite the rebate as a factor that influenced stocking and/or sales.

Detecting Inconsistencies— The evaluation team designed questions to address inconsistencies in responses to stocking and sales influences. For example, if a respondent did not initially state the rebate was influential but later provided a high score (>8) after being prompted, the team treated this as an inconsistency to be explored. If the respondent provided a high score after being prompted about the rebates, then the team asked the following consistency question: "You did not previously mention the rebate as a factor that influenced stocking. By providing a score of [>8] I would interpret this to mean the program was very influential. Could you please explain why you gave this rating? And why you did not mention the rebate initially?" The evaluation team either increased or decreased scores depending upon the responses. Out of the 19 respondents, the team asked the consistency question to five

distributors. Responses to this consistency question were some of the more interesting ones captured in the survey. Examples of responses that exemplify how powerful the rebates were include:

> "*The rebate is always the underlying factor. I do not mention it but it is always the common denominator, it's there. If there were no tiers, 2, 3, or 4 you would definitely [have] sales occur in tier 1 and below. To promote a low-efficiency piece of equipment takes no time, no effort, and our stock of that equipment can be a lot less expensive than our high efficiency equipment. We can live in a commodity world of low-efficiency equipment; we can do that, and we have done that in the past but if we want to elevate ourselves to a high efficiency and stock more expensive high efficiency equipment the only way we can do that is to have the rebate offset and subsidize that.*"

> *"It [rebate] does, I feel like it does in terms of allows us to drive some market demand and differing our carrying costs. The program definitely has influence in those areas. Because the rebate program being in effect has allowed us to defray carrying costs such that there is little to no difference in carrying costs between a high efficiency and a standard performance unit. It's influential in allowing us to make the switch to 60% HE. It also allows us the opportunity to put high efficiency in front of the customer at an attractive enough price point. That drives market demand. If there is little to no difference in the initial costs then high efficiency becomes a determinant; its rare people will go with the less efficient unit."*

> *"Yes in the way I described it is a primary driver in the demand. There are only a few things that a distributor does to sell equipment. You have customer service and sales, price, delivery. And that's what customers are going to use on their decision on what to buy. The biggest factor in the price of the equipment is the rebate. So in the incremental price to go to high efficiency, if the majority of it is covered by the rebate and the payback on energy is 2 years they'll almost always buy it. So the number one factor in selling high efficiency is the rebate. My sales guy can be the greatest but if it's a 10 year payback no one is going to buy it."*

Adjusted Scores -Distributor's scores were adjusted by the evaluation team to apply credit accordingly. The result of the scoring algorithm underwent any necessary adjustments accounting for the verbatim responses that revealed inconsistencies in the scoring. Adjustments were made in both increasing and decreasing directions based on the consistency of scored question responses coupled with the open ended responses. The adjustments made by evaluators decreased the entire program score by 3%.

4.4.3 Applying Weights to NTG Score Algorithm

Below in the results subsection, we present both unweighted and weighted NTG scores. These are defined as follows:

Unweighted Scores - This score was generated by taking the simple average score across all 19 participant distributors.

Weighted Scores - To determine the weighted NTG score, the evaluation team took the influence score and then multiplied it by distributor's share of program savings, then summing. The share of program savings took into account distributors' 3-year average savings claimed from 2010 through 2012. Large participants dominated the total program savings. For example, the lowest share of program savings was less than 1% and the highest share was almost 25%. The majority of participant distributors (84%) each accounted for less than 5% of program savings during this 3-year cycle. In other words the program is made up of a few distributors (13%) who claim a significant share of savings. Distributor's total energy (kWh) and demand (kW) savings as reported by the IOUs (PG&E and SCE) formed the basis of the net to gross weights. Since many (63%) distributors served multiple service territories a single net to gross score was developed using the total savings from SCE and PG&E.

4.4.4 Program Influence on Stocking

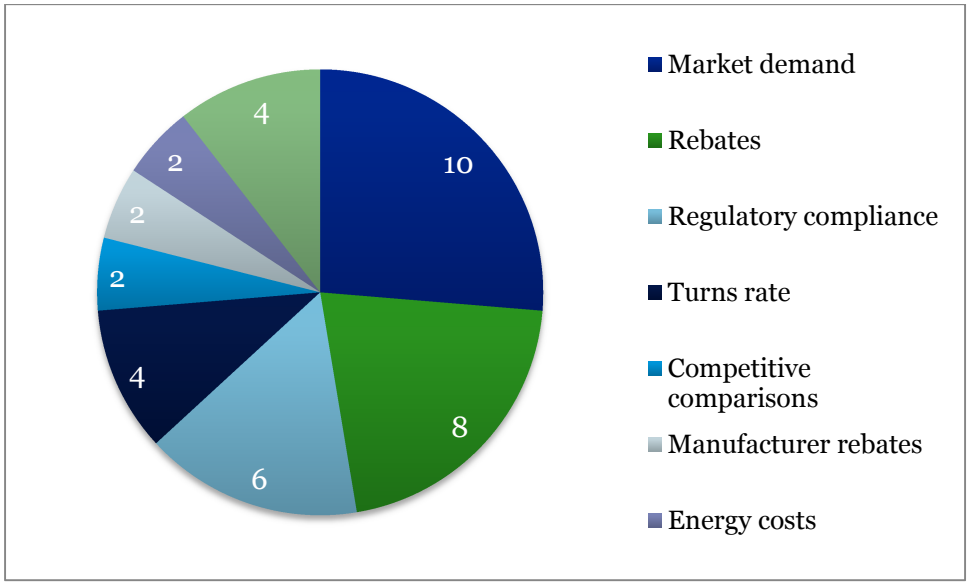
A primary program goal was to influence distributors to stock high efficiency non-residential HVAC equipment. To determine whether the program was successful at meeting this goal, evaluators asked a series of questions about distributor's stocking practices. Given the level of importance that the IOUs have attached to program influences on stocking practices, it was interesting that several (21%) of the distributors do not stock units themselves but rather order equipment directly from manufacturers. From the onset of the survey design the evaluation team anticipated the program would only accept distributors who stocked equipment; this is why the scoring algorithm took into account both stocking and sales.

In most cases, the non-stocking distributors were selling custom equipment that was sometimes very large and therefore could not be kept in-stock. Nearly all of the non-stocking distributors were independent manufacturer's representatives. As previously illustrated these distributors rated energy efficiency important (9 on a 10 point scale). Efficiency is important because these distributors rely on sales staff to sell their products and components. It appears non-stocking distributors can influence their market through sales and design support that incorporates higher efficiency equipment components and/or by directly interacting with design engineers to assist them in their selection process.

Among stocking distributors, the evaluation team asked what factors influenced their stocking decisions. Distributors typically cited 3 or more factors; the number of respondents citing a

given factor is illustrated in Figure 17. As shown, distributors most often stated (10 of 15) that market demand was the primary factor that influenced their stocking of high-efficiency equipment, followed by the rebate (8 of 15) and regulatory compliance requirements (Title 24). The "other" reasons as cited in Figure 17 included: new products, physical limitations of space, cost to carry, and tax rebates. One key limitation of the approach was that for distributors who did stock units, the survey did not determine if there were specific sizes or unit types that were always custom-ordered and therefore there could be little program influence on stocking. One unique spillover effect the program had for a distributor was improving the physical placement of their inventory: *"The accessibility of sales data that includes installation addresses has provided us with the ability to target our stocking on a warehouse by warehouse basis in a way that we didn't have before. Based on this data we have more efficient inventory and more efficient placement of that inventory as the different locations have different size requirements."*

Figure 17: Factors Often Cited as Influential to Stocking among Upstream Distributors (n=15)*



*multiple response

4.5 Upstream NTG Results

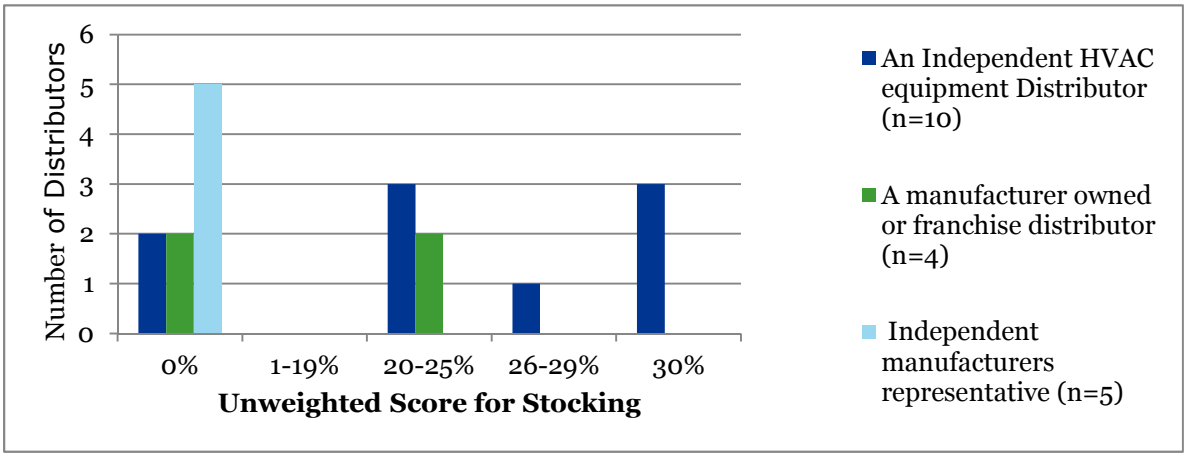
This subsection presents the upstream distributors NTG results for both un-weighted and weighted values.

4.5.1 Un-weighted NTG Results

The evaluation team first reviewed the un-weighted results stocking and sales, respectively, prior to combining the stocking and sales influence with the savings claimed by distributors.

Figure 18 displays the un-weighted results of program influence on stocking by type of distributor. The NTG scores are grouped in bins: 0%, 1-19%, 20-25%, 26-29%, and 30%. (As previously described the evaluation team assigned program attribution for stocking a maximum score of 30% and assigned sales attribution a maximum score of 70%for a total of 100%) To attain the maximum 30% for stocking, respondents must have cited the program as a factor that influenced their stocking practices and given it an influence score of 10.

Figure 18: Un-weighted NTG Results on Stocking by Type of Distributor (n=19)



The average un-weighted score for all distributors, including those that did not stock, was 14% out of a maximum score of 30%[75]. By removing those distributors that do not stock, the average score increased to 18%. As previously described, independent manufacturer's representatives did not stock. One-third of stocking distributors claimed the program had no influence on stocking, and most cited low or no program influence on sales.

As for why the program did not change distributors stocking and sales, two distributors explained they had ineffective marketing campaigns to sell program qualified high efficiency equipment.

One distributor found the promotions they used simply did not generate sufficient demand to change their stocking practices (<5% of their customers took advantage of their promotions) and have since given up on promotions and do not anticipate any changes to stocking practices for high efficiency units.

- Distributor B – "Prior to us taking the money off at the front end we relied on selling jobs that were already specified as high efficiency. Our marketing approach to offer the rebate

[75] Score is determined as 30% assigned to stocking and 70 assigned to sales for a total of 100%. The full equation is as follows: stocking [5% + (0-10*0.25)%] + sales [5% + (0-10*0.65)%] =100%.

once we earn our money from the utility never really took off. If the customer asked for it we would sell it but we were not upselling any equipment then."

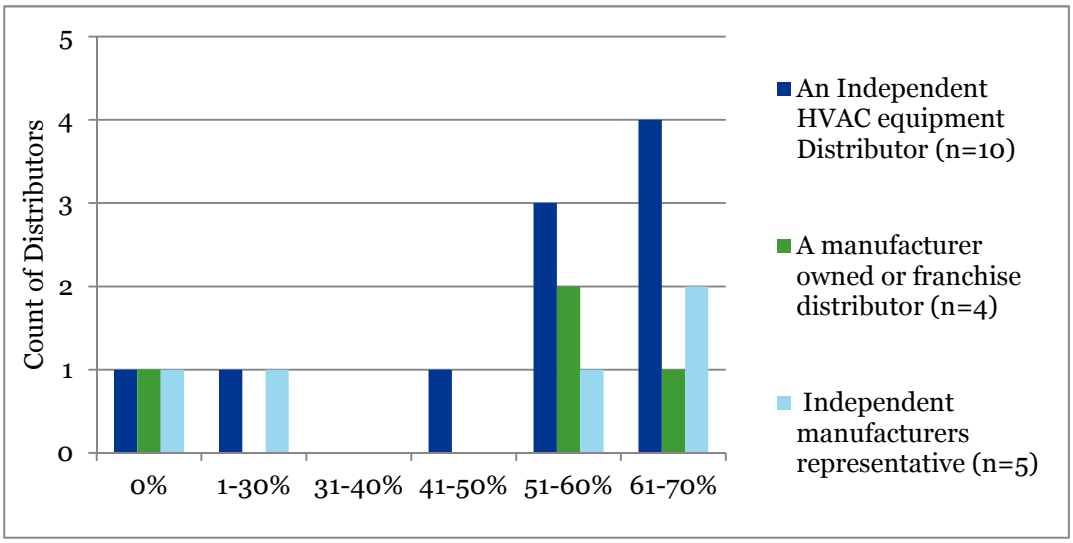
- Distributor D – *"There was a lack of focus; we are at the mercy of the customer and what the customer wants. If a customer says they want a 13 SEER that's what I'm going to give them and that's what the majority of them want."* DNV GL: *"You didn't have a strategy to upsell correct?"* Respondent: *"Right. There were a couple of promotions where we offered a discount if the customer bought a 14-16 SEER unit but in my opinion it was not successful; of the entire customer base maybe 5% took advantage of that promotion."*

A different distributor explained that after changing the way the rebates were provided to their customers they significantly increased their high efficiency stocking volume by a measure of 7,500 high efficiency units, which over time influenced the volume of high efficiency units they sold. This change came only after they tried other approaches that did not work. (It should be noted that while a change occurred from a per-ton rebate to matching the cost of a lower-efficiency unit, no program credit was cited for this evaluation cycle because the change occurred in 2013. The findings suggest low-rebate-claiming distributors could benefit from program sponsored coaching or customized methods to market direct sales towards rebate qualified products.)

The team repeated a similar set of questions to parse out factors that influence the sale of high efficiency program-qualified equipment. Figure 19 displays un-weighted results of program influence on sales by type of distributor. The scores were grouped into bins of 0%, 1-30%, 31-40%, etc. The average un-weighted score among all respondents was 47% out of a total of 70%[76].

[76] Recall again, the score is determined as 30% assigned to stocking and 70% assigned to sales for a total of 100%. The full equation is as follows: stocking [5% + (0-10*0.25)%] + sales [5% + (0-10*0.65)%] =100%.

Figure 19: Un-weighted NTG Score on Sales by Type of Distributor (n=19)



At one or more points in the survey, distributors cited how the rebates were used. Low-scoring distributors were often non-stocking distributors with a long sales cycle. They cited that they paid incentives to commission-based sales staff, "tracked rebates" (which we would interpret as relying on naturally occurring high efficiency sales), choosing not to lower high efficiency equipment purchase price and/or ineffective promotions.

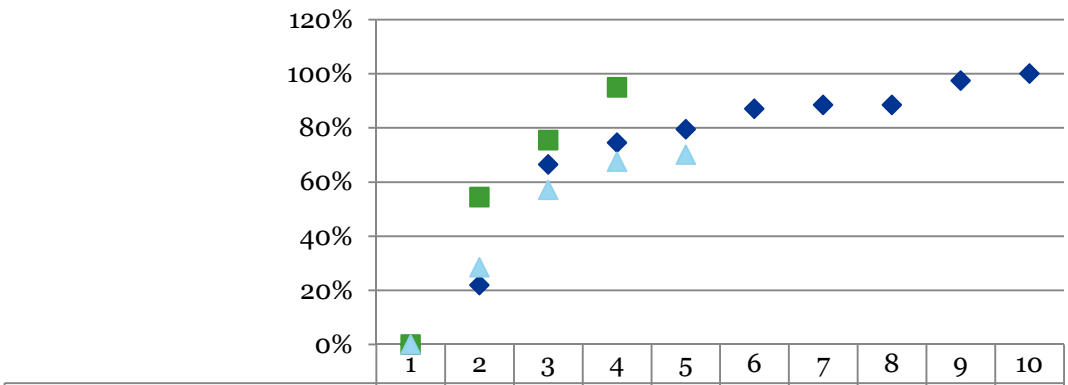
Distributors with long sales cycles (primarily due to custom-built equipment) may benefit in a different rebate framework or distribution model such as a reservation system. Due to a sales cycle that could span months or years, some distributors cited the uncertainty of claiming a rebate as reason for not incorporating the rebate into their purchase price. The uncertainty of the rebate availability and uncertainty of obtaining installation address information (a requirement) were both challenges for distributors.

- Distributor P – *"[Utility] has been good about saying there is limited funds; we never count on [the rebate] when we're quoting a project because we don't know when it will close/ship. Our sales cycle is lengthy; it could be several years long before we ship any equipment. We don't know whether the rebates will be there or have money."*
- Distributor B – *"We can't guarantee the rebates will be available when we bid the job nor can we guarantee we will get the necessary information to submit the rebate. Occasionally a rebate could be used on an immediate replacement job but we really don't use them on most jobs."*

Distributors with high scores generally used rebates to generate demand; the high-efficiency market had to be developed by incorporating rebates into price offerings, or by offering a high-efficiency unit at the same price as a lower-efficiency unit.

Prior to weighting and final adjustment, the simple average overall program score was 61%. The individual overall scores by distributor are illustrated in Figure 20.

Figure 20: Un-weighted Individual NTG Scores (n=19)



	1	2	3	4	5	6	7	8	9	10
◆ 1-An Independent HVAC equipment Dist	0%	22%	67%	75%	80%	87%	89%	89%	98%	100%
■ 2-A manufacturer-owned or franchise distributor	0%	55%	76%	95%						
▲ 3- Independent manufacturers' representative	0%	29%	57%	68%	70%					

4.5.2 Weighted and Adjusted NTG Results

The evaluation team determined the final net-to-gross results using the methodology described above in Section 4.4. The team tabulated individual scores and weighted the results of individual respondents using the proportion of program savings each respondent accounted for. (Energy and demand savings reported by the IOUs formed the basis of the net to gross weights.) The team made a final adjustment based on the open-ended responses to the survey (adjustments are described in detail in Appendix D). The goal of the final adjustment was to catch any inconsistencies in the responses and adjust the score up or down if a distributor's algorithm-based score did not line up with their responses to the open-ended questions.

Table 35 contains the program's un-weighted and savings-weighted (kWh and kW) net-to-gross scores. The un-weighted NTG score was 61%, and the energy-savings and demand-savings weighted scores were both80 %. Weights were determined by distributor's share of total kWh and kW savings.

The table shows, by distributor, the results of the scoring NTG algorithm and adjustments made by the evaluation team based on verbatim responses (supportive evidence) as described in Appendix D. The team made adjustments in both increasing and decreasing directions based on the consistency of scored question responses with the open ended responses. All adjustments

were independent of the savings weights. The overall adjustments decreased the programs un-weighted scores by 3%: from 61% to 58%.

The final adjustments included:

- **Four distributors** whose scores were reduced (none of which received full program credit before the adjustments were applied); reductions applied to distributors of all business models.
- **Five distributors** whose scores were increased (all of which whose scores were already high (75% or higher) before the adjustments). Only independent HVAC distributors' scores increased.
- **Ten distributors** whose scores were unchanged.

Savings values were based on the 2010-12 tracking data for PG&E and SCE. Since numerous distributors (63%) serve both service territories, the team developed a single net-to-gross score using the total savings from the two programs. The SDG&E program had relatively small levels of savings that were not assigned an Upstream flag in tracking data, but measures that indicated packed or split systems and mentioned Upstream in the name also receive this net-to-gross adjustment, but these measures were not considered in the weights as they could not be directly assigned to the interviewed distributors.

The evaluation team estimated the final net-to-gross as 0.80 for energy savings and 0.80 for demand reduction. The distributors with large shares of program savings reported the most program influence on high efficiency equipment sales. These are slightly less than the ex-ante net-to-gross of 0.85. As a comparison, the results are also less than the scores reported in the 2006-08 impact evaluation, which had values greater than 0.9.

Table 35: Net-to-gross Results by Distributor

Distributor	Un-weighted Original NTG Score	Un-weighted Adjusted NTG Score	Energy Savings Weight (kWh)	Demand Savings Weight (kW)	Energy Savings-Weighted NTG Score	Demand Savings-Weighted NTG Score
A	0%	0%	1.8%	1.7%	0.0%	0%
B	0%	0%	0.1%	0.1%	0.0%	0%
C	0%	0%	0.2%	0.3%	0.0%	0%
D	22%	0%	0.2%	0.2%	0.0%	0%
E	29%	0%	2.8%	2.7%	0.0%	0%
F	55%	55%	22.0%	19.7%	12%	11%
G	57%	57%	0.5%	0.6%	0.3%	0.3%
H	67%	74%	0.2%	0.3%	0.1%	0.2%
I	68%	0%	0.7%	0.9%	0.0%	0.0%
J	70%	70%	0.5%	0.4%	0.0%	0.3%
K	75%	100%	18.4%	16.5%	18%	17%
L	76%	76%	15.2%	14.9%	12%	11%
M	80%	80%	0.2%	0.2%	0.1%	0%
N	87%	100%	0.7%	1.0%	1%	1%
O	89%	100%	3.2%	4.3%	3%	4%
P	89%	100%	5.5%	7.4%	6%	7%
Q	95%	85%	2.0%	2.7%	2%	2%
R	98%	98%	19.2%	17.6%	19%	17%
S	100%	100%	6.8%	8.6%	7%	9%
Total	**61%**	**58%**	**100.0%**	**100.0%**	**80%**	**80%**

The results by type of distributor provide some addition insights. As illustrated in Table 36, the program is getting very little savings or program attribution from independent manufacturers' representatives. The manufacturer-owned and franchise distributors reported less influence on stocking driving the stocking score and overall score.

Table 36: Adjusted Weighted Scores for Stocking and Sales

Type of Distributor	Stocking Score	Sales Score	Overall Score	Proportion of Program Savings
Independent HVAC equipment distributor	16.2%	37.5%	53.7%	56.1%
Manufacturer-owned or franchise distributor	4.1%	21.3%	25.4%	39.2%
Independent manufacturers' representative	0.0%	0.6%	0.6%	4.7%
Total (Maximum Potential Total)	20.3% (30%)	59.4% (70%)	79.7% (100%)	100%

The final net to gross ration was applied to gross energy and demand savings for 2010-12 programs. Table 37 shows the SCE program represented a majority of the statewide savings for the Upstream program.

Table 37: Upstream Net-to-Gross Ratio and Net Savings

IOU	Gross Energy Savings (kWh)	Gross Demand Savings (kW)	Net-To-Gross Ratio	Net Energy Savings (kWh)	Net Demand Savings (kW)
PG&E	17,705,130	9,100	0.80	14,164,104	7,280
SCE	64,368,795	21,952	0.80	51,495,036	17,562
SDG&E	560,854	203	0.80	448,683	162
TOTAL	82,634,780	31,255	0.80	66,107,824	25,004

4.6 Conclusions and Recommendations

The following conclusions and recommendations are based upon evaluators' observations and participating distributors input.

4.6.1 Conclusions

- The largest distributors in the state of California are active participants in the Upstream program. (This information was confirmed through responses from fellow distributors when asked who the largest distributors were.)
- The program attracted a variety of distributors, many of whom have non-competing product offerings.

- Approximately ¾ of distributors serve markets in states other than California[77]. None were aware of nationwide Upstream programs and few were aware of mid or downstream programs at the national level.
- How distributors utilize Upstream rebates is discretionary. The program in its current design allowed distributors (if they so choose) to steer market demand towards high efficiency equipment by lowering equipment costs, by covering equipment carrying costs, or by increasing stocking and sales attention given to high efficiency units.
- Non-stocking distributors had a very small share of the claimed rebates and had less opportunity to use them due to uncertainty of rebate availability because of long sale cycles.
- One resourceful distributor, with multiple distribution centers in California, found by analyzing the program's required data they were able to more efficiently manage their stock placement. Knowledge sharing of using program-required data such as this could be marketed to current and prospective distributors as a way to more efficiently manage their supply.
- There was some evidence of distributors enhancing their service offerings (they were able to hire more staff, take more time to communicate the lifecycle benefits to customers, etc.). (See example citation in Appendix D under "Distributor P")
- The program obtained a relatively high weighted NTG score (0.80) because a few distributors with significant market shares of high efficiency equipment and program rebates rated the program as influential, while in contrast the adjusted unweighted score for all distributors was just 58%.
- There were no program process-related questions included in the survey, but we did find participants complimenting the program's simplicity. Although for some distributors, the required unit-level installation data posed a challenge, as their customers (contractors) generally do not provide distributors this information. (This issue was not the case for distributors who required the information for warranty purposes.)
- Based on responses to the questions on sales volume by tier levels (examined more closely in Market Effects Work Order 54), we found that most sales occur in Tier 0

[77] The program tracks and provides addresses where units are installed and there is a program inspection process. Only units installed in California are claimed and verification is required for rebates.

(standard efficiency) and Tier 1 categories.[78] The lack of sales above Tier 1 could be due rebate levels and/or due to manufacturer's limited product offerings. [79].

- As identified in the sales volume questions (examined more closely in Market Effects Work Order 54), for a limited number of distributors, standard efficiency (Tier 0) still makes up the vast majority of their sales[80].
- We found to reap the program benefits, distributors must be willing to take risks by stocking more high efficiency (HE) units then the demand is currently requesting with the expectation they can direct demand toward high efficiency units.

4.6.2 Recommendations

The evaluators determined that the program succeeded, based on the savings weighted net to gross values. The first recommendation may apply to all participants and would increase gross savings. The other two recommendations target the lower volume distributors that had lower individual net to gross scores, but these enhancements may have marginal impact on program results. Note that the evaluators did not test these recommendations for cost effectiveness.

The program may want to re-evaluate incentive caps and rebate levels for higher efficiency equipment above Tier 1. The program may want to expand to ultra-large tonnage[81] (in excess of 60 tons) and offer larger rebates for the higher tier levels[82] [83] [84]. The larger units may not benefit from any influence on stocking, but rebates could influence sales of high efficiency large units. Based on the data collected from the sales volume questions, distributors' sales primarily occur in Tier 0 (non-program qualifying) and tier one, the first level

78 Baseline Characterization Market Effects Study of Investor-Owned Utility Residential and Small Commercial HVAC Quality Installation and Quality Maintenance Programs in California ,February 2015. Section 2.4, pg. 19 11"The number of tiers and tier standards, defined based on minimum unit SEER, EER, or IEER ratings, vary by HVAC unit type and capacity. Almost two-thirds of single-phase air-cooled HVAC units (60%) sold in 2011 and 2012 fall into Tier 0 and do not meet minimum program standards for this type of unit. Most of the rest of this unit type (40%) are rated at Tier 1, the lowest qualifying efficiency level for single-phase air-cooled equipment. At the other end of the spectrum, most ductless multi-split units sold are higher-efficiency units with over three-quarters (78%) of units sold rated at Tier 2 and most of the remaining units rated at Tier 1. Air-cooled three-phase and-water cooled units were sold over a wide range of efficiency levels from Tier 0 to Tier 4."

79 "Distributor Q: "Tier one, if you get into the higher tiers you get into a very select limited product offering for any manufacturer. The tier one is what sell the most because the price jump from tier zero to a tier one is an increase but not an overwhelming increase so it makes sense for the customers to do purchase tier one vs. two, three, and four."

80 Distributor A: "Our greatest increase is in the standard baseline equipment."

81 Distributor J – "One of the things I would love to see done is to create additional tiers for the larger tonnage equipment that would incentivize the higher efficiency (larger than 60 tons). We have designed our product lines to beat these efficiencies already."

82 Distributor O – "They have come out with more tiers of higher efficiency between 2 and 3 and 3 and 4 they have really racked up the efficiency but the dollars that they offer for that efficiency increase is not bridge[ing] the gap to get to that efficiency for those top tier levels."

83Distributor N – "The rebate has caused us to have more high efficiency then less. The highest tiers are the most expensive and slowest selling pieces and we had a whole bunch because we were buying blindly, but we have been doing a much better inventory analysis and metrics and we may have 2 years vs. 60 days so we would cut back on those very high efficiency unit."

84 Distributor I: "I don't know that the programs are high enough to offset participation to greater efficiency levels. We will stock whatever is selling. It's how we run the business. We tend to stock the same things. We probably stock a little higher with high efficiency because with standard efficiency we can always give them the next best. If you are out of stock on the best you don't have anything else to give them. So our tendency is less turns of inventory on the high efficiency materials. Standard efficiency accounts for approximately 60% of the inventory and 70% of the volume."

of participation. Evidence of this was identified through the sales-volume questions as reported in the Market Effective WO54.

Individual marketing support may help distributors, particularly those who are less successful at claiming rebates. It appeared some distributors don't know how to "go to market" with the rebate. Some of the challenges included obtaining unit installation information from contractors and how to market a rebate-discounted unit. Distributors may benefit from a marketing or inventory analysis and sales plan. The program should not assume distributors necessarily know how to use the rebates to their advantage, particularly given some may be risk averse. Marketing to increase demand for the highest tier of efficient equipment could create more demand for these units.

Distributors who have long sale cycles or custom built (non-stocked) equipment would likely benefit in a reservation system or some guarantee, such as bridge funding. The absence of a guarantee[85] [86] for a limited number of distributors was cited as a challenge. Note that this assumes different program logic and there is no stocking barrier, only a cost barrier to install high efficiency systems that are custom built.

85 Distributor B – "We can't guarantee the rebates will be available when we… bid the job nor can we guarantee we will get the necessary information to submit the rebate. Occasionally a rebate could be used on an immediate replacement job but we really don't use them on most jobs."

86 Distributor J – "Certainly we don't advertise the rebate to our customers because you know the program incentivizes us to promote those products and we do in many cases pass on those savings to make jobs more viable but we don't want that to be particularly visible by the customer because it's not a 100% guarantee that we are going to get the incentive so we'll sometimes hedge our bets with it but we don't advertise that to our customers."

5. Packaged Rooftop Unit Laboratory Testing Preliminary Results

The evaluation team conducted laboratory tests to evaluate field measurement instrument accuracy, economizers, and a dual-compressor commercial roof top unit (RTU). Tests were performed at Intertek Testing Services, Inc., Plano, Texas. The laboratory is AHRI-certified. Additional laboratory tests continue currently and will be performed in the future on packaged units from other manufacturers. The team initially conducted tests in a vertical configuration to simulate field conditions. Subsequent tests and AHRI tests were performed horizontally for safety and time constraints. R-22 systems were tested as part of this effort because they currently dominate systems in the CQM program. Additionally, new R-22 systems were sought out for testing while a few were still available. Tests on R410a systems are planned.

The evaluation team tested a 7.5-ton two-compressor commercial packaged unit with an economizer at varying damper positions, refrigerant charge, and airflow.[87] The team chose the 7.5-ton unit for testing because its manufacturer family of units[88] has 15%program market share,[89] higher than any other manufacturer family of units. The 7.5-ton unit has six fixed-orifice metering devices, one on the header of each circuit. The unit was fully instrumented and tested in an AHRI-certified laboratory per ANSI/AHRI Standard 210/240-2008 (cycling tests) and ANSI/AHRI 340/360-2007 (efficiency tests). The test setup conformed to ASHRAE Standard 37. Most tests were performed at a range of outside dry-bulb and wet-bulb temperatures found in AHRI standards and current and past CPUC field studies (i.e., 55/51 °F, 60/54 °F, 65/57 °F, 70/60 °F, 82/68 °F, 95/75 °F, and 115/80 °F) to simulate various diurnal temperature swings across the California coastal, inland, mountain, and desert climate zones.

Based on discussions with the laboratory staff and the experience of the EM&V team, the laboratory tests with actual cabinet leakage and functioning economizers are the first of their kind. These tests provided critical new findings on the diagnosis of system faults and the efficiency impacts of repairs. In future program cycles, the evaluation team will perform additional laboratory tests on packaged units from other manufacturers.

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[87] These tests are in progress. A ton is a unit of cooling capacity equivalent to 12,000 British thermal units (Btu) per hour. The Btu is the energy required to raise one pound of water one degree Fahrenheit.

[88] A family of units includes units of multiple sizes with the same initial characters in its model number and all of the units are covered in the same installation and service manual.

[89] Program market share is based on 2006-08 and 2010-12 tracking data. The general population includes more small units.

Critical findings from laboratory testing with an economizer include:

- The impact of economizers on system efficiency is significant and unexpected. All tests show that even optimally adjusted systems with an economizer perform significantly lower than their expected system efficiency.

- The diagnosis and adjustment of charge is difficult to achieve in the field since both unit total airflow and the presence of outdoor air intakes affect the reliability of fault detection diagnostics (FDD). This finding led to the field work described under Commercial Quality Maintenance of refrigerant charge diagnostics compared to a charge weigh out/weigh in procedure.

- The test results demonstrate that eliminating typical unit air leakage can be a more reliable measure to improve cooling efficiency than what is typically obtained from refrigerant-side repairs. See the commercial quality maintenance program recommendations presented in chapter two on additional field requirements and considerations for this strategy.

5.1 Role of Lab Testing in Impact Evaluation

Understanding the efficiency impacts of faults can be challenging. In reviewing the results, the expectation should be that the efficiency of all units will be relatively lower at higher outdoor and indoor temperatures. Faults may have different impacts at different conditions, but generally should reduce efficiency relative to optimal at a given condition. The effects of outdoor and indoor conditions and faults on efficiency are non-linear and become more complex when combined, requiring empirical testing to derive efficiency impacts. Once known, the efficiency impacts can be used in engineering analyses to estimate energy and demand impacts of faults.

The field measurements needed for program impact evaluations have physical constraints and other inherent limitations, while laboratory testing relieves the limitations to the greatest extent possible. The testing laboratory controls all of the temperature conditions and faults and uses sensitive instrumentation to measure unit performance. The influence of system issues on the unit can also be eliminated. In the field however, the weather and occupants control the conditions, faults are diagnosed but are not known directly, and instrumentation must sacrifice sensitivity for reliability and cost per sample point. The evaluation found that detailed laboratory testing became essential to understanding the findings from fieldwork.

5.2 Out-of-Box Factory Charge, Optimal Charge, and Diagnostic Tests

Out-of-box tests were conducted to evaluate rated and field efficiency based on factory charge, optimal charge, and diagnostic conditions. Test results are for a unit placed on a platform to simulate rooftop unit conditions. These tests were all performed under standard AHRI rating conditions. Economizers were not installed. Lab results and field findings from this study indicated that adjustments for air flow and supply fan power are relevant for DEER assumptions and that using values obtained in the AHRI rating process are misleading. These tests were all performed under standard AHRI rating conditions without economizers. Measured efficiency increased by 7% at the "A" rating point when manufacturer's charging diagnostics were used to establish "correct" charge levels in lieu of nameplate charge values.

Table 38 provides the rated EER versus "out-of-box" factory charge and laboratory optimal charge for 2-stage cooling (i.e., both compressors), 1-stage cooling, no economizer, and airflow of 3,000 standard cubic feet per minute (CFM).[90] The out-of-box factory charge was 7.6 pounds (lbs.) in circuit 1 (C1) and 8.1 lbs. in circuit 2 (C2). The laboratory optimal charge was 8.59 lbs. in C1 and 10.35 lbs. in C2. The optimal charge was established using manufacturer charging charts where target suction temperature (ST) is a function of suction pressure and outdoor air temperature as shown in The total static pressure, change in pulley size, and cabinet sealing represent conditions allowed in rating tests that are not feasible in field conditions. Additional testing for faults was based on more typical field conditions.

Figure 21 (Carrier 2005)[91]. The total static pressure, change in pulley size, and cabinet sealing represent conditions allowed in rating tests that are not feasible in field conditions. Additional

[90] EER is the cooling capacity in thousand Btu per hour (kBtuh) divided by total air conditioner electric power (kW) including indoor fan, outdoor condensing fan, compressor, and controls. This is the manufacturer AHRI rating.

[91] Charging chart conditions presume 400 CFM/ton at 0.25 in WC static at near sea level conditions

testing for faults was based on more typical field conditions. The measured ST must be within ±5°F of the target ST. These tests were all performed under standard AHRI rating conditions without economizers. Measured efficiency increased by 7% at the "A" rating point when manufacturer's charging diagnostics were used to establish "correct" charge levels in lieu of nameplate charge values.

Table 38: Rated EER vs. Tested EER for Out-of-Box Factory and Laboratory Optimal Charge – Vertical Flow Configuration

Test	Manufacturer Rated EER	Out of Box Factory Charge EER	Laboratory Optimal Charge EER
Verification "A" Test Sealed Cabinet 10" Pulley	11.0	9.6	
2 Stages "A" Test 95°F OD 80/67°F ID No Seal, 7" Pulley	11.0	8.4	9.0
2 Stages "B" Test 82°F OD 80/67°F ID No Seal, 7" Pulley	13.5	9.8	10.9
1st Stage "A" Test 95°F OD 80/67°F ID No Seal, 7" Pulley		6.0	6.5
1st Stage "B" Test 82°F OD 80/67°F ID No Seal, 7" Pulley		6.8	8.0

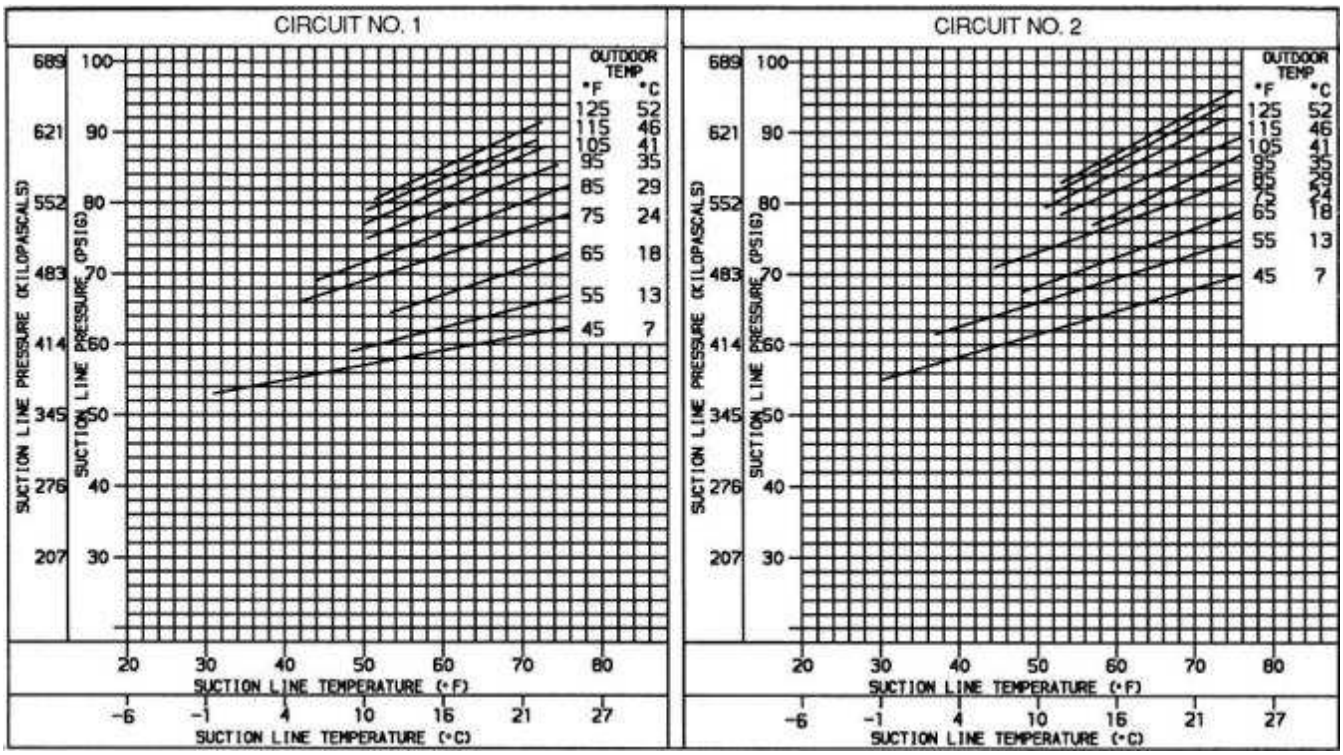
Source: Intertek, Plano, TX
We were able to replicate the manufacturer EER within the allowable tolerance when tested with a horizontal flow setup.

Indoor (ID) conditions were 80°F dry-bulb/67°F wet-bulb and outdoor (OD) conditions were 95°F dry-bulb for the "A" tests and 82°F for the "B" tests. The verification "A" test was performed with cabinet seams taped to eliminate leakage, 10-inch diameter motor-drive pulley, A55 V-belt, and 0.25 inches water column (in WC) total static pressure to reduce blower fan power and achieve maximum EER per AHRI test protocols.[92] The AHRI standards consider verification tests to meet claimed ratings if they are within 5%. The out-of-box verification "A" test with sealed cabinet and 10 inch pulley was 13% less efficient than the manufacturer-rated EER. The out-of-box factory and optimal charge tests with no seal, 7 inch pulley[93], and A49 V-belt were 18% to 27% less efficient than the manufacturer-rated EER. The total static pressure, change in pulley size, and cabinet sealing represent conditions allowed in rating tests that are not feasible in field conditions. Additional testing for faults was based on more typical field conditions.

[92] The inch of water column is defined as the pressure exerted by a column of water of 1 inch height at 39°F (4°C) at standard acceleration of gravity. 1 inWCin. WC is approximately 0.0361 pounds per square inch (psi) or 249 Pascals at 0°C.

[93] The 7 inch pulley was supplied with the unit.

Figure 21: Manufacturer Charging Charts for Dual-Compressor Unit (Carrier 2005)



Tests of refrigerant charge diagnostic conditions versus economizer outdoor air damper position for C1 and C2 are provided in Table 39. Tests were conducted at 2500 CFM airflow. The charge level corresponding to maximum efficiency was 13% and 28% greater than factory charge for C1 and C2, respectively[94]. The superheat (SH) protocol was based on the same manufacturer superheat table used in the Title 24 RCA protocol (CEC 2008).[95] Diagnostics for C1 were

[94] Charge was increased from factory charge up to 60% overcharge incrementally. The optimal charge was determined after review efficiency results for the incremental data. An optimal charge was not sought for all fault conditions by the evaluation team given the iterative process required.

[95] In the 2010-12 statewide programs the service technicians could use any method and Title-24 verification procedures were observed to be used in the absence of program protocols.

acceptable for all damper positions since ΔSH and ΔST are within ±5°F. Diagnostics for C2 indicated undercharge (i.e., "fail") for all outdoor air damper positions and both protocols (ΔSH and ΔST were greater than +5°F). C2 received more warm outdoor air and less cool return since it is above C1 and more aligned with the outdoor air dampers. This increased the cooling load on C2 relative to C1, as indicated by higher actual superheat and suction temperatures (pressures). The diagnostic numbers in italics failed, while other numbers indicate pass diagnostics.

Table 39: Refrigerant Charge Diagnostics versus Outdoor Air Damper Position

Test	OA %	Outdoor DB/WB °F	Indoor DB/WB °F	Mfr ΔST C1	T24 RCA ΔSH C1	Mfr ΔST C2	T24 RCA ΔSH C2
Laboratory Optimal Charge with No Economizer	4.5	95/75	80/67	-3	2	-1	3
Closed Economizer Dampers (Rated at 10 CFM/ft^2)[96]	15.4	95/75	75/62	1	2	*25*	*27*
Economizer Dampers Open 1 Finger "10% OA"	19.5	95/75	75/62	-1	1	*26*	*26*
Economizer Dampers Open 2 Fingers "20% OA"	23.2	95/75	75/62	-1	1	*26*	*28*
Economizer Dampers Open 3 Fingers "30% OA"	30.1	95/75	75/62	-1	1	*26*	*29*
Economizer Dampers Fully Open	62.1	95/75	75/62	-2	1	*26*	*30*

Source: Intertek, Plano, TX

Table 40 provides laboratory test results of system[97] efficiency, designated as EER-star (EER*) versus refrigerant charge and outdoor air damper position for the 7.5-ton two-compressor packaged unit. Relative EER* is the cooling capacity in thousand Btu per hour (kBtuh) supplied to the space divided by total air conditioner electric power (kW) including indoor fan, outdoor condensing fan, compressor, and controls. This is not the manufacturer EER rating which includes the same power inputs, but only includes the coil load and would not consider outside air as an inefficiency. Compared to the approximate (~) factory charge, the +20% charge (laboratory optimal) improved efficiency by 8% to 13% for closed damper, and by 9% to 39% for 1-finger open. Under charge of -20% reduced efficiency by 27% to 55% for closed dampers and 27% to 95% for 1-finger open. Tests of +60% overcharge relative to factory yield diagnostics within manufacturer ST specifications for both. However, +60% overcharge yielded negligible efficiency improvements of -8% to +2% when compared to +20% overcharge laboratory optimal.

[96] Closed damper outdoor air fraction is approximately 15% consistent with ASHRAE 62.1.

[97] The system efficiency is that seen by the space and differs from the appliance efficiency obtained in AHRI tests. The significant difference is that O/A (either through dampers or cabinet leakage) is treated as a system inefficiency rather than a space load.

Table 40: System Efficiency versus Refrigerant Charge and Outdoor Air Damper Position

Test	Refrig. Charge c1/c2 (lb)	Airflow (CFM)	EER* 82/68°F OD 75/62°F ID	EER* 95/75°F OD 75/62°F ID	EER* 115/80°F OD 75/62°F ID
No Economizer AHRI Rated Efficiency	7.6/8.1	3000	12	10	7.5
~Factory Charge Closed Damper	7.07/8.73	2500	7.9	5.3	2.9
~Factory Charge 1-Finger Open		2500	7.5	4.4	1.8
-20% Charge Closed Damper	5.55/7.11	2500	5.8	3.3	1.3
-20% Charge 1-Finger Open		2500	5.5	2.3	0.1
+20% Charge Laboratory Optimal Closed Damper	8.59/10.35	2500	8.6	6.0	3.2
+20% Charge Laboratory Optimal 1-Finger Open		2500	8.2	5.1	2.5
+40% Charge Closed Damper	10.11/11.97	2500	8.7	6.0	3.2
+40% Charge 1-Finger Open		2500	8.3	5.2	2.2
+60% Charge Closed Damper	11.63/13.59	2500	8.7	5.8	2.9
+60% Charge 1-Finger Open		2500	8.4	5.1	2.0

Source: Intertek, Plano, TX, Factory charge tests with economizer are pending.

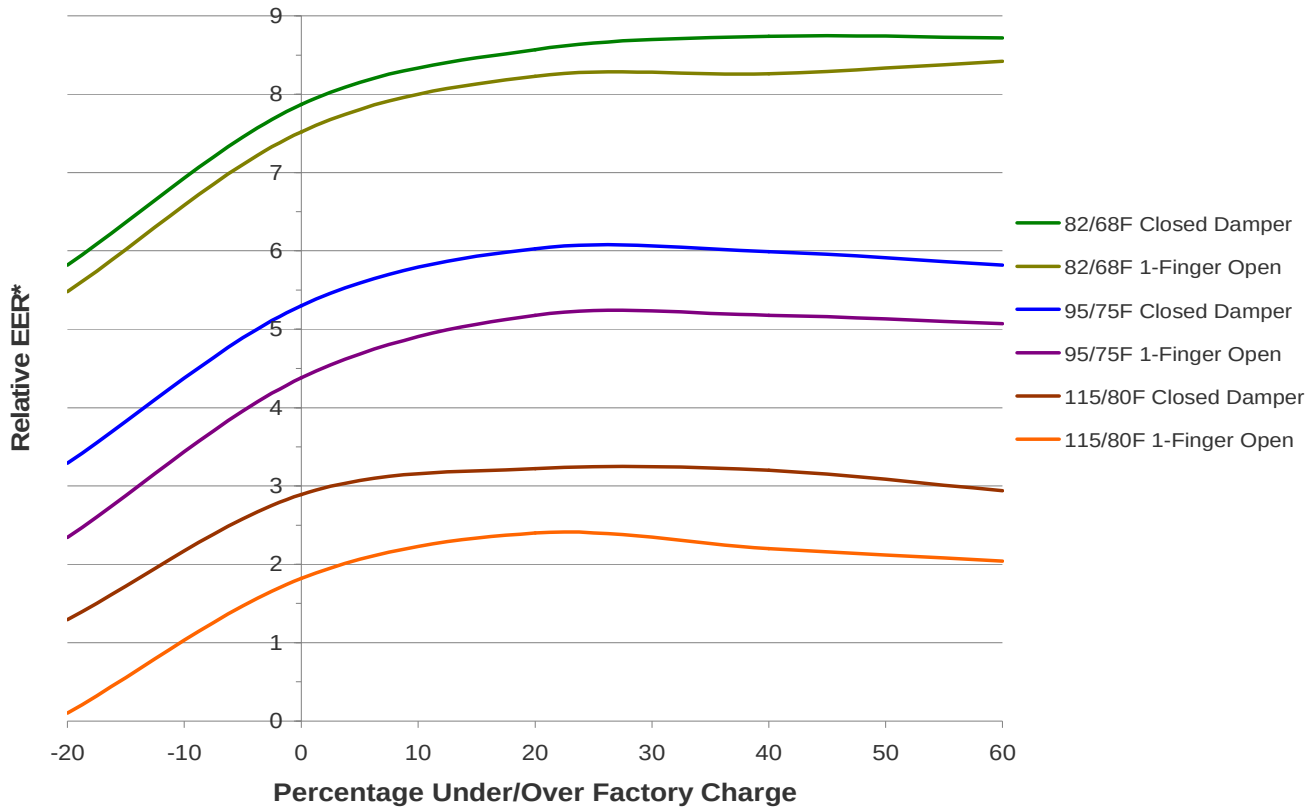
Outdoor air damper position is important for FDD, especially for multiple circuits. The efficiency-optimal charge is difficult to achieve in the field since the economizer should be replaced with a panel to eliminate outdoor air coming into the unit and allow an accurate measurement of coil entering temperature. Technicians must be careful to follow manufacturer's charging charts when adding refrigerant to a fixed-orifice system since overcharging can cause liquid refrigerant to flood the compressor at startup or when refrigerant incompletely vaporizes in the evaporator and enters compressor during operation.[98] Repeated flooding during normal off cycles or excessive flooding during steady-state operation can dilute oil in the compressor and cause inadequate bearing lubrication and premature failure.[99] Ultimately, factory charge is assumed to provide the best value, which is close to optimal efficiency and eliminates potential liquid flooding. It can reliably be achieved by evacuation and re-charge using a refrigerant scale, but the use of diagnostic readings could not establish factory charge via diagnostic readings and two typical protocols for the unit tested.

[98] Tomczyk, J. 1995. Troubleshooting and Servicing Modern Air Conditioning and Refrigeration Systems. ESCO Press. Mt. Prospect, Ill.: Educational Standards Corporation.

[99] Emerson 2010. AE-1280 Application Guidelines for Copeland® Compliant Scroll Compressors (ZR*1 Models). Emerson Climate Technologies. 1675 West Campbell Road, Sidney, OH 45365.

These tests show that even optimally adjusted systems with an economizer don't perform anywhere close to their expected system efficiency. Outside air that is brought in for ventilation requirements is an appropriate unit load, but unintended leakage acts an efficiency loss. Figure 22 shows laboratory test results of relative EER* versus percentage under/over factory charge for varying damper positions and outdoor drybulb/wetbulb temperature conditions. The -20% factory charge tests indicated a -26% efficiency impact at 82/68°F, -38 to -47% impact at 95/75°F, and -55 to -95% impact at 115/80°F. Increased unintended outdoor airflow through an economizer reduced system efficiency across all charge conditions. The impact was greatest at the hottest outdoor conditions. The +20% overcharge tests (i.e., laboratory optimal) indicated an efficiency improvement of 9% to 14% with closed dampers and 9% to 32% improvement with 10% open damper setting. The 40% to 60% overcharge tests indicated negligible or negative impacts on efficiency of +2% to -8% depending on damper position. These test results illustrate the challenge associated with trying to improve efficiency with refrigerant charge adjustments. Units serviced in a program might already be slightly overcharged, and simply adding more charge can reduce efficiency. The field evaluation found many units were in fact overcharged after service, and as stated above, overcharge can lead to compressor flooding and damage. The test results demonstrate that reducing unintended air leakage can be a more reliable measure to improve cooling efficiency. In the results presented, the underlying cause for overcharge insensitivity is the metering device used in the system. The metering device for the particular manufacturer produced results similar to a thermostatic expansion valve (although it operates differently) which also mitigates the impact of overcharge on system efficiency.

Figure 22: Relative EER* versus Percentage Under/Over Factory Charge for Varying Damper Positions and Outdoor DB/WB Temperature Conditions



5.3 Impact of Economizer Damper Position and Airflow

Outdoor airflow through economizer or make-up air dampers is not measured by program technicians and not included in efficiency tests used to rate packaged units. The following "rule-of-thumb" is assumed by most technicians: closed dampers 2% outdoor air (OA), 1-finger 10% OA, 2-fingers 20% OA, 3-fingers 30% OA, and fully open 100% OA.[100] Approximately 74% of observed units in the programs after maintenance had economizer or make-up air dampers set to one or more fingers open after maintenance was completed. Observations at a post-maintenance site with small packaged units found 75% of make-up air dampers fully open. Typical as-found conditions varied, but closed dampers were the most common for the pre-maintenance baseline.

[100] One-finger open is approximately 0.7 inches – typical finger width (1.8 cm), 2-finger is 1.3 inches (3.3 cm), and 3-finger is 2 inches (5.1 cm).

Minimum outdoor air damper position can have a significant impact on energy efficiency. Table 41 provides laboratory tests of the relative energy efficiency ratio (EER*) versus outdoor air damper position for a 7.5-ton two-compressor packaged unit and rated airflow of 3,000 CFM. Indoor conditions were 75°F dry-bulb/62°F wet-bulb for all tests. Outdoor conditions varied as follows: 95°F dry-bulb/75°F wet-bulb, 82°F dry-bulb/68°F wet-bulb, and 115°F dry-bulb/80°F wet-bulb. The laboratory tests were performed with no economizer installed as well as with an ASHRAE 90.1 compliant economizer rated at 10 CFM/ft² or 67.1 CFM outdoor air leakage with closed dampers per ANSI/AMCA Standard 500-D-12 (ANSI/AMCA 2012). The actual outdoor air leakage with closed dampers was 462 CFM or seven times greater than the 67.1 CFM rated damper leakage.

Table 41: System Efficiency (EER*) versus Outdoor Air Damper Position for 7.5-ton Unit

Test	Outdoor Air %	Outdoor Air (CFM)	EER* 82/68°F OD 75/62°F ID	EER* 95/75°F OD 75/62°F ID	EER* 115/80°F OD 75/62°F ID
No Economizer Factory Charge AHRI Rating	4.5	135	12.0	10.0	7.5
Closed Economizer Dampers (Rated at 10 CFM/ft^2)	15.4	462	8.7	6.4	3.7
Economizer Dampers Open 1 Finger "10% OA"	19.5	585	8.3	5.7	2.9
Economizer Dampers Open 2 Fingers "20% OA"	23.2	696	8.0	5.1	2.1
Economizer Dampers Open 3 Fingers "30% OA"	30.1	903	7.8	4.5	1.4
Economizer Dampers Fully Open	62.1	1577	6.6	1.9	-1.4

Source: Intertek, Plano, TX

Note the damper leakage measurement used in the lab is for the entire economizer unit and did not follow the ANSI/AMCA damper test procedure. The leakage includes any leakage around the perimeter of the economizer where it is bolted on to the packaged unit, plus any other cabinet leakage sites. The team set test conditions to replicate field conditions determined at the time lab tests were initiated. The external static pressure (actually return plenum negative pressure) is known to be a factor in economizer operation. Additional testing at varied return plenum pressure is underway and planned.

Table 41 also shows that with economizer dampers closed, the 7.5-ton unit is 38% to 104% less efficient than the same unit tested without an economizer per the ANSI/AHRI 340/360 and

ANSI/AHRI 210/240 test procedures (ANSI/AHRI 2007, ANSI/AHRI 2008, and Carrier 2001).[101]

Tests were performed in compliance with ANSI/ASHRAE 340/360 for a specific set of test conditions. The lab tests expanded the test envelope (ambient conditions) beyond that of the standard, but tested in a manner consistent with the standard. With economizer dampers open from 10% to 30% (1 to 3 fingers), efficiency is reduced by 5% to 62% compared to closed dampers. Reduced efficiency is, of course, expected at the test conditions where the outside air is warmer than the thermostat set-point temperature. Economizers save energy when the outdoor air is cooler than the indoor cooling set-point, and they replace fixed outside air dampers to provide fresh air to satisfy ventilation standards in CA Title 24 and ASHRAE 62. These standards are written in terms of CFM/person and CFM/building square feet, requiring a calculation specific for each building. HVAC technicians rarely know the required building ventilation, and often err on the side of providing too much outside air or closing off economizers. Providing excess outdoor air will reduce efficiency and increase space cooling and heating energy use.

Building occupancies require different minimum amounts of outside air. Laboratory tests indicate closed dampers provide 15.4% outdoor air, 1-finger open provides 19.5%, 2-fingers open provides 23.2%, 3-fingers open provides 30.1%, and fully open provides 62.1%. The SCE statewide program provided three training videos about economizers. The trainer recommended 3-fingers open to achieve 15% outdoor air, but this damper setting not only provides twice the stated outside air but will also reduce cooling efficiency by 11% to 62% if 15% is the appropriate target. Test and Balance (TAB) certified technicians are required to make the appropriate measurements and settings prior to ongoing program maintenance. However, a more appropriate maintenance suggestion would be to seal known cabinet and economizer assembly leakage areas.

5.3.1 Economizer Impacts with Low Airflow

Table 42 provides laboratory test results of relative EER versus airflow and outdoor air damper position for the 7.5-ton two-compressor packaged unit. Compared to optimal refrigerant charge and airflow and closed damper position, low airflow of 16% to 33% reduced efficiency by 2% to 23%. For 1-finger open damper position, low airflow reduced efficiency by 1% to 24%. Note that these findings do not necessarily indicate potential benefit associated with a change in air flow via a maintenance effort. The tested unit can increase air flow via a change in the pulley opening position. Doing so on an existing system would result in an increase in supply air fan power.

[101] Manufacturer EER ratings based on the AHRI 340/360 do not include cabinet or economizer outdoor air damper leakage.

Tests were all performed at a fixed external total pressure. Increasing air flow in the field via pulley adjustments would produce an increase in external pressure and thus fan power.

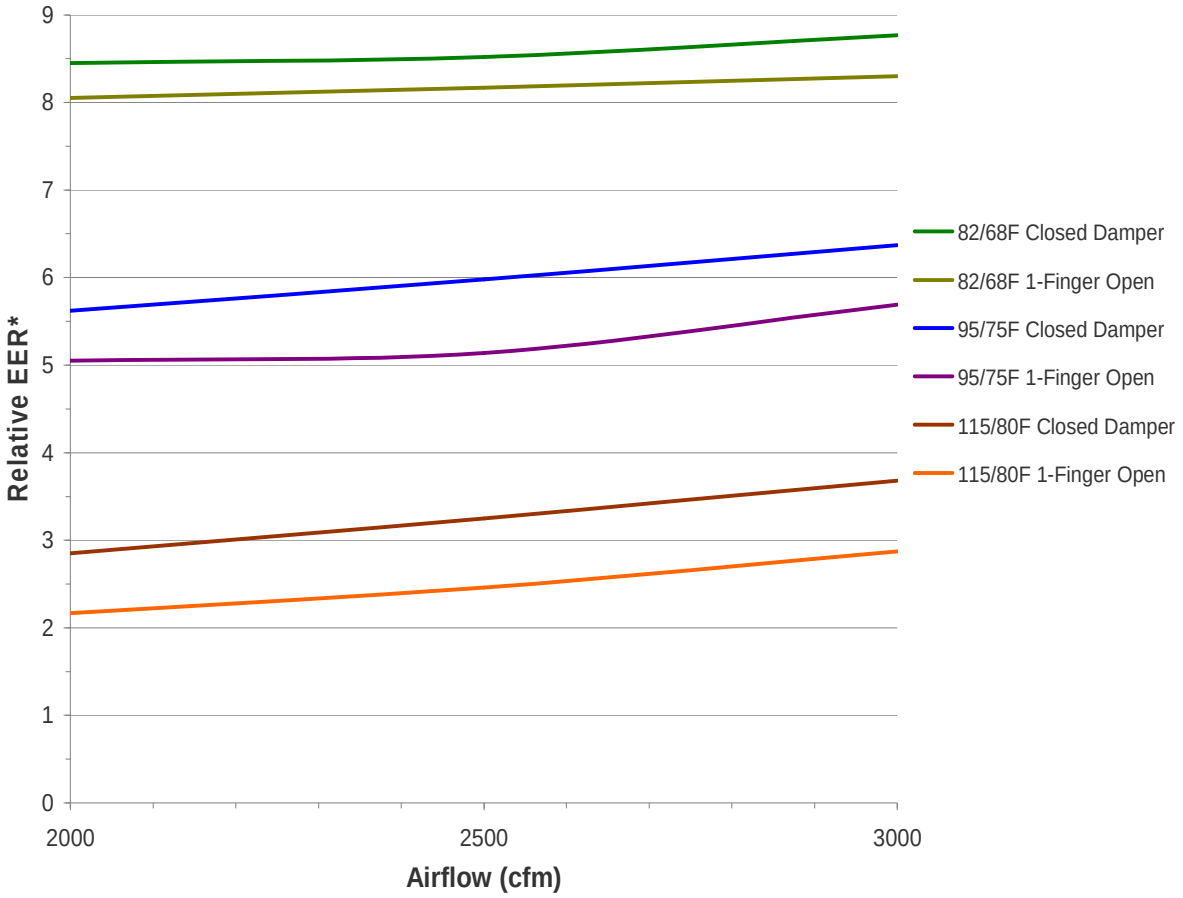
Table 42: System Efficiency versus Airflow and Outdoor Air Damper Position

Test	Refrig. Charge c1/c2 (lb)	Airflow (CFM)	EER* 82/68 OD 75/62 ID	EER* 95/75 OD 75/62 ID	EER* 115/80 OD 75/62 ID
No Economizer Factory Charge AHRI Rating	7.6/8.1	3000	12.0	10.0	7.5
Laboratory Optimal RCA Closed Damper	8.59/10.35	3000	8.7	6.4	3.7
16% Low Airflow Closed Damper	8.59/10.35	2500	8.5	6.0	3.2
33% Low Airflow Closed Damper	8.59/10.35	2000	8.4	5.6	2.9
Laboratory Optimal RCA 1-Finger Open	8.59/10.35	3000	8.3	5.7	2.9
16% Low Airflow 1-Finger Open	8.59/10.35	2500	8.2	5.1	2.5
33% Low Airflow 1-Finger Open	8.59/10.35	2000	8.0	5.0	2.2

Source: Intertek, Plano, TX
*System efficiency, Not EER at AHRI conditions of return air only, relative EER includes outside air.

Figure 23 shows relative EER* versus airflow (CFM) for varying damper positions and outdoor DB/WB temperature conditions. Low airflow has more impact on efficiency in extreme weather conditions, even when dampers are closed. One-finger open dampers have a larger impact on EER* than low airflow.

Figure 23: System Efficiency (EER*) vs. Airflow for Varying Damper Positions and Outdoor DB/WB Temperature Conditions



5.4 Preliminary Conclusions

The laboratory testing provides new insights into unit performance under conditions similar to those found in the field for units in QM programs. Additional laboratory results and conclusions will be included in a separate report as part of the 2013-14 evaluation projects. Results of the 7.5-ton dual-compressor packaged roof top unit tests provided the following preliminary conclusions:

- Unit rating conditions include horizontal flow, cabinet sealing, and no outside air intake. This differs from field conditions where systems often are installed on rooftops with sharp bends to vertical flows, unsealed cabinets, and outside air intake that mixes with return air. In a controlled laboratory experiment the impacts of these conditions on efficiency can be assessed. In the field, the maximum achievable measured efficiency will be impacted by these physical differences.
- Tests of out-of-box efficiency without an economizer indicated an 8.4 EER, which was 24% less efficient than the AHRI rating of 11 EER at outdoor conditions of 90°F dry-bulb

and indoor conditions of 80°F dry-bulb and 67°F wet-bulb. Adding charge improved efficiency but was still 22% lower than the unit's rating. It should be noted that these tests were made with the unit in a down-flow position rather that the standard horizontal-flow arrangement of AHRI tests. Additional tests are being conducted in the horizontal-flow arrangement of AHRI tests. Out of the box tests with AHRI conditions and horizontal flow replicated the manufacturer EER within the allowable tolerance.

- Tests of the economizer open from 10% to 30% indicated that efficiency is reduced by 5% to 62% compared to closed dampers (which deliver 15% outdoor air).
- Outdoor airflow was 15% with closed dampers, 20% with 1-finger open, 23% with 2-fingers open, 30% with 3-fingers open, and 62% with dampers fully open. Designers, technicians, and program implementers incorrectly assume 2% outdoor airflow with closed dampers and 100% outdoor airflow with fully open dampers.
- Minimum damper position of 3-fingers open (30% outdoor air) reduced efficiency by 10% to 62% and reduced economizer savings by approximately 50% compared to closed damper.
- Factory charge tests with and without an economizer indicated that C1 and C2 were above manufacturer charging chart specifications for suction temperature. This indicated an undercharge condition.
- Tests of +60% overcharge (relative to factory) yielded diagnostics within manufacturer ST specifications. However, +60% overcharge yielded negligible efficiency improvements of -8% to +2% compared to +20% overcharge (laboratory optimal).
- Tests of 16% to 33% low airflow indicated a 2% to 24% reduction in efficiency (depending on damper position). Low airflow had more impact on efficiency in hot weather conditions.
- Tests indicated that unintended leakage can have a larger negative impact on EER* than improper refrigerant charge or low airflow. Additional testing should provide more definitive results relative to the impacts of various faults.
- Appendix C provides the results of service instrument accuracy tests. Tests of measurement instruments indicated that it can take 5 to 10 minutes for sensors to measure refrigerant temperatures. Tests were conducted with eight sensors on liquid and suction lines. The smallest differences between reference probe and tested sensors were with specific Type-K clamp probes with accuracy ranging from 1.1 ± 0.6 °F on suction lines at 115°F. Some Type-K clamp probes had suction line accuracy ranging from 6.8 ± 1.0°F when tested at 115°F outdoor conditions. Differences in accuracy are attributable to design and manufacturing. The team found the largest differences relative to reference probe with Type-K bead probes and thermistors. Bead probes had differences of 10.7 ± 3.3 °F, cylindrical thermistors had differences of 9.7 ± 7.1°F, and clamp thermistors had differences of 5.4 ± 2.1°F. The largest differences were with the suction line measurements where tube temperatures were 25°F to 40°F less than ambient. The liquid line temperature is typically 8°F to 12°F above ambient so there were smaller variations from measured temperatures to actual tube temperatures. The recommended pipe

temperature instruments are low tolerance Type-K clamps. Pressure measurement instruments and sensors available for future evaluation measurement require further testing.

Additional testing and studies should evaluate potential savings. A thorough examination should be made that considers an efficiency estimate of "free cooling" that acknowledges the small amount of cooling provided relative to fan power consumption when outdoor conditions are close to the economizer changeover setpoint.

6. Public Comments and Responses

Note that table, section, and page numbers refer to the draft for comment and may have changed. Comments are as posted on the Public Display Area.

#	Name	Comment	Response
1	Adrienne Thomle, Honeywell ECC, Commercial Buildings	The requirement of proper on-going maintenance of the unit is clearly needed. A unit can be operating at peak performance and if not properly maintained can slowly become an "energy waster" rather than an energy saver. We spend a lot of time training technicians on the refrigerant section of a RTU we need to spend more time training the technicians on energy saving devices.	We agree on the needed focus on training for energy savings
2	Adrienne Thomle, Honeywell ECC, Commercial Buildings	There are numerous field studies that have been completed over the past 25 years that prove if economizer controls are applied as recommnded by the manufacturer, the sensors are located in the recommended locations, the dampers are equiped with side and edge seals and the system is properly set up for the RTU then the system will save energy and provide comfort for the occupants including proper ventilation. The issue we have in the field is many technicians do not understand the operation of an economizer as most learn on the job and not in their training. There are a high number of technicians who do understand the operation and provide good results. As the demand for energy savings and codes become more defined for proper application of the economizer systems, suppliers and technicians will continue to improve. Economizer housings will be assembled to low leakage and the controls are now simple for the technicians to understand the setup and operation. I would like to suggest a follow up study completed on unts that have been installed in the past 2 years by technicians that have passed a written and hands on certification.	Recommendation noted on studying new installations. This study focused on maintenance of existing commercial systems.
3	Adrienne Thomle, Honeywell ECC, Commercial	The practice of using "cold spray" to force the OA damper open is not a good practice as it tends to create a "wild" economizer affect and will damage	Most economizers in QM programs that need repair are older than 6 years old.

	Buildings	the sensor with repeated refrigerant spray on the electronic components. The practice of using cold spray was used on electro-mechanical economizers which have not been manufactured for 6 years.	We would appreciate other functional test suggestions
4	Adrienne Thomle, Honeywell ECC, Commercial Buildings	Most RTUs in the years between 2010 and 2012 had old analog economizers installed with leaking dampers. What wa the age of these units? Did they comply with Title 24 - 2013? The requirements were changed to allow for the short comings of the analog economizers with leaking dampers. The new digital economizer controls with low leakage dampers would definitely show better results. With the requirements in Ttile 24 -2013 for Demand Control Ventilation - I suggest the OA damper be set at 0% open and allow the CO2 or occupancy sensor to control increased ventilation based on the number of occupants or allow the use of using cfm input from the technician to set the minimum damper position. Every technician has their own idea on how to set the damper for ventilation and the one, two or three finger or listening for air flow is not the answer but this is what they use today. Technician training and certification is needed in the field.	Exact unit ages are not known in all cases. Existing systems in QM would not comply with Title 24-2013 We agree the rules of thumb are not ideal for setting outside air flow rates, but appreciate the confirmation that those methods are used by some.
5	Adrienne Thomle, Honeywell ECC, Commercial Buildings	There are many reasons the OA damper could be opening in the system and performance of the economizer system is based on the application and location of the sensors. Were the MAT sensors on the old analog units before or after the coil? The location of the coil can make a huge difference in the operation of the system.	The primary issue reported are economizers that do not operate after maintenance. The sensor location is one possible issue. The location varied by unit.
6	Adrienne Thomle, Honeywell ECC, Commercial Buildings	The work order stated that opening the economizer reduced the energy savings, the question is was the economizer damper opening due to a call for cooling and OA conditions were good for economizing or was the damper opening to provide more ventilation based on a call from a CO2 sensor in the sapce?	The statement can be clarified. The economizers were not responding to conditions measured by temperature or CO2 sensors, the dampers were essentially fixed in one position prior to maintenance. The fixed position % open was increased after

			maintenance but the economizer still did not respond to temperature signals that would indicate favorable operation.
7	Mark Lowry WHPA Chief of Staff	Attached is a letter submitted on behalf of six industry organizations represented on the Western HVAC Performance Alliance (WHPA) Executive Committee. In short, it requests an extension of the comment period (to September 22, 2014) to allow additional technical and methodological review of the report. http://energydataweb.com/cpucFiles/0/comments/comAttach_2504.pdf	Extension was granted
8	Richard Hatlen, Joint Journeyman Apprentice Training Center (JJATC)	I was listening in on Monday with all the data and comments and questions. I few things come to mind I know that a great deal of work has gone into putting out a Energy program that will benefit the end user and the folks involved in doing the work. There has been a great deal of data analized and research done. I dont feel there has been a fair sampling of evaluation of the processes. I also feel that and I mean no disrespect but arent we making something more complex then it needs to be? If we want an effective program with a process that works you have to make it less cumbersome to implement and you will get much better results , resultanting in True Energy savings to the customers and the utility will benefit with across the board reductions not just in some areas. Thank You.	The project was designed as an impact evaluation and did not include a process evaluation. Some process work was done for the SCE program based on interim findings of WO32, but the process evaluation recommendation seems reasonable. The recommendation will be raised within the HVAC Project Coordination Group.
9	Darryl DeAngelis, Belimo	The investigating team is correct when they state that combined Economizer and RTU efficiency testing has not been performed in certified testing laboratories. I wanted to make the Commission aware that the Consortium for Energy Efficiency is currently supporting a combined approach for these two technologies as an improved energy rating. It is my understanding that AHRI has formed a committee to work on a combined test standard. This would provide a test method that and metrics	We appreciate this comment and support development of combined testing standards.

		to fully evaluate the RTU with Economizer. I am not arguing that unintended leakage has a negative effect nor that of the intended ventilation air, however what is not highlighted is the efficiency benefit of Economizer and part load efficiency improvements at lower ambient.	
10	Don Tanaka, UA	Nothing was mentioned about the evaluators, how many years of actually working with the tools and any ac certifications or education? What qualifies the evaluators to perform the evaluation? In volume I, page 20 2.2.1, "Observation Methods". Who is a "Master HVAC Tech"? What is his background in the industry	All evaluation firms are vetted by the CPUC Energy Division prior to contracting. The prime contractor has performed numerous evaluations including the previous program cycle evaluation of the RCA and duct seal programs. The Master Technician firm includes staff with over ten years' experience each and all relevant technician certifications such as NATE as well as several manufacturer specific certifications.
11	Don Tanaka, UA	In volume I, page 21, the fourth bullet point. To disassemble and removing panels and condenser fan motors to clean inside and outside of coils. This cannot be cost effective to the owner of the unit (depends on size of unit) to take apart the unit to clean it. There are other ways to do this, and how much can we save (energy) the owner by taking this apart?	The energy savings and persistence associated with following the manufacturer recommended procedure and any alternatives that take less time must be quantified and then cost effectiveness considered.
12	Don Tanaka, UA	Volume 1, page 34, second paragraph. "Most technicians did not install fan belts with proper tension or adjustment". A good technician can tell proper alignment on visual inspection for wearing of the belt or use a string or a straight edge. For proper belt tension, a simple ruler can be used to check belt tension and what is not noted in this report is checking amp draw of the motor. You can have proper belt	We evaluated this measure according to manufacturers' recommendations, which includes checking alignment with a straight edge and checking tension with a tension gage. Power draw is an

		tension but over amp the motor or have a bearing go bad.	important measurement and our inspections did not include this aspect of the fan system.
13	Don Tanaka, UA	Volume I page 43. Reconsider Diagnostic Based Refrigerant Charge Measure. "Identifying and adjusting units with low charges proves to be extremely difficult on commercial units with outdoor air intakes due to problems making accurate measurement of coil entering wet bulb temperature and general unreliably of diagnostics protocols" What about dry bulb reading, it takes two readings to be correct. That is the WB and DB to be the correct way to check a properly charged unit.	It is true that coil entering DB is important, but the statement is based on the fact that unit performance is driven more by WB. Both readings have the issue of determining appropriate sensor placement due to unmixed and temperature-stratified air on inlet side of the coil.
14	Don Tanaka, UA	Volume I page 43, Use manufacture maintenance and diagnostic protocols. "Energy savings potential exists by adjusting fan to factory specifications and following fan-belt alignment and tension guidelines" Not all units have fan belts. There are many 5 ton package units at the mini malls that have direct drive fan units. I have been in the field for 22 years and 13 years behind the desk. Being out so long and new and modern equipment are in the field, I check with the younger techs to see if direct fans are still out in the field. The techs said yes on mini malls and some computer room application.	This is true, but many systems in the programs are larger than 5 ton and have belts. There are also many direct drive small systems that this recommendation does not apply to.
15	Bob Sundberg BNB Consulting	The CQM program evaluation seemed to be missing even a mention of a vital part of implementation of Standard 180, that is, the discussion and evaluation of the agreement maintenance program consisting of the HVAC equipment/component inventory (NOT equipment evaluation but a listing of equipment to be maintained by the service provider) and the maintenance plan. Also missing is any discussion,	The impact evaluation was designed to measure energy savings resulting from maintenance activities.. The evaluation was not designed to study longer term market transformation or market

		suggestion or criticism as to whether there even was establish maintenance "performance objectives" or "condition indicators" which would guide the ongoing discussion of adequate service being provided. Without these key elements, all outlined in detail in Section 4 of the standard, right after the Section 3 Definitions, there is hardly the likelihood of any higher level of QM being continued after the utility incentives end. Far from effectively promoting "market transformation" such a practice encourages the same old practice of bribing end users with utility incentives, only to have them quit the practice after the incentives end. It would be far, far wiser to invest in QM practices which would establish the benefits, energy savings, reduced repairs/service, improved IAQ and equipment reliability, drastically reduced failures and forced replacements, far wiser to work to establish evidence of the undeniable benefits of a QM approach so that after the incentives expire, the QM practice continues. Where did the evaluators address this key element of the CQM programs?	effects, although these could be addressed in a future study.
16	Bob Sundberg BNB Consulting	CQM is a process. Its benefits and repeatability cannot be adequately captured simply in technical terms and measurements. I'll let others focus on argue the merits or demerits of the evaluator's proficiency, or lack thereof, in evaluating QM maintained systems. But, we're talking about the goal of changing behavior here. The degree on the part of building owners, or their designated representatives, to move from total neglect, run to fail or very minimalist service task list approaches to those of adequate inspection and evaluation AND taking action to authorize and remedy "out of acceptable range" operation of their HVAC equipment. I think that a more adequate evaluation approach would have to include interviews with those owner decision-makers or surveys at least to get some idea about how many, what %, to what degree they would consider OR would commit to	The long term approach presents an issue for program evaluation. The evaluation goals were stated to program staff and implementers. Even if the program allows multiple years for service actions the key actions must be taken as soon as possible to be considered first year savings. The process outlined to the evaluation team was that most issues would be identified and repaired early in the process. If it was known that most

		continuing with a QM practice. Where's the focus on that whole market transformation issue? I don't see it in the evaluation at all.	actions would not be identified and addressed until the end of the 3 year agreement then it would be recommended that savings be claimed in later years.
17	Bob Sundberg BNB Consulting	Evaluators seem to be criticizing the QM program, like fault detection and diagnosis, where there is hardly, if any agreement in the industry on what FDD means or how it should be implemented. One example being charge evaluation. Even the "master technicians" retained by the CPUC/ED as experts seem to only quote the manufacturer's original instruction for newly installed equipment correct charge procedures. Those do NOT apply for systems installed one, five, ten or more years with the impact of all the variables and past contractor practices or neglect of the system. Standard 180 does NOT go into any detail on how to correctly assess charge, for instance. Check our Table 5-22, task "n" to see. Check refrigeration temperature and .....which one? How about system pressures which correlate to proper liquid and suction temperatures. Enough said. Others will or could provide better comments on these more technical issues.	We agree there is no single set of FDD standards. We have referenced studies by others on these issues. We agree that Standard 180 does not provide specific guidance on evaluating refrigerant charge. Most important for the evaluation is that because different FDD methods produce different outcomes then the savings associated with charge adjustment may produce positive savings, negligible savings or negative savings. We disagree with the statement that manufacturers' service recommendations only apply to new units. Manufacturers' recommendations represent an independent benchmark to evaluate various FDD protocols.
18	Bob Sundberg BNB Consulting	RQI: I believe the approach to evaluation was incorrect in its comparison target for claimed savings. The evaluation team chose to compare program participants to a sample selection of non-participants. I and many others involved think that the best	This comment speaks to the difference between customer bill savings analysis and program evaluation. Program evaluation attempts to

		comparison would be comparing the newly installed system to the system voluntarily retired or one that was still operating but in a failed or failing mode and most likely guzzling energy in the process. Since such a small sample of home systems were actually evaluated, full performance of the old and new system could be subjected to exactly the same measurements, calculations and performance assessment. The home would have remained the same -- avoiding the necessity altogether of properly selecting some other home of similar size, location, design/layout, altitude, insulation, window and overhang....you get the point. Avoiding all of the variables which skew results and make them questionable at best.	quantify what the customer would have done absent the program (the counterfactual). If the customer would have otherwise chosen not to replace the system, then the previous system is the baseline for the remaining useful life of the existing system. This is the "early replacement" scenario. If the customer would have otherwise replaced the system but not hired a QI contractor, then the baseline is the installation practice for a non-QI job as estimated by the non-participant surveys. This is the "normal replacement" or "replace on burnout" scenario. Note, programs can claim early replacement savings, but documentation of the viability of the existing system must be provided. Once the existing equipment reaches the end of its remaining useful life, the normal replacement baseline is used to estimate savings from that point forward.
19	Bob Sundberg BNB Consulting	I believe the approach to evaluation was incorrect even where non-participants were selected for comparison and calculation of energy usage differences and claimed savings. From my understanding at the recent WHPA RQI Committee September meeting, it was confirmed by the PG&E and CEC representatives that non-participants were	1 – This is incorrect. Non-participants were recruited and fielded prior to the PG&E study. There were 50 sites completed. It is still incorrect to assume that the previous

		selected from a PG&E Compliance study participants. This small select sample of about two dozen homes was intended to represent the broad baseline of residential installed systems. Point 1 - too small a sample to be statistically significant. Try looking at data collected from a much larger pool like the SCE RQI program participating homes for data on systems which were removed and replaced. Best yet would be to evaluate performance of those homes PRIOR to replacement with the collaboration and cooperation of program participants. Now you could build a dbase that could be expanded and improved over time as region, climate, house type and other key variables would allow a far more valid "representative sample" to be initially compiled and continuously improved over time. Better yet, increase that "sample" size by taking advantage of additional industry program home system evaluations to add hundreds or thousands of homes to that dbase. Point 2 - I am convinced that few or no homeowners who knowingly had systems illegally installed, that is, without permits being pulled and system inspections conducted and passed for Title 24 compliance, would volunteer to have state government representative test and evaluate their systems. To me it would seem only common sense that those "illegally installed system" home owners would politely decline participation. Only or primarily home owners who were proud of their systems and contractors, who HAD gone through the Title 24 compliance process, BUT did NOT participate in the program, would volunteer. Whether the selected homes had any installation inspections for compliance could and should be determined. I suspect that many did. This could be determined since the actual sample size is so small. Is it really any surprise that the evaluators concluded that the participants and non-participants they selected had very similar results? So much for the ultra low realization rate	installed unit represents the baseline for program installations. See previous response on replace on burnout and early replacement baseline definitions. 2 - Based on the PG&E followup study we know less than half of non-participants pulled permits. The study itself may show bias towards permitted jobs, but it is not true that non-participants are all permitted. The PG&E study also shows little difference in measured aspects (duct leakage, sizing, and airflow) between permitted and non-permitted jobs. The issue of permit rates and compliance will be studied further in a separate project.

		conclusions. I'd suggest that if the sample was flawed or the wrong target, that all of the conclusions at best are suspect. At worst and likely the best answer, you have to set those conclusions entirely aside.	
20	Bob Sundberg BNB Consulting	Technical issues. Other commenter entries will provide much more detailed and thought through comparisons between how the RQI program contractors have been trained to determine capacity requirements, evaluate home loads and select equipment as well as evaluate and establish the need to correct installed system serious issues such as inadequate return airflow and duct leakage. Issues such as the proper implementation of Manual S & Manual J. Evaluators are suspected of taking measurement shortcuts, relying on invalid assumptions and software defaults, among other questionable practices. The RQI Committee has offered to discuss and even provide the training they conduct with participating contractors for program evaluators. RQI program implementers have stressed that thoroughly and consistently following the procedures (ACCA Standards 5 & 9 as guides) is very difficult and not likely to be mastered by evaluators who do not conduct these protocols frequently. Please refer to the ACCA/IHACI and Roltay Inc. (Buck Taylor) and other RQI program implementer comments for more details.	These referenced additional comments have individual responses.
21	Abram Conant, Proctor Engineering	CQM: The evaluation found no savings for the statewide CQM program and lower than expected savings for other HVAC maintenance programs. The report notes that some program modifications have occurred since 2012, but does not attempt to project the 2010-12 results to current programs. In light of these results, we suggest that a recommendation of urgency regarding evaluation of the current residential and nonresidential HVAC maintenance programs in all IOU territories would be appropriate. We further suggest the field impacts should be of primary concern and greatest urgency. While laboratory activities are instructive	There are plans for both field and laboratory efforts in the 2013-14 evaluation cycle. Given the uncertainties in field measurements, laboratory measurements are critical to providing empirical evidence of the potential benefits. Lab tests are coordinated with field tests to establish realistic test conditions. Field

		for future program improvements, the field impacts are essential to understanding if the current programs are using ratepayer funds effectively to produce measurable energy savings.	measurements are also made to establish in-situ efficiency changes within the limitations of field measurement accuracy.
22	Abram Conant, Proctor Engineering	The CQM program design assumes savings will occur through future maintenance activities. Did the EM&V study find compelling evidence to support this hypothesis? Is there evidence to suggest that future maintenance activities can be confidently projected to be substantially different from and more effective than the activities that occurred during the 2010-12 EM&V study? If so, please detail the findings and describe how confidence estimates were derived.	It was always know that service actions could be performed over several years under the CQM program. The pre-post monitoring had some limitations on duration and coordination with the programs indicated that most of the service would be performed first, followed by scheduled routine maintenance. We made it clear the intention was to get the service actions to be performed within the monitoring period and alert the team when service was performed in order to observe the process. We cannot project benefits for what may have occurred later. The CPUC expects IOU program planners will review and discuss the evaluation findings, including the issue you note, when planning for future programs.
23	Abram Conant, Proctor Engineering	CQM: We suggest modifying the report to be extremely explicit regarding which equipment types the findings are applicable to. Many readers of this report are not HVAC experts, or have only limited understanding of a certain class of equipment. Misunderstanding and misinterpretation of these	We agree that CQM is focused only on commercial rooftop systems. However smaller rooftop systems do have outside air intakes even if

		findings leads policy discussions in counterproductive directions. For example, the findings regarding challenges obtaining return air wet bulb temperature measurements are already being misunderstood and misinterpreted as applicable to residential split system equipment. In reality, these findings are specific to mid to large tonnage nonresidential equipment with economizers. According to the appliance saturation surveys these comprise only 10.4% of all nonresidential systems and 0% of residential systems.	they do not have economizers. The measurement issue mentioned does apply to all units with outside air intakes. A minor note, There is a fraction of residential systems that are small rooftops, but the saturation studies did not evaluate whether fixed outside air dampers were set to closed
24	Abram Conant, Proctor Engineering	CQM: The report body discusses the following program design and implementation findings: a. "Observations of training classes indicate that the programs provide training on how to enter data into the program database, but do not provide procedures for technicians to diagnose and repair faults that lead to improved energy efficiency." (section 2.4) b. "the training did not include functional testing of economizers or repair processes" (section 2.4) c. "Field observations of technicians indicate a lack of understanding regarding how to properly diagnose faults and implement repairs to save energy, both related to program measures and other issues that affect the measure performance." (section 2.4) d. "In one program, program technicians from multiple contractors installed new economizer sensors and new controllers, but the economizers were not set up such that the controller or sensor actually changed the damper position." (Executive Summary) e. "The statewide programs did not record the amount of refrigerant charge added or removed or specific adjustments made to the system such as economizer minimum	Items a through e are quotations from the report without specific questions or comments. f) The report methodology was to evaluate the programs and savings claims. The evaluation was based on the workpapers which only attribute savings claims to a subset of the ASHRAE/ANSI/ACCA Standard 180 checklist. The evaluation did not include a process evaluation and focused on technical issues observed. The conclusions were revised to explain the actions observed that led to the estimated impacts and installation rates. The conclusions cannot make connections to program processes that were not

		position" (section 2.4) – meaning that the program design failed to capture basic information needed to validate energy savings claims f. The EM&V report does not specifically address the effectiveness of ACCA Standard 180 as the basis for energy efficiency program design, but it has been discussed in other venues (California Public Utility Commission presentation to the WHPA and guests, Nov. 7 2013) that Standard 180 is not an energy efficiency standard. The majority of activities specified in Standard 180 do not directly impact energy efficiency. For the activities that can directly impact energy efficiency, no specific procedures or specifications are provided. Interpretations of these activities may vary, and there is no enforcement mechanism specified to ensure any of the activities are completed in a manner that accomplishes energy savings. It is therefore difficult to understand why the Conclusions focus on the refrigerant charge test and do not discuss program design and implementation issues. The programs were built around a standard that was not designed to accomplish energy savings, implementers were observed to provide inadequate technical training, post installation inspections found that work was not done correctly, technicians were observed doing work incorrectly even when they knew they were being observed. Yet the conclusions state that the reasons for the finding of 0% realization rate "center on the programs providing incentives for adding or removing refrigerant charge without diagnosing other faults such as low airflow and refrigerant restrictions or non-condensables." (section 2.5.1, Conclusions, first paragraph). We recommend that the report clarify the directly observed causes for 0% realization rate, including a discussion of program design and implementation issues and their impacts. If in fact, the EM&V work actually confirmed the presence of the stated complicating	evaluated. Comment on procedures – added more emphasis that for all units the evaluation team measured data to evaluate units based on manufacturer procedures. A subset of that data also allows the calculation of comparison diagnostics such as the Title-24 superheat and subcooling metrics on all systems. In addition to the revised conclusions mentioned above a table of the frequency of faults across and within programs was added to the Appendix.

		faults for charge diagnosis (contaminants, line restrictions, etc.) please provide the method by which they were confirmed (sampling of refrigerant, etc.), how often they occurred in the sampled locations, and the distribution of their severity.	
25	Abram Conant, Proctor Engineering	CQM: The 2006-08 HVAC impact evaluation found savings that were below expectations, but above zero. The 2006-08 programs suffered from design and implementation flaws, including: a. Incentives were offered for activities with low probability of producing energy savings. For example very small duct leakage improvements, very small refrigerant charge adjustments, coil cleaning without supporting evidence that coils were sufficiently dirty to impact performance, etc. b. Inadequate, or no technical training requirements for HVAC contractors and technicians. c. Inadequate oversight and technical support to ensure HVAC technicians understood how to perform the work correctly. d. Inadequate quality assurance and quality control to ensure that contractors and technicians participating in the programs were actually performing the work correctly. e. Inadequate enforcement of quality standards. Poor performing contractors faced no consequences and were allowed to continue doing work under the programs. We suggest that a comparison to the 2006-08 programs and results would be useful. In particular it would be helpful to discuss whether the public funds expended redesigning the HVAC programs for 2010-12 and applying the redesign statewide for four years resulted in improved program designs and implementation strategies that successfully corrected the 2006-08 design and implementation problems. a. Is less ratepayer money being spent on activities that don't produce energy savings? b. Has technician training and competence improved? c. Has the quality of work being performed	A full comparison to previous evaluations and evaluations from other regions was not part of the evaluation. The CPUC expects that IOU program planners will take into account all of these study findings when planning for future HVAC programs.

		improved? d. Have robust quality assurance procedures been implemented, including the removal of contractors who fail to perform work according to specifications? This is of particular importance since previous studies have found no statistically significant difference between industry trained and certified contractors and technicians and those with no special training or certification when programs do not implement quality assurance procedures and enforce quality control standards (Northeast Energy Efficiency Partnerships 2006, Strategies to Increase Residential HVAC Efficiency in the Northeast, Appendix C, pages 55-58). "Findings of this study were consistent with recent baseline studies in the Northeast, in that that the quality of the majority of the central AC installations was inadequate. There were no statistically significant differences between installations in new and existing construction or by certified and uncertified contractors, with respect to sizing, airflow, or refrigerant charge at the 90% confidence level. The quality of duct sealing was higher among certified contractors; this difference was significant at the 99% confidence level. However, even the higher quality duct sealing was not compliant with building code, since duct tape rather than mastic was used in many cases." e. Have the delivered energy savings improved?	
26	Abram Conant, Proctor Engineering	CQM: It is very important to deal with the reality of the field, rather than a laboratory construct. A particular fault is worthy of diagnostic effort IF: a. It occurs a significant amount of the time in the field b. The severity of the fault is large enough to produce significant efficiency degradation c. The cost of diagnosing and repairing the fault is less than or equal to the value of the energy saved and reduction in peak demand. An example of these primary principles not being applied is shown in the evaluation. On package rooftop units, 60% of the units received refrigerant	Cost effectiveness is not part of the impact evaluation and therefore we cannot make statements for or against which faults are worthy of diagnostic effort. If you have data supporting the cost effectiveness of various fault diagnosis /repairs, it would be helpful for that to be provided to the IOUs.

		charge adjustments. It is frankly inconceivable that 60% of these units have sufficiently incorrect charge to warrant an adjustment. It is important to make a distinction between the installation standards for a split air conditioner and the service checks for equipment (both package and split) in the field. Service checks in the field must have a wider range of acceptability (decision to leave it alone) to be viable. This program design obviously did not have that protocol in place. It is possible, but unclear if the 60% installation rate refers to the fraction of the instances where refrigerant charge adjustments were reported where the work was found to have been done correctly, or how "correctly" was defined. We request that these findings be clarified, including the specific procedures used to determine the installation rate. We suggest that the report Conclusions and Recommendations, along with discussions in various other sections of the report regarding fault diagnostics, include data showing that recommended efforts are worthwhile. We suggest that "worthwhile" be defined as cost effective for ratepayers as evidenced by data regarding prevalence in the field, severity of efficiency impacts, and cost to diagnose and repair. Conclusions, Recommendations, and other discussions of activities that are not proven to provide cost effective energy saving benefits for ratepayers should be removed from the report.	Unproven methods are suggested for further study given the uncertainties with methods that are currently part of programs. This was also not a process evaluation, which would have assessed the program design issue raised. The section on installation rate was revised and provides additional information. We provided installation rate information specifically to inform the review of workpapers that address a specific set of issues. Fault frequencies and repair frequencies for other energy-related issues are also provided in the revised section.
27	Abram Conant, Proctor Engineering	CQM: The report Conclusions state that: "The program team reviewed all of the detailed data and observations and concluded that the underlying reasons for the result of a realization rate of zero were that the current program has various inherent challenges, many of which were likely unknown until the field and laboratory research under this study are available. The reasons center on the programs providing incentives for adding or removing refrigerant charge without diagnosing other faults such as low airflow and refrigerant restrictions or non-condensables."	Revised the conclusions to focus on the findings based on the field work and laboratory work. The misunderstanding here is that we are assuming that the measures are not capable of saving energy. The actual statement is that assessing the faults and making adjustments in the direction of energy

		(section 2.5.1, Conclusions, first paragraph). We request that above conclusion be substantiated with supporting evidence including measured data, or else that it be removed from the report Conclusions. Supporting evidence should include: a. Data conclusively proving that no energy savings can be accomplished when refrigerant charge is adjusted using the manufacturer specified charge testing procedures if the system also happens to have non-condensables or some other problem. Claims that such adjustments do not produce the exact refrigerant weight specified by the manufacturer are not particularly meaningful in the context of efficiency programs. Energy efficiency programs should be concerned about kWh, not lbs of refrigerant. The relevant question is: "Can energy savings be achieved?", not "Is the refrigerant weight exactly equal to the amount indicated on the nameplate?", or even "Is the EER the maximum it could possibly be?". Pre-Post treatment change in energy performance is the only relevant question. It is important to understand that the reports referenced in the EM&V study do not provide conclusive proof that energy savings are not possible. These reports have been extrapolated well beyond the authors' findings, and have been misinterpreted to infer meanings that are not supported by the data. The data do not show that refrigerant weight must equal the nameplate charge for any energy savings to occur. The data do not show that EER must equal the maximum possible value achieved in a laboratory for any energy savings to occur. The data do not show that energy performance improvements are not possible through refrigerant charge adjustments if another fault happens to be present. The data do not show that energy savings are not possible unless every single fault that could potentially exist is tested for and corrected, or that it would be cost effective to do so. b. Data proving that the incidence and severity of other faults was sufficiently present in the sample	savings are more challenging than previous thought. This is supported by the data and other research that it is much more difficult than previously known to diagnosis commercial unit faults. IOU workpapers assume maintenance activities will optimize system efficiency. Agree that incremental improvements in efficiency are valuable, assuming the benefits outweigh the costs. The impact evaluation attempted to measure incremental savings wherever they existed.

		to significantly impact the potential of HVAC programs to improve efficiency through refrigerant charge adjustments. The data should include the methods by which such faults were confirmed to exist, and the methods by which their severity was measured. The data should be representative of the equipment types addressed by the evaluated programs. c. Evidence that the 0% realization rate was not actually caused by program design and implementation issues.	
28	Abram Conant, Proctor Engineering	CQM: The report states that: "Approximately 92% of technicians had issues with tools or procedures. None had proper tools to evaluate economizers or outdoor air damper position. Approximately 50% did not have EPA low-loss fittings on their refrigerant hoses. Those that did have low-loss fittings often did not purge hoses of air and water vapor prior to attaching to the system. Lack of low loss fittings and failure to purge hoses causes non-condensables or contaminants to enter the system when adding refrigerant or attaching hoses. " (section 2.4) Given the number of times the team observed technicians and their use of fittings without low loss attributes, what volume of non condensables were introduced in to the systems, how was that determined and what is the measured efficiency effect of that amount of non-condensables in the systems of the size tested?	The weight of non-condensables introduced through the use of non-EPA fittings was not measured in the field. This is the subject of current lab tests. Field tests indicated the presence of non-condensables, but it was not possible to quantify the amount. Current lab tests are also quantifying the impact of non-condensables on unit capacity and efficiency.
29	Abram Conant, Proctor Engineering	RQI: Was construction date collected for these homes? If so, we request that data be presented by building vintage as there may be differences in duct leakage and airflow results for different construction dates and applicable building codes.	There are gaps in vintage data which would eliminate relevant data points. Therefore data by vintage is not presented.
30	Abram Conant, Proctor Engineering	RQI: We are concerned that the mean values of participant and non-participant installations were fed into the simulation. A number of factors (airflow for example) have non-linear effects on efficiency and the use of the mean produces estimates different from the actual effects, which will be dominated by the more extreme cases.	The analysis plan to aggregate participant and non-participant data was part of the research plan and the workpaper assumes averages not a distribution of cases.

31	Abram Conant, Proctor Engineering	RQI: It appears clear that there was insufficient quality assurance for the program, since on the average the participant systems' airflow fell 62 CFM per ton below the 400 CFM per ton upon which the program design was based. Had the 400 CFM per ton or better been achieved, the airflow savings should have achieved a higher value than specified in the Workpaper.	No response necessary
32	Abram Conant, Proctor Engineering	RQI: It is dangerous to assume that sizing changes alone will produce energy savings. These are interactive systems and the resistance to flow, surface area, insulation value, and location of the ducts interacts with sizing and airflow. Furthermore, SEER 16 or better systems were near half of the installed systems. Some or many of these systems may have been two speed machines. If they were, oversizing is likely to produce energy savings since the machine will spend more time in its more efficient low speed mode.	The workpaper assumes one oversizing estimate for all installed efficiencies. Our analysis was not setup parametrically to simulate savings for each case. This may be an additional analysis that can be performed in the future.
33	Abram Conant, Proctor Engineering	Upstream: Please clarify the apparent contradiction between findings of the Market Baseline Characterization Study and the Upstream HVAC EM&V Study. The Baseline Characterization Market Effects Study of Investor-Owned Utility Residential and Small Commercial HVAC Quality Installation and Quality Improvement Programs in California found that "40% of single-phase air cooled units and 56% of air cooled three-phase packaged and split equipment sold in 2011 and 2012 meet a Tier 1 or better performance standard.". How do these findings relate to the Upstream HVAC program? If these percentages are truly market baselines, then questions regarding the finding of 0.8 net to gross ratio for the Upstream Program arise. Alternatively if these percentages include a disproportionate number of units within the Upstream Program or other programs that are incentivizing higher efficiency equipment, then the market baseline estimates may assume efficiencies that are too high and not representative of the general market.	We are uncertain on the number of program participants present in the market baseline characterization, but the interview data leveraged may be overlapping.
34	Abram Conant,	Lab: We understand that the laboratory results are	In the results presented,

	Proctor Engineering	still being compiled and we look forward to reviewing them. Please include more information regarding possible causes for performance differences between various system types. For example, the insensitivity of the larger tonnage two circuit units to refrigerant overcharge. Other than general equipment class, is there any other characteristic of these systems that contributes to the finding that these units are sensitive to refrigerant undercharge but are very insensitive to refrigerant overcharge? Is there a receiver or some other refrigerant management component present that is not typically used in smaller systems?	the underlying cause for overcharge insensitivity is the metering device used in the system. The metering device for the particular manufacturer operates similar to a thermostatic expansion valve (TXV) which also mitigates the impact of overcharge on system efficiency.
35	Chandler von Schrader, National Program Manager, ENERGY STAR Verified HVAC Installation	ENERGY STAR currently partners with Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E) to deliver the ENERGY STAR HVAC Quality Installation (ESQI) program. The ESQI program is designed to achieve energy savings by verifying that contractors are installing replacement HVAC equipment in accordance with guidelines based on the Air Conditioning Contractors of America's (ACCA) HVAC Quality Installation Specification (ANSI/ACCA 5 QI-2010) and their verification protocols (ANSI/ACCA QIVP 9). SCE has made tremendous progress in their program's delivery; it is the flagship program for ENERGY STAR's QI program and serves as an important resource for ESQI to share best practices across the country. Successful energy efficiency programs in California often lead the nation to achieve greater energy savings. However, if a California program is perceived as not being successful or cost-effective, it can have a chilling effect on other utilities across the country that might be considering a similar program. As the manager of ENERGY STAR's existing homes' HVAC programs, I've been invited to join the Western HVAC Performance Alliance in order to gain insight on how best to leverage and grow our ENERGY STAR brand inside California's HVAC	The pre and post energy consumption is not equivalent to the savings from quality installation since the baseline for unit efficiency is energy code, not the existing system. See discussion of customer bill savings vs. program evaluation above. A primary conclusion from the study is that some aspects of the program could further exceed energy code, but much more importantly the baseline homes indicate many cases where performance is not as poor as assumed. The larger sample would allow for more analysis to determine the frequency in which there are poor installations and the frequency of installation that already achieve code minimum performance.

		programs. Our recent WHPA calls have focused on Work Order 32. I wish to echo comments I've heard by members of the working group concerned that this study's methodology could have been more rigorous, and as a result the study's findings may be of limited validity. The report's authors seem to agree, as they propose to expand the non-participant sample size "given the relatively small size of the sample in this study." Unfortunately, many readers of the study may jump to the seemingly precise realization rates presented in Table 5 and conclude that HVAC QI programs are not cost-effective, while not realizing that 1) the baseline assumptions were built on a small – and likely unrepresentative - sample size and 2) a more accurate baseline study might significantly alter the realization rates shown in Table 5. I suggest that the realization rates be removed or at least be bounded by an appropriate margin of error based on the appropriate statistical methodology. I certainly recognize the importance of quantifying the impact of residential HVAC replacement and maintenance programs through evaluation, monitoring, and verification activities. Establishing a meaningful and transparent baseline condition to account for savings going forward is challenging. Yet I encourage the CPUC to consider taking a hard look at the actual energy usage (pre and post utility history) of SCE's 8,000 plus HVAC quality installations as a backstop to this and any future Work Order studies. Here's a novel thought: – let's make energy savings decisions by looking at metered data!	For the results in the executive summary the upper and lower bound and sample sizes have been added to the results tables.
36	ACCA & IHACI	CQM: In January of 2014, ACCA and ASHRAE sent a joint letter in regards to the KEMA study's portion of the final report on commercial quality maintenance (CQM) Standard 180 practices. In that letter, ACCA and ASHRAE stated that: "… the Study draws conclusions that are either generalizations or that cannot be verified. Furthermore, important aspects of a complete	No response.

		analysis were omitted." ACCA and ASHRAE recommend further analysis of applications in the field before CPUC undertook any actions based on the report. See the attached letter for the CQM inputs provided in January 2014.	
37	ACCA & IHACI	RQI: Poor Sample Selection: The report seeks to compare installations of program participants and nonparticipants. However, Section 3.2.1 (page 46) describes an inherent flaw, "This program is subject to self-selection effects at two different levels, and at each level it is more likely that the self selection effects will lead to increasing bias in the savings results." (Emphasis added) It later admits that "… the results should be interpreted as most likely being an upper bound" for comparison of program participants to upper tier contractors with very similar installation practices. Therefore these findings, which seek to compare the installations of QI program participants and "typical" nonprogram participants should be rejected.	The report includes this quote and other statements to clearly outline the limitations of the study. In addition, in the report the sample sizes and confidence intervals have been added with additional text on the validity and statistical significance of the findings. The direction of potential bias is acknowledged, but the study recruited customers and got a variety of contractors across tiers and followup study indicated a majority were not permitted.
38	ACCA & IHACI	RQI: Non-representative Baseline Group: It is widely acknowledged that less than 10% of the residential market has permits pulled when existing HVAC equipment is replaced. Hence, utilizing permitted homes (which entails that Title 24 requirements are followed) as the comparative baseline group to utility program participants (entails satisfaction of Title 24 requirements) is misleading and greatly underrepresents the performance degradation of non-compliant installations in California. Furthermore, since the requirements of Title 24 and the ANSI/ACCA 5 QI Standard are well-aligned (i.e., Title 24 embodies the QI requirements), it should be expected that the participant group and the baseline group would have smaller performance differences than if the participant group was compared to a cohort sample drawn from typical	The wide acknowledgement of 10% is not based on a definitive study on permitting or the efficacy of non-permitted installations. Please see the PG&E Permit study which followed this study and shows that the non-permitted installations are also not as inefficient as assumed in workpapers

		California installations (i.e., the non-permitted, other 90%).	
39	ACCA & IHACI	RQI: Incorrect Procedures: Section 3.3.2 (page 50) describes equipment sizing procedures, "… nonparticipants… were assigned the default SHR in the Manual J software used in the analysis." Yet, use of sensible heat ratio (SHR) is not an appropriate method for equipment selection. Manual S procedures only use the SHR to select a preliminary target airflow for the heating / cooling system. The use of the SHR for any other aspect of equipment selection is in violation of Manual S. Furthermore, the verification process for the underlying load calculations were inconsistently undertaken between the program participants and the non-program participants. Non-participant's equipment sizing was based on assumptions or field measurements/observations. Hence, the Manual J load calculations were inconsistently followed and the equipment sizing comparisons were flawed; thereby, invalidating the comparative load sizing results. Therefore, the resulting findings fail to properly evaluate equipment sizing and should be dismissed.	It is incorrect that Manual J processes were inconsistent between participants and non-participants. It is correct that Manual S was part of program participant analysis and not part of non-participants. This key difference is acknowledged in the report
40	ACCA & IHACI	RQI: Comparison of Different Metrics: Section 3.2.3.7 (page 47) describes the data collection protocol to measure duct leakage – the metric is duct leakage to the outdoors (LTO). However, Section 3.3.1.1 (page 49) describes the Title 24 duct leakage tolerances – the metric is Total Leakage. Section 3.3.3 (page 52) states, "Both participant and non-participant duct leakage could be compared with Title 24 requirements and the work paper assumptions on duct leakage." Section 3.3.3 Table 19 (page 52), seems to compare measured LTO metric to the Title 24 Total Leakage metric. The comparison of disconnected metrics should be discarded.	Total leakage and leakage to outside was measured for all sites. We only compare like metrics. This is incorrect that TL is ever compared to LTO. This was clarified in the revised report.
41	ACCA & IHACI	RQI: Failure to Meet the Studies Purpose: Section 3.2 (page 45) states, "The team conducted site visits	It is important to first note that the overall average

		at 50 program participant and 50 non-program participant sites." Section 3.3.3 (page 52) states, "Five non-participants were in climate zones where duct testing and sealing were not required; these sites were excluded from the duct leakage findings." Section 3.3.3 Table 19 (page 52), notes only 36 nonparticipants duct systems that were tested for leakage, while Table 20 (page 53) notes only 32 duct systems were tested. This indicates that an additional 14 - 18 duct systems were not tested, or not reported. A valuable opportunity to evaluate the difference between the installations of participants and California-typical non-participating contractors was lost, or not reported. Because the study failed to meet an important objective, the findings need re-evaluation.	leakage findings do not change when reporting the results for the climate zones without duct leakage requirements. The remaining difference is due to additional exclusions due to testing issues. Note that five participants and nine non-participants were excluded due to QC. Leakage to outside was a secondary test and the difference in sample size between tables was due to unusable blower door conditions making the LTO test invalid. The data collected has been added as an Appendix, but report comparison table is unchanged.
	ACCA & IHACI	RQI: It is noted that Volume 2 (Appendices) of the Draft Report has extensive supporting data for all sections, except the Residential Quality Installation Section. Given the glaring faults in the report, the supporting data might have help third parties to duplicate the results or to better review the validity of the often conflicting, inconsistent, or flawed sections.	Added Appendix with RQI data
42	ACCA & IHACI	Based on the comments above, and the absence of collaborating information, ACCA and IHACI recommend that: • the WO32 report not be released in its current form; • report flaws be addressed and once the subsequent update is available, that	The reporting process in place allows a round of review and comment. Edits to the report based on these and other comments have been undertaken.

		adequate time be provided for dissemination, review, and vetting; and • in the interim, the WO32 report information and purported findings not be used for decision making.	
43	Donald Prather, ACCA	The California Public Utility Commission Energy Division programs are driven by incentives. Those incentives are designed to save energy during peak demand under cooling loads. WO 32 is designed to establishing maintenance and installation methods that will result in higher efficiency levels on peak demand days. This methodology ignores the consumers need to have savings based on monthly billing averages for heating and cooling. Until the utilities have the authority to look at what is the best plan for the home and building owners: peak demand energy saving measures will not be widely embraced and implemented by the market.	Noted, but the evaluation did show issues in achieving annual energy savings as well as peak demand reductions The CPUC expects the IOUs, as program administrators, to research, develop and propose new HVAC programs or modifications to existing ones to the CPUC for approval.
44	Donald Prather, ACCA	HVAC Impact Evaluation DRAFT Report WO 32 HVAC- Volume 2: Appendices 8/11/14 A.1: Performance Changes and Savings Estimates from Pre- and Post-loggers appear to be flawed. Since there is no airflow measurement taken after the service by the data loggers, the formula must use a constant value for CFM/SVsupply-I. Since part of the maintenance is changing filters one would expect the difference between enthalpy temperatures to decrease thus skewing the scores. A better approach would have been to use the fan law to evaluate the airflow based on the supply duct static pressure and the measured CFM. Thus, results on tables 11, 12, and 13 do not reflect the actual operational efficiency based on actual CFM at the times when the data was measured.	Airflow was measured pre and post. Clarification added to the report.
45	Donald Prather, ACCA	Table 24 on Page 61: It appears that energy savings for heat pumps were based solely on peak demand for cooling. From a consumer perspective that may not be the actual annual savings and benefit received. Thus, ignoring annualized energy usage and focusing on peak cooling demand probably does not reflect the annual cost for the consumer.	Since the CA IOUs are “summer peaking,” the benefit to the IOUs occurs during the summer when system demand is highest.

46	Donald Prather, ACCA	3.2.3.4 Refrigerant Charge on Page 47 does not state if Superheat and Subcooling were recorded. Pressures alone do not provide the information needed to evaluate system charge.	Superheat and subcooling were measured for all units. Statement in report clarified
47	Donald Prather, ACCA	Section 3 States in the 2nd bullet point on page 45 airflow should be 400 CFM. However, it is not noted what the design CFM should have been based on Manual S equipment sizing guidance (Manual S equipment selection is a code requirement).	Manual S was not a requirement of the 2008 code which pertained to the installations in this report. We are stating that the workpaper assumed 400 CFM in the measure case
48	Donald Prather, ACCA	Section 3 page 45 States in the 1st bullet point that units are typically oversized by 20%. It is not clear if this is over the Sizing limits in Manual S or over the sizing based on load calculations.	Agreed. The workpaper makes this assumption without documentation on whether that is based on Manual J or Manual S.
49	Donald Prather, ACCA	Page 42 2nd paragraph mentions decommissioning economizers as an option. Locking them in the minimum outside air position may provide the best result for obtaining the optimal peak load efficiency for facilities where they see no value in the additional maintenance required by economizers (needed to save energy during off-peak operation hours).	The recommendation referenced says replace economizers, which means replacement with a modern working economizer and not removing or using the non-operating economizer as a fixed outside air damper. De-commissioning is not an energy efficiency measure for programs, the statement is not intended to suggest decommissioning as a measure.
50	Donald Prather, ACCA	Section 2.5.2 page 41notes that contractors see economizer set up as retro-commissioning not maintenance is partially true. Making sure the dampers operate, and open and go to a marked minimum position would be considered as maintenance and technicians would have the tools for doing that as maintenance. However, measuring airflow and marking the minimum damper positions	Agreed that TAB technicians are needed since many units need minimum positions identified. Additionally, technicians should be able to verify the economizer responds to favorable

		requires additional tools, and the higher skill set. In the field that work is generally done by TAB certified technicians or senior start up technicians during equipment commissioning.	outdoor conditions through a cold spray test or similar test procedure.
51	Donald Prather, ACCA	Page 34 3rd paragraph notes that maintenance technicians do not have the tools to set economizer airflows. This relates back to the recommendation for Page 11 bullet 3: Upgrades in economizer controls that include temperature and humidity measurement increase the building owner's savings.	Agree with the statement that upgraded controls when setup correctly may aid technicians with this task
52	Donald Prather, ACCA	Section 2.3 page 27: Performance Changes and Savings Estimates from Pre- and Post-loggers appears to be flawed. Since there is no airflow measurement taken after the service by the data loggers, the formula must use a constant value for CFM/SVsupply-I. Since part of the maintenance is changing filters one would expect the difference between enthalpy temperatures to decrease thus skewing the scores. A better approach would have been to use the fan law to evaluate the airflow based on the supply duct static pressure and the measured CFM. Thus, results on tables 11, 12, and 13 do not reflect the actual operational efficiency based on actual CFM at the times when the data was measured.	Airflow was measured pre and post. Clarification added to the report.
53	Donald Prather	Table 8 on Page 19 does not appear to be justified for the number of pieces of equipment in each type of program. The CQM Package vs the Individual Measures is based on gross program numbers. Not savings per ton, Btuh, or per square foot or some other method for correlating what the numbers reflect based on the equipment. Thus, the claims are meaningless for comparison other than as a popularity contest.	The total savings by program are still relevant given the large differences. Clarification on total tonnage added, but total savings are most relevant for the comparison.
54	Donald Prather, ACCA	On page 12 all three bullet points: The idea is correct, however, the percentages listed are totally unfounded for field comparisons and the 1 finger and two finger damper setting will almost always result in exceeding ASHRAE 62.1 requirements and drive up the peak load cooling cost.	The percentages are based on laboratory measurement and are not estimated. The second statement is true that the rule of thumb methods do not achieve ASHRAE

			standards
55	Donald Prather, ACCA	Page 11 bullet 3 states: "The test results demonstrate that reducing minimum damper position can be a more reliable measure to improve cooling efficiency." Based on my experience in TAB in the field, dampers in the closed position will often provide up to 200% of the ASHRAE 62.1 required outside air. Upgrades in economizer controls that include temperature and humidity measurement increase the building owner's savings. To increase peak demand savings the only metric that will save on the load is to set the minimum outside air properly. Thus, from a utility peak load perspective, incentivizing upgrades on economizers that measure the operating airflow through the economizers offers the maximum energy saving potential.	This statement supports the economizer replacement/upgrade recommendation
56	Donald Prather, ACCA	From the recommendations I am in agreement with the first bullet point on page 9. Since all of the homes compared were Title 24 or title 24 plus QI the common practice bar was probably too high. Thus, the savings that could be achieved if equipment in all homes had permits pulled would be an interesting study. The one question that remains unanswered is: how many of the title 24 only homes were done by contractors that implement the QI standard for all of their installations? Many ACCA members have opted to do all jobs to the QI Standard to eliminate call backs and increase customer satisfaction.	There is not clear information on installing contractor for all non-participants. In many cases the installations were unpermitted based on the PG&E followup study. CALMAC ID: PGE0349.01
57	Donald Prather, ACCA	It was noted on Page 7 in the 1st paragraph that the older DEER calculation method was used based on data collected based on a previous QI work paper. That data and the work paper do not appear to be available for review. It appears that energy savings for heat pumps were based solely on peak demand for cooling. From a home/building owner's perspective that may not be the actual annual savings and benefit received. Thus, ignoring annualized energy usage and focusing on peak cooling demand probably does not reflect the annual cost for the consumer.	Annual cooling savings was included, and the heating savings was not addressed in the either the workpaper or the evaluation analysis. IOU workpapers and documentation of the DEER prototypes are available on the DEER website www.deeresources.com.

			Customer bill savings and program evaluation have separate objectives. See response on program evaluation objectives above in response number 18.
58	Donald Prather, ACCA	Page 5 the 1st paragraph appears to support retro-commissioning before implementing an ongoing maintenance plan. This is a nonstarter due to the expense involved. However, requiring system documentation and installation to meet the QI Standard's requirements on new equipment and using that data as a reference point for maintenance plans would be a viable approach for transforming the market in the future and for providing the information needed to do the maintenance plan design.	The utility programs could consider overcoming this cost barrier, since much of the energy savings result from repairing faults that affect unit efficiency through a retrocommissioning activity. The statement on using maintenance after QI for a long term MT strategy is noted
59	Buck Taylor, Roltay	LAB "The optimal charge was established using manufacturer charging charts where target suction temperature (ST) is a function of suction pressure and outdoor air temperature as shown in Figure 22 (Carrier 2005). The measured ST must be within +/- 5°F of the target ST." Can evaluation team better explain this? The target ST is also a function of mass flow across the coil – what AF setting was the "Laboratory Optimized" charge determined to be, and what was the barometric pressure?	The charging chart conditions are 400 CMF/ton at .25" static for near sea-level conditions.
60	Buck Taylor, Roltay	LAB "The out-of-box verification "A" test with sealed cabinet and 10" pulley was 13% less efficient than the manufacturer-rated EER. The out-of-box factory and optimal charge tests with no seal, 7 inch pulley, and A49 V-belt were 18 to 27% less efficient than the manufacturer-rated EER." Why was the pulley size changed to affect airflow? Is this something an HVAC contractor would do during normal set-up or maintenance?	No this procedure is done in AHRI lab testing to establish static pressure conditions specified in the AHRI standards. It would not generally be done in the field.
61	Buck Taylor, Roltay	LAB "The actual outdoor air leakage with closed dampers was 462 CFM or seven times greater than the 67.1 CFM rated leakage (Table 37)." Can you elaborate on the method to determine leakage	Airflow measured with and without sealing off the economizer. Evaluating HRV was not in

		here? Given the extremely high efficiency hit economizers seem to cause, would it make sense to explore the use of HRV ventilation for some of the cooling zones?	scope, but could be a measure for future IOU program consideration.
62	Buck Taylor, Roltay	LAB "Economizers save energy when the outdoor air is cooler than the indoor cooling set-point and they replace fixed outside air dampers to provide fresh air to satisfy ventilation standards in CA Title 24 and ASHRAE 62." What is the potential savings for the use of economizers versus the penalty?	We did not evaluate potential savings. A thorough examination should be made that considers an efficiency estimate of "free cooling" that acknowledges the small amount of cooling provided relative to fan power consumption when outdoor conditions are close to the economizer changeover setpoint.
63	Buck Taylor, Roltay	LAB "These standards are written in terms of CFM/person and CFM/building square feet, requiring a calculation specific for each building. HVAC technicians rarely know the required building ventilation, and often err on the side of providing too much outside air." Technicians may set them up this way initially, but they are also savvy and practical – usually economizers are closed and disabled immediately after the first cooling, comfort of bill complaint.	This acknowledges a primary issue that could be addressed through programs.
64	Buck Taylor, Roltay	LAB Sect 5.2 & 5.3, Tables 36 and 38: Why isn't there any data showing the factory charge in these series of tests? No technician is going to mess with the charge until he/she is paid to do so (or by a utility program); these tests introduce too many variables (although they are good bits of information).	Additional laboratory report is needed to show more performance at factory charge
65	Buck Taylor, Roltay	LAB Sect 5.2 & 5.3, Tables 36 and 38: If the intention of changing pulleys is to simulate changes in airflow, it would seem to me that you are getting false fan power information – was any attempt made to alter the airflow by increasing flow resistance to mimic an actual application?	Note that certain adjustments are made to pass rating tests and measurements with appropriate static pressures found in the field are part of ongoing tests

66	Buck Taylor, Roltay	RQI "When time permitted, after measuring the air flow in cooling mode, the team switched the unit to either fan only or heating mode depending on the effect on residents' comfort, allowed it to stabilize, and measured airflow again." Why was airflow measured in fan only or heating mode? How was this (above) used in the airflow analysis? Was airflow volume corrected for temperature and air density (altitude)? Without static pressure data we can only speculate whether "poor" airflow results are due to restricted ducts, poor coil choices or improper fan settings. Was Total External Static pressure data collected during the airflow tests?	Pressure data was collected and will be shown in the new RQI Appendix. Additional measurements were taken to assess whether cooling airflow was set differently in other modes, meaning there would be potential to easily increase flow through fan settings. Temperatures were recorded but mass flows were not calculated.
67	Buck Taylor, Roltay	RQI "The refrigerant liquid line and suction line temperatures and pressures were measured with the unit in cooling mode." What instrumentation was used to do this with?	This data was not used or reported. Similar high grade instrumentation as was used in 2006-08 evaluation, including industrial grade Crystal pressure gauges and platinum thermistor temp sensors CALMAC ID: CPU0028.01;
68	Buck Taylor, Roltay	RQI "For split systems, the cooling mode power and power factor for the entire condensing unit and the entire air-handler unit were measured." What instrumentation was used to do this with?	Fluke 345 meters
69	Buck Taylor, Roltay	RQI "Next, the Duct Blaster fan was then attached to the untaped return register and used to pressurize the conditioned space to 25 Pa above ambient pressure. Then the Duct Blaster fan was used to pressurize the duct system to 0 Pa relative to the conditioned space." Did you use the Duct Blaster to pressurize the building in addition to the ducts?	A blower door pressurized the building and ductblaster pressurized the ducts
70	Buck Taylor, Roltay	RQI "…there was no consistent information about what scope of installation work was done or how equipment was selected for non-participant sites. It was unknown if the installations included other changes to duct systems or if furnaces were	Data on fan motor was not explicit gathered but is part of Furnace information based on make and model number.

		included in air conditioning replacements." Was any data collected regarding the size, nominal efficiency rating and refrigerant type of the previous system? Was Fan Type (ie. PSC vs ECM) data collected? Was Fan Speed Setting (Tap or dip switch) data collected?	Fan speed setting types were also collected. All evaluation data is being made available after the final reports as part of the data warehouse effort.
71	Buck Taylor, Roltay	RQI "HVAC replacements within California must comply with relevant sections of Title 24, Part 6, which define the baseline regulatory codes for the program" Can you please confirm or provide a clearer citation for this – the 2008 Title 24 RCM we have refers to HVAC work under section 8.4 (page 8-20).	Footnote reference to Title 24 Residential Compliance Manual added.
72	Buck Taylor, Roltay	RQI Sect 3.3.1.1 pg 46. Title 24 requires a Load Calculation on all replacements. This is not mentioned in the requirements section. How many of the Non-participants that were permitted complied with this requirement?	Evidence of the load calculation was not available
73	Buck Taylor, Roltay	RQI "Residential-sized units are typically available in half-ton increments, so the analysis looked at distributions of units sized within half ton increments higher or lower than calculated." Except there are typically no 4.5 ton units. Additionally, most multi-speed systems (high-efficiency) are only manufactured in 1-ton increments.	Added clarification that 4.5 ton is not available
74	Buck Taylor, Roltay	RQI "The QI programs require the use of both Manual J and Manual S30 for equipment sizing; therefore participants' project folders contained a calculation of the sensible heat ratio (SHR) in accordance with Manual S. The SHR was used by participants' contractors to inform equipment selection." Manual S does not inform or create a SHR. Equipment capacity is a function of outdoor ambient, elevation, and return duct loads (airflow, temperature and grains of moisture). The AHRI capacity rating is performed at 95° outdoor, 80°F dB/67°F wB entering coil with 400 to 450 CFM and no additional duct loads that would modify the entering air density. The Manual S procedure is about calculating the return air entering coil conditions which are not	Manual S was not a requirement of the 2008 code which pertained to the installations in this report.

		only different than AHRI ratings, but may be different than the interior design or space conditions due to return duct location (attics) and leakage. Since the Manual S procedure is an obvious difference from code, why was this ignored in the study?	
75	Buck Taylor, Roltay	RQI "The data in Table 17 show oversized and undersized units in both the participant and non-participant samples." The QIV program requires units at design conditions to fall within 115% of load for A/C and 125% of load for Heat Pumps. How do the units depicted in Table 17 compare to the QIV requirements?	15% of any of the loads will be within a half-ton
76	Buck Taylor, Roltay	RQI "The evaluation team applied Manual S site-specific SHRs provided by the participants' contractors." Please better describe this process by providing an example. What document did the contractor site-specific SHR come from? How was this used to determine oversizing?	Each program participant had a project file including calculations and other documentation. The data source was the program project file. This altered the target value to determine if the program participant unit was installed within one half ton of the Manual S result.
77	Buck Taylor, Roltay	RQI "Since non-participants did not use Manual S calculations, they were assigned the default SHR in the Manual J software used in the analysis." How does this method compare to the actual Manual S procedure used by participant contractors? How do the Manual S capacity calculations compare to the Manual J load calculations for participating sites? If Manual S was used on non-participants, would it result in a different outcome? How do the Manual S capacities provided by participant contractors compare to the AHRI rated total capacity? Did the evaluation team utilize the coil interpolation tool in the RHVAC software to perform any Manual S calculations?	Participant Manual S and Manual J results are shown in the report. Comparison of Manual S to AHRI are exactly what is shown in the final comparison figure. We did not perform independent Manual S calculation using RHVAC

		If yes, how did they compensate for the entering air conditions?	
78	Buck Taylor, Roltay	RQI "The QI workpapers assumed that non-participant units provide airflow of 350 CFM per ton." Can you please define the CFM per ton metric? Is this "per nominal ton", per AHRI rating divided by 12,000 or per Manual S capacity divided by 12,000 BTUH? Can you expand Table 21 to illustrate the above 3 definitions of CFM per ton applied to the sample data?	Cooling tons established per AHRI rating The New RQI Appendix can show all data needed to make the calculation
79	Buck Taylor, Roltay	RQI "There were participant systems with low airflow as well and improving the airflow of those systems would increase program savings." Were tap speeds or dip switch settings noted for any of these tests? The tap speed setting should inform the evaluator to the ballpark CFM. This should then be compared to the designed CFM from the contractors Manual S results. How do participant sites actual CFM compare to the design CFM?	Speed settings were captured We did not compare measured to design CFM
80	Buck Taylor, Roltay	RQI "Table 22 shows the mean power consumption per ton was lower for participants (0.486 W/CFM) than for non-participants 0.569 W/CFM)" What was the distribution of fan types between the respective populations? What were the static pressures relative to the relative populations? What was the change in fan power (pre versus post) and power factor by fan type for the various populations? What affect would altitude have on power draw for an ECM motor? What affect would station pressure and humidity have on the measured CFM for and ECM motor? What affect does a high-efficiency evaporator coil have on ECM fan power consumption versus a standard 13 SEER coil?	Fan type was not an explicit variable so this analysis was not conducted. Recorded pressures added to new RQI Appendix. There is no pre-post information. Sites were in low altitude locations We did not evaluate the variation in fan power based on coil efficiency
81	Buck Taylor, Roltay	RQI "Simulation…. The results were then input into the same single-family prototypes used in the program workpaper…" Can you elaborate on what this simulation is? Is this a spreadsheet analysis or	The IOUs used an eQuest DEER prototype. The same model was used and only the inputs addressed by

		something else? Do all the IOU's use the same assumptions and/or prototypes?	the workpaper were altered. The DEER prototype models are documented on the DEER website: www. Deeresources.com
82	Buck Taylor, Roltay	RQI "For non-participant sites, peak cooling loads were calculated with Rhvac Version 9.33" Can the evaluation team please confirm this version number? The highest (latest) version publically available from Elitesoft and in current use by RQI contractors is Version 9.01.129.	Corrected - 9.01.129 was used
83	Buck Taylor, Roltay	RQI "The analysis team reviewed each of the participant models to confirm that the input values were consistent with the data we collected at that site." Were any differences found, and if so, how were they treated?	The data was consistent as stated in the sentence.
84	Buck Taylor, Roltay	RQI "Ambient conditions were modeled by selecting a reference city based on geographic proximity to the site or, in the absence of a nearby reference city, on the most climatically similar reference city available." How does this method compare to the individual IOU implementation teams methods for design weather data? Were there any differences between the various IOU implementation teams in their design methodology including this parameter? Title 24 requires the use of the design data in Table J2. The QIV standard requires compliance with all code specified requirements. The J2 table data can be several degrees different and altitude may be dramatically different. Can you explain how this may affect your load calculations?	This is the same method, but not all communities are listed in the table. Sensitivity of load calculations to differences in temperature and altitude was not evaluated.
85	Buck Taylor, Roltay	RQI "Within The General Project Data Section, modelers selected duct roughness factors based on the observed predominant duct material (e.g., aluminum, fiberglass, steel), as well as minimum and maximum air velocity based on the observed predominant duct type (rigid or flexible)" What impact does this have on the load calculations?	A sensitivity analysis was not performed
86	Buck Taylor,	RQI "The winter (heating) and summer (cooling)	We did not do a

	Roltay	thermostat set-points were entered from the observed heating and cooling schedule.36 Where schedule information was not available, default-modeling setpoints were 68°F for winter and 80°F for summer." What interior design temperatures are required by Title 24 versus the QIV Standard? Were any deviations in the QIV standard interior design values observed among participating sites? What impact(s) on the load calculation will any differences in this design parameter have?	comparative analysis on actual onsite values and Title 24
87	Buck Taylor, Roltay	RQI "The difference between the air entering the rooms and the inside design temperature of the system is the winter or summer leaving coil-room delta T value (in degrees). The inputs for these modeled values were taken from the difference in supply and return temperature logger readings during the cooling and heating mode operations. In two cases the supply and return temperature information were unavailable for the heating or cooling modes, the default values of 70°F for winter and 20°F for summer were used." What is this information used for in the load calculations or software in general? If the purpose of a load calculation is to design a system prior to its installation, why did you use logged data for the model? Are the default values listed here the same in all the design software suites?	For the ex post evaluation we focus on measured in-situ conditions, as these conditions provide the best estimate the impact of design choices on energy consumption. We are not certain of defaults in all software available as this effort was not part of the scope of the evaluation.
88	Buck Taylor, Roltay	RQI "The building shell infiltration data were entered into the Rhvac single-point blower door method section" What method did the participant sites use? Was infiltration testing performed on participant sites, and if so, were the participant sites load calculation modified to reflect the actual measured data? How did the participant contractors values compare to the evaluation teams measurements?	Infiltration data was recorded and variation between program files and measured value was within the measurement uncertainty of the blower door
89	Buck Taylor, Roltay	RQI "When TrueFlow data on system air flow in cooling or heating modes were available, the modeler changed the default system air type from "auto" to "fixed" and entered the average recorded airflow rate for the cooling or heating mode. When	Measured airflow provides a key metric for the assumed workpaper savings. The airflow element is not directly

		TrueFlow data were not available, the default 'auto' system air type was used, and Rhvac calculated the required airflow rates." Please explain what the "auto" setting provides for airflow compared to the "fixed" setting? How does the evaluation team's method compare to the participating contractors or IOU Implementation methods? If the purpose of the load calculation and system design procedure is to prescribe design airflow (the goal or target CFM), can you explain the justification for using measured airflow? How can your model describe a delta if the goal is the result? How does the measured airflow compare to the initial Manual J design CFM?	measured for participants using the same method so we focused on comparison of like methods between participants and non-participants
90	Buck Taylor, Roltay	RQI "For ductwork characteristics, modelers selected the inclusion of sensible and latent cooling duct gains." If this setting is not selected, how does it affect the load calculation? How does this compare to the methods utilized in the QIV program?	For sizing calculations this was done consistently with program calculations. In addition, this is consistent with program modeling using the DEER prototypes. Sensitivity analysis was not performed
91	Buck Taylor, Roltay	RQI "The duct leakage rate was calculated as the quotient of the flow rate (in CFM) result from the DuctBlaster duct leakage to the outside at 25 Pa and the Rhvac calculated total duct surface area to produce an overall ductwork leakage rate in CFM/ft2" How does this compare to the method used by QIV participants? How does this compare to the Title 24 leakage metric of 15% of Total System Fan Airflow?	Duct leakage for Title 24 is separate in the report, this is just focused on and is consistent with load calculations done by the program
92	Buck Taylor, Roltay	RQI "If the attic R-value was unknown, the modelers selected insulation values based on the vintage of the home and the historical Title 24 attic insulation R-value code requirements40, which are presented in the table below." How many sites used the assumed values versus actual values for attic insulation?	This was collected but is not in the new RQI Appendix data table. All building shell information will be compiled in the data warehouse
93	Buck Taylor, Roltay	RQI "The following window characteristics were used for modeling all window fenestration except	Consistent with program

		skylights: internal shading blinds 45 degree light color and 50% drawn, insect screens outside with 50% coverage, ground coefficient = 0.23 (green grass), and no overhangs or projection included in models." How does this compare to the method or specifications used by QIV participants?	
94	Buck Taylor, Roltay	RQI "For all modeled sites, internal equipment loads of 2,400 Btuh sensible heat and 350 Btuh latent heat42 were used." How does this compare to the method or specifications used by QIV participants?	The evaluation reviewed program assumptions in models which did include site variation as well as variation in detail based on which of the two approved software packages were used. The site-collected data was used to develop assumptions for non-participants that were consistent with the level of detail of assumptions in program models
95	Buck Taylor, Roltay	RQI "Internal occupant loads were accounted for by entering the reported year-round occupancy into Rhvac…" How does this compare to the method or specifications used by QIV participants?	Unclear on how program collected occupancy data
96	Buck Taylor, Roltay	RQI "Load-calculation models were created for non-participants, while existing load-calculation models for participants were reviewed for consistency." Are the load calculation procedures used for non-participants consistent with the methods and specifications used by the participant population? Were any discrepancies found in the participant population calculations?	Yes although all non-participants used one software and participants could use two options. We chose the option that allowed inclusion of all available collected data
97	Buck Taylor, Roltay	RQI "Energy savings for participants relative to non-participants was then determined on the basis of proper system sizing, correct airflow, and reduced duct leakage." The savings for any projects is driven by the changes in overall system performance. The IOU's are forced to utilize existing DEER measures to estimate savings. The report does not describe any deltas for the respective populations, nor does it provide any insight into the relative mix of	Permitting is part of the PG&E follow-up study, and will be further studied in an upcoming project. CALMAC ID: PGE0349.01 NP contractor generally unknown but in many cases would be impossible due to location of NPs as

		permitted versus non-permitted projects and assumes the evaluation method correctly estimated loads, target airflows and system sizing. Were any of the non-participant projects installed by QIV trained contractors outside the program? Since Title 24 does not require sizing, wouldn't the evaluation team need to perform the same Manual S procedure to determine if the selected default SHR method described in the paper provides the same results? What affect does the difference in R-22 versus R-410A have on system performance at higher (than AHRI rating) outdoor temperatures? If there is a difference in system performance due to refrigerant properties at higher (or lower) outdoor temperatures, wouldn't this compound the sizing issue?	they were outside QIV qualified contractor service territories. We acknowledge the Manual S calculation difference, but are not performing an additional analysis. R-22 is not used in any of the sampled projects. Updated DEER models that include new performance curves for R-410A systems were not used in the IOU workpapers or this analysis. The impact of the new curves was not specifically studied, but agree they should be used in future studies.
98	Buck Taylor, Roltay	RQI "Participant units were found in single-family homes, duplexes, and apartment and condominium complexes throughout the SCE service area." What was the mix of the various housing types described?	Building type added to Appendix table
99	Buck Taylor, Roltay	RQI "Since the workpaper assumed non-compliance, it essentially presumed a standard practice baseline, not a code baseline. If it was assumed that participants would have met code requirements in the absence of the program it would have been possible to estimate free-ridership." Part of the purpose of this study was to determine a baseline. Please indicate the number of non-participants that meet the Load Calculation requirement in the code? Of the non-participants, how many in this study paid a permitting fee? Wouldn't you be able to determine the Free-ridership issue by defining the baseline case practice for load calculations? Since code doesn't require Manual S, wouldn't this make free-ridership "0" for this element?	See PG&E Permit Study for number with permit documentation on Load calculation – CALMAC ID: PGE0349.01

100	Buck Taylor, Roltay	RQI "Manual S allows up to 140% sizing relative to Manual J which leads to participant systems that don't meet the workpaper assumption that all participant systems are sized to the load." Manual S allows up to 115% for cooling only and 125% for heat pumps and 140% for heating only – at design conditions. Given the evaluators used the AHRI rating total capacity to determine sizing, what affect would using the correct standard (Manual S) have on the results? What percentage of heating systems falls above the 140% threshold due to fan sizing requirements (for cooling)?	We compared Manual J to installed AHRI and then Man S for participants to AHRI. We did not summarize findings for heating
101	Buck Taylor, Roltay	RQI "Non-participants did not systematically oversize, but rather there was a wide range of sizing relative to load calculations." Since no sizing was performed by non-participants we would expect the sizing to load ratios to form a typical population bell curve, did the Evaluation Team determine the size of the system previously installed? Were any building improvements made between system change-outs? If not, is it assumed that the new system is the same tonnage as the old?	Previous system size is irrelevant to the savings calculation. This information is recommended to be collected in the report to document early replacement claims
102	Buck Taylor, Roltay	RQI "There is no data provided for reviewers to perform a proper review and engineering checks on to validate or properly react to the statements made in the report." The Non-participant houses did not get the same level of engineering that was applied in the program, how can comparisons be properly made across the different populations? Please list the training classes and experience of your modelers in the use of the RHVAC software used in the analysis? Did your modelers have access to any EPIC-ACCA certified instructors for support during the modeling efforts? Did any evaluation staff attend any of the various IOU Implementation providers QIV training prior to modeling efforts? If yes, please list dates and details of training. Did the evaluators compare program QC data to	This is begins with a quote of another comment. See previous responses. The program participants had documentation generated by the program that was not present at non-participants. The calculations and data collection for EM&V were consistent for both groups and the evaluation is based on that consistency. The report shows that the Manual S process for participants improves correct sizing. Since non-

		their test data? Please provide copies of load files, system information and site surveys (we will need location information as well) along with any testing of systems.	participants did not have the program documentation requirements their sizing remained relative to Manual J. The evaluation firms were vetted by the CPUC for qualifications related to the evaluation. Personnel information cannot be provided in the public response format. Evaluation staff have been trained on the data collection and analysis software used in the evaluation. The specific courses mentioned were not attended. The program files were compared to data, but QC data was not provided, program data was after QC when provided via request. The data request is noted and all data is provided to the CPUC after report finalization.
103	Buck Taylor, Roltay	CQM Are psychrometric calculations being adjusted for atmospheric pressure?	Yes
104	Buck Taylor, Roltay	CQM Was the Outdoor Air Fraction calculation adjusted to account for fan heat? Please provide an example or illustrative example of how this calculation was performed.	Yes, more detailed site files added to the Appendix
105	Buck Taylor, Roltay	CQM Power factor is an important consideration - if fan speeds were changed or static pressure change due to other measures then power factor may have changed. Input voltage also affects sync speed and	This is unclear, static pressure measured and true RMS power meters were used to measure fan

		slip: was any of this accounted for in air mass calculations?	power, which include consideration of power factor in the metering.
106	Buck Taylor, Roltay	CQM Was voltage data analyzed on 3-phase systems for voltage imbalances, or otherwise low-voltage? Voltage can affect fan and compressor speeds – were any adjustments made for changes in voltage if there were differences between tests? Was logged power measured on one leg, or all legs? Were spot measurements taken with hand-equipment (Fluke) to compare legs and against data suite?	True RMS watt transducers used with power measured on all legs. See Appendix A for site instrumentation documentation. These values were verified with spot true kW measurements.
107	Buck Taylor, Roltay	CQM "Figure 1: Packaged Unit Airside Metering Schematic" Can you explain what the item labeled "Relief Hood" is – what function does this serve? Did the tested units have fixed ventilation intakes with hoods?	Units had economizers and fixed ventilation, the schematic may not represent all units and is intended to be illustrative of measurement points not unit layout
108	Buck Taylor, Roltay	CQM "The metering suite included nine (9) temperature/relative humidity (temp/RH) sensors. In a typical installation, the evaluation team installed two (2) sensors in the return plenum just upstream of the unit's curb mount; one (1) underneath the economizer hood in an area shielded…" I commend the evaluation team for taking this approach; however was any effort given to determine mass flow for each or any of those sensor locations? Are reported airflow measurements adjusted for temperature and altitude or just raw output?	Enthalpy calculations included compensation for altitude and air density. Volumetric flow rates measured for supply flow rate only; no volumetric measurements made at OA intakes or returns. Air density calculations considered temperature and altitude.
109	Buck Taylor, Roltay	CQM "Units were not weighted by program savings, but rather the specific results were turned into an average savings per ton and then extrapolated to the program tonnage claimed." Any chance the analysis shows a pattern between those that showed positive versus negative savings? IE – overcharged versus undercharged, economizer adjustments, airflow adjustments, and coil cleanings?	There is no measure level analysis given the numerous combinations. Revised analysis includes an engineering review for each unit; one could make some generalizations about the types of faults or repairs made to the best and worst

			performing sites, but cross-sectional analyses were not performed.
110	Buck Taylor, Roltay	CQM "Lab testing indicated that manufacturer refrigerant charge protocols provided the best set of diagnostics for all possible faults, but still provided false diagnostics in some cases." Please clarify: does this mean weighing in charge clears other faults (other than charge) or that when the system was analyzed afterwards that other faults were now more easily assessed?	No – this means the manufacturer FDD protocols were most effective in identifying faults set up in the lab. They however were not 100% effective in identifying all fault conditions.
111	Buck Taylor, Roltay	CQM "Field staff and master technicians only assessed installation rates for charge adjustments and economizers given the challenge of assessing coil cleaning months after service." How does the Master Technician determine the effectiveness of coil cleaning? What objective data is used to do so? Wouldn't this data also be important months after the cleaning to determine a fouling rate to help guide the use of coil cleaning as a measure in the future?	We did not report the installation rate on coil cleaning due to the timing of assessments. Activity is planned for 2013-14
112	Buck Taylor, Roltay	CQM "The evaluation team found that a majority of economizers (75%) were not functional after servicing, and that a number of other issues were not addressed by the maintenance, which likely led to misdiagnosis or misadjustment of refrigerant charge." How does the presence of an economizer play a role in refrigerant charge analysis? This statement seems misleading.	This connection is based on lab data. The reason is that FDD targets such as superheat require coil entering conditions, but when these targets are developed it is on systems in labs with no outside air. Once an economizer or outdoor air intake is added to a system, the coil entering conditions are difficult to measure in the field, confounding the results of the FDD tests.
113	Buck Taylor, Roltay	CQM Are the CQM programs utilizing formal FDD methods, or does this statement refer to limited evaluations such as Charge Diagnostics? Can you provide a table of what FDD methods are being applied in the respective programs?	FDD methods can vary for 2010-12 statewide programs. This is clarified and the methods used by third-party /local are

			clarified in the text.
114	Buck Taylor, Roltay	CQM There is no mention of maintenance rates or previous program participation of equipment prior to measures or monitoring. What affect does prior service have on the program? What data can you provide that shows the various faults your team and master technician identified in the field and data logging sets? Was evaluator field data compared to technician reported data in respective IOU tracking systems?	A new summary table provides pre-maintenance issues. Yes the field data was compared where data was provided. There are gaps in the IOU data sets. Existence of stickers indicating prior program participation was noted in the site reports.
115	Darryl DeAngelis, Belimo	The following statement is apparently made without taking in consideration economizer savings, only the waste potential; "If economizer dampers are closed when units are decommissioned, laboratory tests indicate cooling efficiency can be improved by 5% to 140% depending" A non working economizer may waste energy, the resolution is to fix the problem. As noted in a previous comment, the net energy savings need to be identified. The operation of the supply fan (thermostat on Auto or On) will also have a big effect on IAQ and energy waste. The damper only leaks when there is a pressure differential. A damper, if the control and mechanical are properly functioning, will only be at a correct or excessive minimum airflow position when the fan is operating. Future study efforts need to focus on these items and the Net Energy use, not just wasted energy in Mechanical Cooling or Heating mode.	Agree that savings must account for all aspects affected by the program. We re-analyzed the data to look at ventilation and cooling and compressor heating from heat pumps with changes to the report. We did not record gas data.
116	Darryl DeAngelis, Belimo	Certainly not verifying mechanical functionality is a deficiency. Proper training is required coupled with new control with FDD. The FDD will help identify the problems, but is not a complete solutions. Training and technology must be hand in hand. Our FDD will identify if a damper doesn't fully open, it will also identify if supply air is not where is should be. This can assist with identifying a problem. Giving up and decommissioning economizer is wrong approach towards energy savings.	Agreed that decommissioning is not a measure. Replacement of the component is recommended. See comment response #49

117	Darryl DeAngelis, Belimo	One of the largest challenges with a new RTU or existing is to properly set the OA ventilation rate. Such a effort is not QM, it is TAB and Commissioning and requires special tools, skills, and equipment. Without properly applied and tested airflow measuring equipment, every adjustment is a rule of thumb or rough calculation assumption. Even with good airflow measuring systems, there are still accuracy tolerances may provide excess air. The CPUC should be careful with assuming what the ventilation should be. Do not loose focus on building IAQ chasing after energy savings.	Distinction to be made. See previous comment and response #50 and 55 on TAB versus QM.
118	Darryl DeAngelis, Belimo	Note that this study was done prior to the industry introducing and implementation new economizer solutions. Belimo developed the ZIP Economizer to assist the industry in solving many of the problems noted in this report. Belimo would be happy to work with CPUC and IOUs to identify how this new solution (built in tools) can assist in correcting some of the problems, such as setup, commissioning, diagnosis, position. It also should be noted that the IOUs are making an effort to change the CQM program to using new controllers. Although there needs to be improvement in technician training to ensure sustainability as this report has pointed out if a new control is installed without ensuring mechanical functionality, then it isn't worth the effort. Manufacturer certified training should be a pre-requisite.	Noted
119	Darryl DeAngelis, Belimo	Is there any measured data and calculations showing efficiency improvements and degradation related to the following statement "In some cases, there were negative savings due to increased loads from opening economizer dampers, which diminished any efficiency improvement benefits" This report focuses so much on economizers as energy wasters, and they may be if not working correctly, it doesn't emphasize enough the benefits. Making many people suggestion eliminating them altogether or decommissioning them as opposed to ensuring they work. For this report to be effective, the potential energy savings for a properly	The goal is not decommissioning. The goal is to get economizers functioning and understanding optimal setup. Clarification added that we are not suggesting decommissioning. See response #49.

		functioning economizer should be highlighted and only then the net loss of energy for broken economizer or assumed over ventilation.	
120	Darryl DeAngelis, Belimo	Future testing should be performed with actuators that provide position feedback. I have provided the WO32 team with a sample actuator for use in the Plano lab. Note: the new ZIP Economizer Control uses this feedback to provide position. Additionally it scales actuator to damper to always work 0-100% operating range for clearer position identity.	The results of this should be presented by the 2013-14 lab testing study as the ZIP Economizer Control was provided after the WO32 funded lab activities
121	Darryl DeAngelis, Belimo	The statement "closed dampers that deliver 15% outdoor air through damper and other sources of leakage. This amount of leakage, 15%, satisfies the minimum outdoor air requirements for most building occupancies per ASHRAE 62.1 and Title 24." is assuming RTU supply fans are on 100% of occupied time. Often owners run fan in auto position. In this case the space may be under ventilated with dampers closed. Recommend attention to operation modes and IAQ measurements in future studies before determination to close all dampers assuming that the correct ventilation is maintained.	This statement can be clarified. It is correct that fans cycling on with compressors may not meet OA requirements solely through leakage. Agree that outside air rates need to be evaluated and the leakage must be taken into account such that it is known and part of calculations
122	Darryl DeAngelis, Belimo	Certainly a replacement will ensure new parts and expected quality factory assembly, however it will not improve leakage and doesn't solve the problem of service technician lack of knowledge to properly maintain economizer. Without proper training, the cycle will repeat. Additionally, manufactures of economizers aren't currently improving designs for old RTUs. Only if an RTU is currently manufactured would there be potential to obtain 10 CFM leakage design.	The recommendation text is revised to note that factors such as unit age should be considered in determining whether to repair or replace
123	Bob Baker, ASHRAE; EC Co-Chair	Maintenance is a Process; not an Event – Most of the content of the Evaluation Report focuses on discrete technician visits to a facility (one-time events). In developing Standard 180, the consensus body determined early on that Maintenance is a process that is dependent on a close relationship between the facility owner/manager, technicians performing the maintenance and service tasks and others (such as utilities) who contribute to the	The long term approach presents a challenge for program evaluation. The evaluation goals were stated to program staff and implementers. Even if the program allows multiple years for service actions the key actions

		maintenance process and this relationship matures over time. Only through periodic visits to and inspections of HVAC system components and the intervening discussions, reports and authorizations with and from facility management do technicians (service providers) gain the knowledge about and understanding of an HVAC system that leads to greater efficiency, enhanced sustained performance and an optimal indoor environment. In addition, decision makers over time develop the trust and confidence in service providers that leads to the needed authorizations to do what is needed to best enhance operational performance. By concentrating on individual 'service' visits, the evaluators have failed to develop any way to evaluate the success of the long term approach that is the objective of Standard 180 and related utility programs.	must be taken as soon as possible to be considered first year savings. The process outlined to the evaluation team was that most issues would be identified and repaired early in the process. If it was known that most actions would not be identified and addressed until the end of the 3 year agreement then it would be recommended that savings be claimed in later years.
124	Bob Baker ASHRAE; EC Co-Chair	Reliance on Manufacturer Maintenance Instructions – The report suggests that the best source of maintenance information is manufacturer literature. The Standard 180 Project Committee concluded that manufacturer literature fails to be a useful basis for HVAC System maintenance for several reasons: • Manufacturer literature can be difficult to obtain – Owner manuals and other manufacturer provided service guidance is almost never available to service technicians. Such documentation is kept at a location distant to the equipment, may have been lost and, where available, such archives are not well organized. Attempts to access the correct literature over the internet can be frustrating due to the many different models and configurations of equipment. Similar models from the same manufacturer may have very different performance and operational specifications so correct data for one model may not apply to another. • Manufacturer generated service information cannot incorporate field conditions – The essential reality of an HVAC system is that it is a SYSTEM and as	We agree with the difficulty in obtaining the documentation, but do not believe that should deter an incentive program. We also agree that manufacturer instructions are not based on field conditions. It should be noted that manufacturer troubleshooting guides do provide some methods that may work under many field conditions and others that may require incentive programs to develop new methods. Recent lab tests indicate manufacturer protocols perform more reliably than generic protocols. The lab test conditions were established to

		such is the sum of the various components rather than being those components. A given package unit may have very different operating parameters depending on its interaction with other system components such as controls, the air distribution system and ambient conditions where it is installed. Attempts to conform to 'laboratory' conditions as provided in manufacturer literature ignores the influence of all these factors. • For these and several other reasons, the Standard 180 Project Committee (which included several manufacturer representatives) rejected manufacturer provided service instructions as a basis for our useful content to be included in the standard. Correct refrigerant charge, for example, is highly dependent on the specific instillation of a unit and ambient conditions. The 'factory charge' is a starting point and often has to be adjusted to achieve the appropriate performance for the conditions on site. It would be a serious error for the commission to mandate (or even encourage) exclusive use of manufacturer protocols and other service information.	replicate realistic field conditions. An update of the lab test results will be provided as part of the 2013-4 evaluation activities. What maintenance instructions would the Standard 180 Project Committee recommend? If manufacturer instructions are not used then technicians and programs are open to using any method they deem suitable to meet the criteria of the standard. For energy efficiency programs there needs to be specific methods. Other studies (Braun) show issues using other available charge diagnostic procedures and other procedures for faults have been studied less. The report does not recommend exclusive use of any specific method but offers a recommendation that manufacturer protocols performed most accurately, but not without some issues, within the scope of the evaluation. The evaluation team encourages and applauds efforts of development and demonstration of methods that better focus

			on energy efficiency improvements.
125	Bob Baker ASHRAE; EC Co-Chair	Sample size – In every case in the report, the observations and conclusions were based on sample populations that were so small that any statistical reliability is impossible. Although I understand the challenges that the evaluators faced in securing both large populations to study and economic limitations that restricted the scope of the investigations, I am greatly concerned about the failure to acknowledge this inherent lack of reliability when stating conclusions and proposing recommendations. The samples are simply too small to serve as a basis for changing policy direction and this should have been acknowledged in the report.	The issue of sampling and coordination of activities was a mutual issue of both the study and the program. The report does not explain the results of the supplemental observations conducted which show similar issues for top contractors. Overall better coordination and cooperation would have mitigated the primary issues, thus we have reported based on the sample available. The confidence interval is provided, along with a discussion of potential biases in the sample. The small samples will be better acknowledged and supplemental samples explained. It is also acknowledged that a more representative sample with pre-post monitoring was the goal which was not achieved despite concentrated efforts.
126	Dale Gustavson, Better Buildings Incorporated	Commendation: Energy Division is to be commended for its inclusion of so many stakeholders over the months required for this evaluation. Actions of note include distributing the Interim WO32 Reports to the full WHPA member list, co-hosting the 3-hour WO 32 Interim Reports Webinar(s) with the WHPA, custom tailored	No Response Required

		reports/disclosure to WHPA committees and working groups by ED's consultants, WHPA Working Group attendance by ED consultants even when they are not presenting, distribution of the WO 32 DRAFT Reports to the full WHPA Member list, inviting WHPA members to attend WO 32 Reports Public Workshop, and setting up a system for WHPA members and other stakeholders to record comments on the Reports. It is clear that ED has bent over backwards to been inclusive, most particularly in the last six months following the release of the WO 32 Interim Reports.	
127	Dale Gustavson, Better Buildings Incorporated	Recommendation: Future evaluation plans would benefit by including more HVAC industry input into the Project Coordination Group (PCG). The 2010-2102 evaluation plan suffered in ways that could be avoided if HVAC industry SMEs were engaged as guests in PCG meeting/dialogue environments rather than simply been solicited for comments on proposed evaluation plans by email. I will comment further on some if the deficiencies in the evaluation plan below, but here simply make the observation that despite decades of energy efficiency and policy expertise participating in the PCG as currently configured, PCG expertise is not as strong as it could be in the business models/processes/procedures one the contractor/customer aspects of the CQM programs. Many of the difficulties/challenges cited by the evaluators themselves could have been overcome by having had industry input up front. NOTE: This is not a recommendation that the PCG operate under WHPA rules of governance. PCGs have their own rules of engagement.	Efforts have been made to ensure the industry is aware of the release of 13-14 research plans to provide comments on research before it is conducted. CPUC staff have reviewed these comments and replies and note this suggestion. Some PCGs have formed Program Advisory Groups (PAGs) that consist of non-IOU stakeholders. This may be appropriate for the HVAC work as well.
128	Dale Gustavson, Better Buildings Incorporated	Recommendation: Have ED staff or consultants more comprehensively capture oral questions and comments from stakeholders during webinars and workshops and then reply to the questions and comments in writing. While sending replies to individual spoken remarks might not be possible, those replies could be forwarded to the WHPA support team for posting and/or distribution. This recommendation simply builds on another outreach	A summary of stakeholder comments at the September 8 Workshop was compiled, but many more detailed comments were received in writing. We have taken into account comments made at that meeting in our

		effort for which ED is also to be complimented. When the WO 32 Interim Reports were distributed to the WHPA member list, at ED's direction the WHPA support team requested that members to send written comments and questions to the WHPA. WHPA support team organized them into a single document and forwarded them to ED. ED and its consultants provided written responses. Expanding this to include the capturing of more oral comments is important. WHPA volunteers have donated over $3 Million worth of time and expertise to helping implement the California Energy Efficiency Strategic Plan (CEESP). When they sit in two to four to even full-day workshops and make provide constructive criticism or answers to direct questions, those comments should be considered and responded to. This would further expand the engagement of business leaders and subject matter experts in California energy efficiency efforts, a cornerstone objective of Decision 07-10-032.	final report draft. We do not have a summary of all the effort in the meetings mentioned so we cannot respond to comments outside of those provided in WO32 specific venues.
129	Dale Gustavson, Better Buildings Incorporated	Recommendation: Plan ahead to allow more time for written comments and questions especially by non-intervener stakeholders such as those who make up the WHPA membership. To ED's credit, in response to a written request from several stakeholder groups, the comment period was extended. Going forward, it would be better to build in a longer comment period at the outset. Expecting the IOUs and SMEs WHPA member organizations to reply in a matter of days to a report that took a year to write seems to fly in the face of ED's know desire to engage more fully with HVAC industry leaders/institutions.	CPUC staff have noted this comment. A balance is required on report review timelines and delivering more timely results
130	Dale Gustavson, Better Buildings Incorporated	Recommendation: Heed criticism, believe statements of fact, seriously consider recommendations, admit when mistakes are made, and cite important contributions by stakeholders, so that dialogue around EM&V literally becomes a two way street. Though ED's process of transparency and taking input have no doubt had a positive impact of the evaluation plan, substance of	The feedback will affect the analysis and plan of the 2013-14 efforts more so than the 2010-12 efforts since primary data collection between the interim and draft report was minimal

		the report, and the next round of CQM evaluations, those changes/improvements/course directions are not as obvious on the outside looking in because stakeholder input/contributions are not cited. Example: ED and ED's evaluation consultants were told by unimpeachable experts in the November 2013 WO 32 Interim Reports webinar that the consultants were misinterpreting the definition of "Inventory" in Section 4 of Standard 180. This is important because if the definition is misunderstood, the evaluation's observations/conclusions will be wrong. A more constructive process would be to acknowledge that the SME's were correct, that the consultants would adjust their evaluation to align with the facts, and thank the experts (in this case members of ASHRAE and ACCA who wrote Standard 180) in writing. Leaders of the WHPA seem to be asking, "If the WHPA is the official statewide HVAC advisory group, but nobody takes our input/advice, why should we waste our time trying to help." Of the $3 Million of volunteer in-kind consulting contributed by WHPA members since May 2009, $1 Million of effort was put forth in the last 12 months. What a waste if it is dismissed as uninformed, biased, or self-serving.	All comments on public drafts of both plans and reports will be acknowledged Comments and clarifications of the intent of the inventory were very helpful in improving our understanding of the intent of Standard 180. We also appreciate the effort of the WHPA subcommittee in recommending clarifying language to help improve the Standard going forward.
131	Dale Gustavson, Better Buildings Incorporated	Recommendation: Have ED's evaluators and researchers communicate their recommendations for improvements to standards, or training, or products, to the organizations who have the power/responsibility to make the recommended changes, and do so honoring those organizations' rules. For example, the ASHRAE Standard 180 Committee operates under a complex set of ANSI rules. Participation in the development of ANSI accredited standards must be broad-based and open. The watchwords are "transparency" and "consensus." Standard 180 was developed and is being updated for the second time by organizations, not individuals, and must adhere to the ANSI rules mentioned above. Thus comments made in as recently of May 2014 made by an ED evaluator during a WHPA Working Group that the definition	The elements outlined on the venues for providing feedback are noted and appreciated. The evaluation did not intend to evaluate industry standards but rather the programs. Since the programs were viewed by others as initial implementation of new standards then a burden was placed on the impact evaluation to do a process evaluation as well. A full list of the various

		of "Inventory" in the standard "…needs to change because the there is no point in doing maintenance if the fundamental concept of performance baseline lost." Nobody acquainted with Standard 180 or the CQM programs has lost the fundamental concept of performance baselines. Not one. The writers of Standard 180 and contractors implementing it in the field simply believe the word "Inventory" does NOT mean "diagnose all the systems to determine how to bring them to baseline." The inventory is a list of HVAC equipment/systems/parts without which a Standard 180-based maintenance plan can be developed. It is by designing implementing of the maintenance plan for the equipment documented in the Inventory that systems are brought to baseline over the timeframe acceptable/affordable to customers given their budgets and priorities, and that other energy savings measures are added. Maintenance plans can and often do include retro-commissioning activity. Maintenance plans can also include planned replacement (early retirement) of old, inefficient systems. You would not call a replacement "maintenance," but the maintenance plan can stipulate am early retirement. All that being said, if ED's evaluation team still believes the definition of "inventory" and its placement in the Standard need to change, it should respectfully submit comments to the ASHRAE Standard 180 Committee, or work with/through the WHPA CQM Committee or its "Section 4 Working Group."	elements controlled by various industry organization would be an excellent starting point for future studies to avoid generalizations made in the draft report. The 2013-14 studies will work towards identifying responsible groups and requesting additional information as necessary. We feel energy efficiency programs need specific procedures which may not align with the open requirement of the ANSI standard. Specific and transparent program procedures can piloted, evaluated, and refined. These specifics should fit within the overall standard.
132	Dale Gustavson, Better Buildings Incorporated	Commendation: One of ED's consulting team has joined or is planning to join the ASHRAE Standard 180 Committee. This ensures that lessons learned by ED's evaluation team will be offered for consideration to the ASHRAE Committee under the rules of the Society and ANSI processes required for this standard. This is a very constructive development, for which the consultant and ED should be highly commended. Collaborating with ASHRAE and the other HVAC industry institutions that donate their time to develop and maintain	No response required

		Standard 180 is an excellent way for members of ED's team to not only improve the Standard for use in California, but for use throughout the world in places such as NASA's headquarters and in Hong Kong where it has already been adopted.	
133	Dale Gustavson, Better Buildings Incorporated	Recommendation: The IOUs should give consideration to making their comments/responses to ED available to a broader range of stakeholders during the comment period. The WHPA could easily serve as conduit for the dissemination of IOU comments. The IOUs are well within their rights by responding to/commenting on the report directly to ED and, in essence, doing so privately. However, HVAC industry stakeholders would benefit greatly by having access to those IOU comments as they were preparing their own. The IOUs sharing their comments might well lead to having HVAC organizations affirm the IOU comments that they themselves had not yet considered. It is also likely that some comments submitted by the IOUs have also been submitted by HVAC industry organizations. This duplication could be avoided if the comments were shared. This is clearly an IOU decision to make.	CPUC staff have noted this comment and will bring it to the attention of and discuss with IOU staff.
134	Dale Gustavson, Better Buildings Incorporated	Recommendation: Future rounds of evaluations need more clearly disaggregate the narrative so that stakeholders can understand it, learn from it, and improve not only the programs, but practice in the private sector. The organization of Volume 1 and Volume 2 makes it nearly impossible to comment constructively and learn from the evaluation because it is too difficult to determine which programs are being discussed in the narrative. While many of the tables broke out data by program, the narrative did not. For instance I don't know which program's economizers weren't working a year after repairs. I cannot learn from this observation. This is just one of many examples.	New tables added to differentiate where possible. The variation in programs is noted and was not foreseen in planning as we assumed a statewide uniform approach
135	Dale Gustavson, Better Buildings Incorporated	Recommendation: When it is known that programs have already been improved, reports should note that changes have been made and that those changes should be applauded. For instance, the	Changes noted in these and IOU comments have been added into appropriate sections. But

		report recommends that advanced digital economizer controls (ADEC) upgrades replace economizer repairs because the new ADEC systems are far superior technology. This would be an excellent recommendation if it were made in 2010. However, ADEC was included in PG&E's program from the beginning, added to SCE's in 2013, and will be or has been added to SDG&E's programs in 2014 when the evaluation was being drafted. The evaluators know that this is the case, having used pictures of what are purported to be evidence of incorrect installations of the Honeywell JADE ADEC.	the information on 2010-12 has to be reported followed by the known changes.
136	Dale Gustavson, Better Buildings Incorporated	Recommendation: The evaluators, especially those making field observations must be cautious about becoming overly confident that they know everything and that only their opinions are correct. This will be addressed further in my responses to the Research Plan, but one example of mistaken overconfidence is worth documenting in these comments. In the WO 32 Reports Interim Report and in presentations made at the ACEEE Summer Study. As mentioned in #2, above, members of the evaluation team provided pictures of JADE ADEC installations claiming that the absence of two wires in the photo evidenced incorrect installations that rendered the ADEC systems useless and thus not able to save energy. But according to the manufacturer, the wires did not need to be connected for the JADE to be operational. One IOU program implementation team in particular was well trained by Honeywell's local JADE distributor as were contractors participating in the program. At the WO 32 Report public workshop the evaluators stated they learned about how to install the JADE ADEC from manufacturer's instructions. The program implementer and participating contractors had hands on field training by the distributor on top of the manufacturer's instructions. The implementer stands by the quality of the installations and that the economizers are operating correctly.	This is noted. Updated accurate information is required to evaluate the cause of measure performance. The units without the wired connections were not functioning at the time of site visit. The lack of functionality was verified through a functional test; the lack of the jumper was identified as the probable cause. If the instruction manual documentation is not correct then a foundation of evaluating the measures independent of the program is difficult
137	Dale Gustavson,	Recommendation: Future CQM Program evaluation	The Standard and the

	Better Buildings Incorporated	would be more constructive and instructive if ED and its teams of consultants became more fully acquainted with Standard 180—its original 2008 version, its 2012 update and the update activity recently commenced. In particular the ED team needs to become more acquainted with maintenance plans as they are envisioned by Section 4 of Standard 180, with maintenance contracts in general—particularly under what circumstances contractors are authorized to correct faults while on site and what energy impact measures must receive prior customer approval—and generally with how contractors and their customers transact business in the real world. Further, the ED team must learn to ask the right questions of the right people. Given the length and complexities of this recommendation, I will only comment on the last in the above list and address the other facets of this recommendation below. The report references interviews with technicians about whether economizer repairs or upgrades were part of the program or not. Apparently some didn't think they were. However, this particular question is more properly addressed to contractors, not technicians. A maintenance technician is charged with reporting economizer malfunctions. In most maintenance contracts, even a Standard 180-based contract, a complete diagnosis of the economizer, repairs, and/or replacements would require the contractor to provide pricing to the customer and require the customer to approve the work and when that work should occur. It is true that contractors do not always quote this work. They certainly should be doing so in the context of the statewide CQM program. A customer cannot approve an expense until provided a quote. When presented with quotes for more in depth diagnosis of economizer malfunctions, repairs or replacements, some customer still say "No" or "Not just yet." The benefit to ratepayers of leveraging the maintenance industry delivery channel, however, is that the maintenance relationship	workpaper assumptions may not be fully aligned based on this recommendation. The 13-14 direction to move towards individual measure workpapers mitigates this issue of assuming all possible repairs are performed on all units where the workpaper savings are claimed. We suggest our recommendation that enacting the standard as a non-resource market transformation effort seems more appropriate than assuming benefits when revisions to the standard is still being disseminated to contractors and technicians as well as evaluators.

		between the customer and contractor does not end. Good contractors, contractors who have a grasp of Standard 180 and the CQM programs and who are committed to promulgating efficiency will persist in those recommendations. Eventually customers say "Yes" as the result of finally grasping the value of the work being quoted and/or as budgets allow. But the entire process described above is certainly not the purview of field technicians. Tech's thinking economizers aren't a part of the program could be a totally irrelevant observation. NOTE: Were my comments being directed to contractors, I would be critical of them leaving their techs out of the loop, but these comments are not directed at participating contractors.	
138	Dale Gustavson, Better Buildings Incorporated	Recommendation: In the interest of California ratepayers, ED should seriously consider ignoring the field observations and perhaps even the metering aspects of this report and simply view it as one step of many in the right direction. The IOUs should NOT be credited with less than zero savings. I leave it to the professional evaluators and engineers to debate the more technical aspects, but make the above recommendation in all seriousness. There is no way the IOUs should be credited with less than zero savings based upon this report. Though the evaluation team will differ with the following, it is upon simple logic the recommendation is based. 1) The evaluators apparently did not review the Standard 180-described maintenance plans that are required by the program, nor the actual maintenance contracts that govern what contractors can and cannot do without prior authorization. Thus they could not accurately determine "where they were in the process." NOTE: According to Standard 180, the maintenance plan should include an equipment inventory, performance objectives, condition indicators, task tables (primarily 5-12 and 5-22 for the program), and task frequencies. To not review these	1 – All data available for M&V units was requested and this information was not provide proactively to the evaluation team. In some cases participants provided maintenance agreements. More importantly it was described to the team that the pre-post monitoring would capture all measures. In cases where additional measures required approval we returned multiple times to sites but were rarely alerted to when those visits occurred. The M&V process cannot wait for the full three years and efforts to accelerate measures to fit them within the M&V period would have been

		documents and the maintenance contracts of which they should be make a part is a serious oversight by the evaluators. This was observed in comments to ED after the WO 32 Interim Report was issued. The original authors describe Section 4 to be "the heart of the standard." Not reviewing these documents relegates them to being of secondary importance when the writers of Standard 180 clearly though otherwise. 2) If the evaluators were unaware of what aspect of the maintenance plan was being observed, the conclusions they draw cannot be relied upon. Certainly the evaluators/observers could be and likely were right about some of what they concluded, but it is also true that they could be totally wrong and often. As a result, many of the very instructive contributions the report might have made, will remain in question, and rightfully so. Example: Evaluation team members made thoughtful, convincing presentations of their findings at the ACEEE Summer Study. The photos were revealing, even disturbing. But what did the photos actually tell us? One picture was of an obviously filthy, energy efficiency killing heat exchanger. The presenters represented, as does the report, that the technician left the premises with the dirty coils still dirty and that therefore, the quality of work by technicians is terrible. By extension—though not explicitly stated in the ACEEE presentations or the report—there is the suggestion that contractors and customers are collecting incentives for work that is not being done. Perhaps surprisingly given the intensity of this criticism, I couldn't agree more that if contractors and customers are collecting incentives for work not being done—especially if they are reporting the work as completed—they should be kicked out of the program and return their incentives. Further and obviously, QA controls would also need beefing up. However, gaming not what is occurring here. Coil cleaning is not normally done "on the spot" when discovered in	captured by the evaluation. 2 – See above. The M&V goals were clearly stated to the programs in coordination meetings, but efforts were not made allow observations of all activities. The team was ready and willing to return to sites multiple times to observe all measures. The primary limitation of the M&V was the coordination with programs more so than the evaluation of whether the plans were adhered to. 3 – As noted in 1 and 2 in some cases the programs were not designed in a way that would allow effective evaluation. An "evaluability assessment" should be included in program designs so that effective evaluation studies can be planned and executed. Programs would not have been penalized for accelerating service on M&V units or allowing observations on units noted to have completed being brought to baseline after initial pre-maintenance observation. There is an obvious need to improve cooperation with program evaluators and design

		maintenance visits. Normally, if techs visually identify dirty coils, the coil cleaning is scheduled for the future—perhaps the next scheduled maintenance. Quite often the cost of coil cleaning (as is also the case for economizer work) must be approved by the customer because it is not in the maintenance budget. When the evaluators conclude that poor work is being done and that techs are leaving rooftops replete with kWh-gobbling systems unaddressed, it is likely they are wrong and their ultimate conclusions are also rendered mistaken. The efficiency measures need to be addressed pursuant to the maintenance plan and the contract that governs which measures can be corrected on the spot and what measures require additional approvals. 3) The SCE program tracks when RTUs are brought to baseline. Many of the RTUs in the report and among the field observations had not yet been brought to baseline. Some still have yet to be. But the point is that they are being and will be if that is what the maintenance plan calls for…. And it should. The evaluation plan needs to accommodate business models that, according to CBECs soon to be updated data, dominate the commercial sector. 4) I hesitate to include a rumor in comments to the CPUC, but it seems serious enough to do so. It was brought to my attention that some of the RTUs metered for the study may have been installed in RTUs that were not running. Thus, the baseline energy use would be zero. Once the RTUs were made operable the energy consumption would skyrocket. If data of this kind was not eliminated from the sample, it unfairly skews the results in the direction of small or zero savings. One could argue that this rare sort of event might occur could/should have been factored into the CQM workpapers, but this data does not belong in the evaluation, especially given the questionably small sample.	programs with evaluation in mind in the future. 4 – If a unit was not running and had no viable pre-maintenance data it was not included in the analysis
139	Dale Gustavson,	The Energy Information Agency considers	Per recommendation we

	Better Buildings Incorporated	maintenance to be an energy efficiency measure. California's plan to use the maintenance delivery channel to also increase retro-commissioning, energy efficiency measures focused on refrigeration cycle tuning, airflow improvements, controls upgrades, and early RTU retirement is sound. It is a sophisticated strategy rooted in market transformation. It is not a "direct install, widget program." The evaluation plan needs to match the sophistication of the program. I conclude with the vision for the HVAC sector as it is recorded in the California Energy Efficiency Strategic plan. Before doing so, it is important to note that Energy Division management personnel have joined members of the WHPA to change one word in what is recorded in the CEESP. The word is "industry." To keep it simple WHPA and some ED PPT presentations and documents replace the word "industry" with the word "market" which is what I plan to do below. This is totally in alignment with CPUC Decision 07-10-032 that concludes that changes in both HVAC industry practice AND utility programs must take place. The $37 Billion per year HVAC industry is not all that must change. Other market actors including regulators, their evaluators, and IOUs need to change as well. We all need to get better at our jobs. This will take innovation and unparalleled collaboration, cooperation, and communication. The residential and small commercial heating, ventilation, and air conditioning (HVAC) market will be transformed to ensure that technology, equipment, installation, and maintenance are of the highest quality to promote energy efficiency and peak load reduction in California's climate.	feel that the larger market transformation strategy would be best assessed as a non-resource effort allowing focused M&V on specific actions that lead to energy efficiency improvements and take into account adjustments for other non-energy benefits that may increase loads. Also agree with comment that unparalleled levels of cooperation are needed.
140	Don Tanaka, UA	Page B-1 B.1 Question I have is, is SCE statewide (Southern California Edison)?	Yes
141	Don Tanaka, UA	Page B-2 Par.4 If circuit 2 has a failed compressor (12th line), how	The assessment of failure is based on the readings,

		can superheat readings and other readings be obtained when the compressor has failed. It's broken.	the compressor is drawing power
142	Don Tanaka, UA	Also there is no mention on most of the comments from the evaluator if the system is a VAV or constant volume system which makes a big difference on taking readings.	Noted, where available this has been added to Appendix site information
143	Don Tanaka, UA	Page B-3 Fifth line from the top The Trane model number according to Trane alphabet may be missing. As it's written now, it's showing a 50HTZ unit and not a 60 HTZ which makes a big difference in the readings.	All model numbers have been reviewed per this comment
144	Don Tanaka, UA	Also no mention of bringing the compressor to full load amps to try to simulate design conditions and to check the charging chart to design conditions for correct charge.	Measurements were made with data loggers but spot measurements could not control ambient conditions. Diagnostic measurements made with unit in stable full cooling operation, but specific test conditions may differ from design conditions. Charging charts account for off-design conditions.
145	Don Tanaka, UA	B-5 Paragraph 7, fifth line Starts off as "Notched BX42 fan belt was improperly". The fan belt may have been to tight but no mention of checking amp draw of motor. This can be an important factor of the motor and bearings.	These measurements are made but tensioning should be independent assessment. Agree motor amp draw is also an important diagnostic.
146	Don Tanaka, UA	B-13 2nd paragraph, 7th line starting from "used discharge pressure instead of liquid". A very good observation, taking pressures on the liquid line instead of discharge line is a better way to get subcool liquid readings.	This is key as many assumptions are made on difference being 15 degrees but this varies often and manufacturers provide diagnostics based on the ports on their system (often discharge)
147	Don Tanaka, UA	B-19 Top paragraph, 10th line, using the word "superheat" The word superheat is used on R-410A, the word	Noted with footnote, but summary table will indicate superheat

		should be “Temperature glide” for this Refrigerant.	
148	Don Tanaka, UA	B-25 Seems like most techs are not checking for wear and checking voltage drop across the contacts.	Voltage was checked by master technician
149	Don Tanaka, UA	) B-26 Paragraph 4, 2nd line stating “compressor contactor was pitted” Did the tech check for voltage drop across the contacts to verify that the contacts are worn and needs to be replaced.?	Voltage was checked by master technician
150	Don Tanaka, UA	C-1 REFRIGERANT TUBE MEASUREMENT INSTRUMENT TEST Fourth line, “ mounted at 10:00 or 2:00 o’clock position” is incorrect. Please see my Attachment on Sporlan Thermostatic Expansion Valves dated June 2011/Bulletin 10-11 for the correct position of the sensing bulb. It should be 8 or 4 o’clock Position.	This is based on which position came closest to the measurement from inside the line in the laboratory. Thanks for noting the discrepancy; could be an error in the product literature.
151	Don Tanaka, UA	C 12 Table 13, Fan Belt Tension and Alignment Measurement Instrument Test Should also have a column on amp draw of blower motor. Again, you can have the correct tension but over amp the motor or destroy the fan bearing.	Noted for lab test reporting, This may not be fully addressed in this report but will be included in 13-14 lab report

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Southern California Edison
2015-2017 ESA-CARE App A.14-11-007

DATA REQUEST SET A.14-11-007-ORA-SCE-015 (2015)

To: ORA
Prepared by: Tory Weber
Title: Principal Manager, Energy Efficiency Portfolio
Dated: 04/16/2015

Question 05:

Please provide SCE Cost Effectiveness results for the ESACET for 2016 and 2017 when avoided CARE discount is included as a non-energy benefit in the calculation.

Response to Question 05:

In Exhibit SCE-02, page 113, SCE calculated an ESACET benefit cost ratio of 0.90 for 2016-2017. SCE's February 2015 cost effectiveness errata revised the calculation for the 2016-2017 ESACET benefit cost ratio to 0.78. SCE's 2016-2017 ESACET benefit cost ratio will increase to 0.91 when the avoided CARE discount non-energy benefit is included in the calculation.

SCE's response to ORA Data Request A.14-11-007-ORA-SCE-016 (2015), Question 1, provided the LIPPT workbook that performs this calculation for the avoided CARE discount non-energy benefit. The E3 calculator that was used to calculate the cost effectiveness results in the November 2014 testimony and the February 2015 errata would remain unchanged. SCE is attaching that E3 workbook to this response. Data produced by both the E3 calculator and LIPPT workbooks is used to obtain the ESACET cost effectiveness results.

Southern California Edison
2015-2017 ESA-CARE App A.14-11-007

DATA REQUEST SET A.14-11-007-ORA-SCE-015 (2015)

To: ORA
Prepared by: Tory Weber
Title: Principal Manager, Energy Efficiency Portfolio
Dated: 04/16/2015

Question 06:

Regarding the administrative costs provided to ORA in SCE's response to ORA-4, Q.3. Are the customer enrollment & energy education costs in Application Table A-1 considered Administrative Costs, for purposes of the Cost-Effectiveness calculation?

Response to Question 06:

As indicated in SCE's response to A.14-11-007-ORA-SCE-009 (2015), Question 3, customer enrollment and energy education costs link to the "c.i. Activity" cells in the "Input" worksheet of the E3 calculator. The "c.i. Activity" subcategory of inputs falls under "c. Direct Implementation (non incentive)." Customer Enrollment and In Home Education include contractor costs related for these activities. For the purpose of calculating cost effectiveness, the result is the same whether the costs are entered under "c. Direct Implementation (non incentive)" or within one of the E3 subcategories under "a. Administrative Costs".

Overall B/C Ratio	0.783440

Per Measure NPV Benefit-Cost (B/C) Ratio, including NEBs

Instructions: This worksheet is used to compute the NEB C/B ratio for each measure. Each populated cell of the white columns contains either "0" or "1". A zero "0" is entered when the energy efficient measure

Measure included is analysis, TRUE=yes FALSE=no	RRM Classification[2]	EULs	Energy Efficient Measure	Per Measure NPV Benefit-Cost (B/C) Ratio, including Non-energy benefits	NPV of Total Life-Cycle Dollar Savings - Over EUL of the Measures	Total Non-energy benefits - Dollars
FALSE		9.24	CFLs - Mobile Home 6		-	$0
FALSE		9.24	CFLs - Mobile Home 8		-	$0
FALSE		9.24	CFLs - Mobile Home 9		-	$0
FALSE		9.24	CFLs - Mobile Home 10		-	$0
FALSE		9.24	CFLs - Mobile Home 13		-	$0
FALSE		9.24	CFLs - Mobile Home 14		-	$0
FALSE		9.24	CFLs - Mobile Home 15		-	$0
FALSE		9.24	CFLs - Mobile Home 16		-	$0
FALSE		9.24	CFLs - Multi Family 6		-	$0
FALSE		9.24	CFLs - Multi Family 8		-	$0
FALSE		9.24	CFLs - Multi Family 9		-	$0
FALSE		9.24	CFLs - Multi Family 10		-	$0
FALSE		9.24	CFLs - Multi Family 13		-	$0
FALSE		9.24	CFLs - Multi Family 14		-	$0
FALSE		9.24	CFLs - Multi Family 15		-	$0
FALSE		9.24	CFLs - Multi Family 16		-	$0
FALSE		9.24	CFLs - Single Family 6		-	$0
FALSE		9.24	CFLs - Single Family 8		-	$0
FALSE		9.24	CFLs - Single Family 9		-	$0
FALSE		9.24	CFLs - Single Family 10		-	$0
FALSE		9.24	CFLs - Single Family 13		-	$0
FALSE		9.24	CFLs - Single Family 14		-	$0
FALSE		9.24	CFLs - Single Family 15		-	$0
FALSE		9.24	CFLs - Single Family 16		-	$0
TRUE		16	Exterior Fixtures - Single Family 6		2,535.68	$309
TRUE		16	Exterior Fixtures - Single Family 8		3,307.41	$403
TRUE		16	Exterior Fixtures - Single Family 9		6,394.32	$779
TRUE		16	Exterior Fixtures - Single Family 10		17,970.25	$2,189
TRUE		16	Exterior Fixtures - Single Family 13		1,543.46	$188
TRUE		16	Exterior Fixtures - Single Family 14		6,614.82	$806
TRUE		16	Exterior Fixtures - Single Family 15		1,874.20	$228
TRUE		16	Exterior Fixtures - Single Family 16		110.25	$13
TRUE		16	Torchiere - Mobile Home 6		4,222.90	$515
TRUE		16	Torchiere - Mobile Home 8		2,413.08	$294
TRUE		16	Torchiere - Mobile Home 9		3,619.63	$441
TRUE		16	Torchiere - Mobile Home 10		13,875.24	$1,691
TRUE		16	Torchiere - Mobile Home 13		301.64	$37
TRUE		16	Torchiere - Mobile Home 14		4,524.53	$551
TRUE		16	Torchiere - Mobile Home 15		7,239.25	$882
FALSE		16	Torchiere - Mobile Home 16		-	$0
TRUE		16	Torchiere - Multi Family 6		51,579.68	$6,284
TRUE		16	Torchiere - Multi Family 8		150,214.52	$18,302
TRUE		16	Torchiere - Multi Family 9		95,316.84	$11,613
TRUE		16	Torchiere - Multi Family 10		41,022.44	$4,998
TRUE		16	Torchiere - Multi Family 13		301.64	$37
TRUE		16	Torchiere - Multi Family 14		12,065.42	$1,470
TRUE		16	Torchiere - Multi Family 15		9,350.70	$1,139
TRUE		16	Torchiere - Multi Family 16		301.64	$37
TRUE		16	Torchiere - Single Family 6		41,032.02	$4,999
TRUE		16	Torchiere - Single Family 8		108,248.93	$13,189
TRUE		16	Torchiere - Single Family 9		110,138.57	$13,419
TRUE		16	Torchiere - Single Family 10		118,506.94	$14,439
TRUE		16	Torchiere - Single Family 13		4,859.05	$592
TRUE		16	Torchiere - Single Family 14		65,327.29	$7,959
TRUE		16	Torchiere - Single Family 15		41,841.86	$5,098
TRUE		16	Torchiere - Single Family 16		269.95	$33
FALSE		14	Refrigerators - Mobile Home 6		-	$0
FALSE		14	Refrigerators - Mobile Home 8		-	$0
FALSE		14	Refrigerators - Mobile Home 9		-	$0
FALSE		14	Refrigerators - Mobile Home 10		-	$0
FALSE		14	Refrigerators - Mobile Home 13		-	$0
FALSE		14	Refrigerators - Mobile Home 14		-	$0
FALSE		14	Refrigerators - Mobile Home 15		-	$0
FALSE		14	Refrigerators - Mobile Home 16		-	$0
FALSE		14	Refrigerators - Multi Family 6		-	$0
FALSE		14	Refrigerators - Multi Family 8		-	$0
FALSE		14	Refrigerators - Multi Family 9		-	$0
FALSE		14	Refrigerators - Multi Family 10		-	$0
FALSE		14	Refrigerators - Multi Family 13		-	$0
FALSE		14	Refrigerators - Multi Family 14		-	$0
FALSE		14	Refrigerators - Multi Family 15		-	$0
FALSE		14	Refrigerators - Multi Family 16		-	$0
FALSE		14	Refrigerators - Single Family 6		-	$0
FALSE		14	Refrigerators - Single Family 8		-	$0
FALSE		14	Refrigerators - Single Family 9		-	$0
FALSE		14	Refrigerators - Single Family 10		-	$0
FALSE		14	Refrigerators - Single Family 13		-	$0
FALSE		14	Refrigerators - Single Family 14		-	$0
FALSE		14	Refrigerators - Single Family 15		-	$0
FALSE		14	Refrigerators - Single Family 16		-	$0
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 6		109,466.09	$13,337
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 8		418,316.83	$50,967
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 9		883,547.70	$107,649
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 10		3,025,955.40	$368,675
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 13		727,167.58	$88,596
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 14		1,196,307.95	$145,755
TRUE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 15		544,082.72	$66,290
FALSE		10	Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family 16		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 6		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 8		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 9		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 10		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 13		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 14		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 15		-	$0
FALSE		18	Duct Sealing - Mobile Home Zone 16		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 6		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 8		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 9		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 10		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 13		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 14		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 15		-	$0
FALSE		18	Duct Sealing - Multi Family Zone 16		-	$0
FALSE		18	Duct Sealing - Single Family Zone 6		-	$0
FALSE		18	Duct Sealing - Single Family Zone 8		-	$0
FALSE		18	Duct Sealing - Single Family Zone 9		-	$0
FALSE		18	Duct Sealing - Single Family Zone 10		-	$0
FALSE		18	Duct Sealing - Single Family Zone 13		-	$0
TRUE		18	Duct Sealing - Single Family Zone 14		85,624.70	$10,432
TRUE		18	Duct Sealing - Single Family Zone 15		26,909.31	$3,279
FALSE		18	Duct Sealing - Single Family Zone 16		-	$0
TRUE		15	Evap Install - Mobile Home Zone 10		492,883.75	$60,052
TRUE		15	Evap Install - Mobile Home Zone 13		85,865.51	$10,462
TRUE		15	Evap Install - Mobile Home Zone 14		177,977.01	$21,684
TRUE		15	Evap Install - Mobile Home Zone 15		223,089.36	$27,181
TRUE		15	Evap Install - Mobile Home Zone 16		2,481.50	$302
TRUE		15	Evap Install - Single Family Zone 10		5,902,343.03	$719,127
TRUE		15	Evap Install - Single Family Zone 13		1,281,051.32	$156,080
TRUE		15	Evap Install - Single Family Zone 14		3,962,519.12	$482,783

	TRUE		15	Evap Install - Single Family Zone 15	1,176,300.38	$143,318
	TRUE		15	Evap Install - Single Family Zone 16	1,476.31	$180
	FALSE		15	Ht Pmp Replace - Mobile Home Zone 13	-	$0
	FALSE		15	Ht Pmp Replace - Mobile Home Zone 14	-	$0
	FALSE		15	Ht Pmp Replace - Mobile Home Zone 15	-	$0
	FALSE		15	Ht Pmp Replace - Multi Family Zone 13	-	$0
	FALSE		15	Ht Pmp Replace - Multi Family Zone 14	-	$0
	FALSE		15	Ht Pmp Replace - Multi Family Zone 15	-	$0
	FALSE		15	Ht Pmp Replace - Single Family Zone 13	-	$0
	TRUE		15	Ht Pmp Replace - Single Family Zone 14	140,035.24	$17,062
	TRUE		15	Ht Pmp Replace - Single Family Zone 15	35,434.93	$4,317
	TRUE		15	CAC Replace - Mobile Home Zone 14	144,560.57	$17,613
	TRUE		15	CAC Replace - Mobile Home Zone 15	227,778.17	$27,752
	TRUE		15	CAC Replace - Multi-Family Zone 14	33,073.59	$4,030
	TRUE		15	CAC Replace - Multi-Family Zone 15	28,771.98	$3,506
	FALSE		15	CAC Replace - Single Family Zone 10	-	$0
	FALSE		15	CAC Replace - Single Family Zone 13	-	$0
	TRUE		15	CAC Replace - Single Family Zone 14	420,663.23	$51,253
	TRUE		15	CAC Replace - Single Family Zone 15	474,170.39	$57,772
	TRUE		9	RAC - Mobile Home Zone 10	3,893.31	$474
	TRUE		9	RAC - Mobile Home Zone 13	1,823.61	$222
	TRUE		9	RAC - Mobile Home Zone 14	2,840.93	$346
	TRUE		9	RAC - Mobile Home Zone 15	4,110.18	$501
	TRUE		9	RAC - Multi-Family Zone 10	804.87	$98
	TRUE		9	RAC - Multi-Family Zone 13	120.58	$15
	TRUE		9	RAC - Multi-Family Zone 14	635.24	$77
	TRUE		9	RAC - Multi-Family Zone 15	513.77	$63
	TRUE		9	RAC - Single Family Zone 10	18,323.93	$2,233
	TRUE		9	RAC - Single Family Zone 13	13,646.39	$1,663
	TRUE		9	RAC - Single Family Zone 14	8,302.10	$1,012
	TRUE		9	RAC - Single Family Zone 15	8,242.51	$1,004
	TRUE		5	Smart Power Strips - Mobile Home 6	2,079.26	$253
	TRUE		5	Smart Power Strips - Mobile Home 8	4,494.87	$548
	TRUE		5	Smart Power Strips - Mobile Home 9	7,766.65	$946
	TRUE		5	Smart Power Strips -Mobile Home 10	21,404.16	$2,608
	TRUE		5	Smart Power Strips - Mobile Home 13	2,446.19	$298
	TRUE		5	Smart Power Strips - Mobile Home 14	9,754.18	$1,188
	TRUE		5	Smart Power Strips - Mobile Home 15	2,415.61	$294
	TRUE		5	Smart Power Strips - Mobile Home 16	183.46	$22
	TRUE		5	Smart Power Strips - Multi Family 6	27,825.41	$3,390
	TRUE		5	Smart Power Strips - Multi Family 8	91,028.85	$11,091
	TRUE		5	Smart Power Strips - Multi Family 9	36,387.08	$4,433
	TRUE		5	Smart Power Strips - Multi Family 10	41,982.74	$5,115
	TRUE		5	Smart Power Strips - Multi Family 13	2,935.43	$358
	TRUE		5	Smart Power Strips - Multi Family 14	26,724.63	$3,256
	TRUE		5	Smart Power Strips - Multi Family 15	5,442.77	$663
	FALSE		5	Smart Power Strips - Multi Family 16	-	$0
	TRUE		5	Smart Power Strips - Single Family 6	29,415.43	$3,584
	TRUE		5	Smart Power Strips - Single Family 8	125,428.39	$15,282
	TRUE		5	Smart Power Strips - Single Family 9	94,636.98	$11,530
	TRUE		5	Smart Power Strips - Single Family 10	203,889.94	$24,841
	TRUE		5	Smart Power Strips - Single Family 13	31,800.47	$3,874
	TRUE		5	Smart Power Strips - Single Family 14	72,774.15	$8,867
	TRUE		5	Smart Power Strips - Single Family 15	19,508.37	$2,377
	TRUE		5	Smart Power Strips - Single Family 16	1,070.21	$130
	FALSE		5	CAC Service - Mobile Home Zone 13	-	$0
	TRUE		5	CAC Service - Mobile Home Zone 14	3,271.65	$399
	TRUE		5	CAC Service - Mobile Home Zone 15	1,439.53	$175
	FALSE		5	CAC Service - Multi-Family Zone 13	-	$0
	TRUE		5	CAC Service - Multi-Family Zone 14	883.35	$108
	TRUE		5	CAC Service - Multi-Family Zone 15	203.85	$25
	FALSE		5	CAC Service - Single Family Zone 13	-	$0
	TRUE		5	CAC Service - Single Family Zone 14	81,116.87	$9,883
	TRUE		5	CAC Service - Single Family Zone 15	23,102.91	$2,815
	FALSE		7	Water Heater Blanket - Mobile Home 6	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 8	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 9	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 10	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 13	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 14	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 15	-	$0
	FALSE		7	Water Heater Blanket - Mobile Home 16	-	$0
	TRUE		7	Water Heater Blanket - Multi Family 6	141.27	$17
	TRUE		7	Water Heater Blanket - Multi Family 8	282.54	$34
	TRUE		7	Water Heater Blanket - Multi Family 9	706.34	$86
	TRUE		7	Water Heater Blanket - Multi Family 10	565.07	$69
	TRUE		7	Water Heater Blanket - Multi Family 13	141.27	$17
	TRUE		7	Water Heater Blanket - Multi Family 14	282.54	$34
	TRUE		7	Water Heater Blanket - Multi Family 15	141.27	$17
	FALSE		7	Water Heater Blanket - Multi Family 16	-	$0
	TRUE		7	Water Heater Blanket - Single Family 6	147.15	$18
	TRUE		7	Water Heater Blanket - Single Family 8	147.15	$18
	TRUE		7	Water Heater Blanket - Single Family 9	147.15	$18
	TRUE		7	Water Heater Blanket - Single Family 10	294.31	$36
	TRUE		7	Water Heater Blanket - Single Family 13	294.31	$36
	TRUE		7	Water Heater Blanket - Single Family 14	441.46	$54
	TRUE		7	Water Heater Blanket - Single Family 15	294.31	$36
	FALSE		7	Water Heater Blanket - Single Family 16	-	$0
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 6	-	$0
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 8	-	$0
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 9	-	$0
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 10	-	$0
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 13	-	$0
	TRUE		11	Water Heater Pipe Wrap - Mobile Home 14	202.79	$25
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 15	-	$0
	FALSE		11	Water Heater Pipe Wrap - Mobile Home 16	-	$0
	TRUE		11	Water Heater Pipe Wrap - Multi Family 6	405.58	$49
	TRUE		11	Water Heater Pipe Wrap - Multi Family 8	608.38	$74
	TRUE		11	Water Heater Pipe Wrap - Multi Family 9	1,419.55	$173
	TRUE		11	Water Heater Pipe Wrap - Multi Family 10	1,013.96	$124
	TRUE		11	Water Heater Pipe Wrap - Multi Family 13	202.79	$25
	TRUE		11	Water Heater Pipe Wrap - Multi Family 14	608.38	$74
	TRUE		11	Water Heater Pipe Wrap - Multi Family 15	202.79	$25
	FALSE		11	Water Heater Pipe Wrap - Multi Family 16	-	$0
	TRUE		11	Water Heater Pipe Wrap - Single Family 6	413.41	$50
	TRUE		11	Water Heater Pipe Wrap - Single Family 8	206.70	$25
	TRUE		11	Water Heater Pipe Wrap - Single Family 9	413.41	$50
	TRUE		11	Water Heater Pipe Wrap - Single Family 10	413.41	$50
	TRUE		11	Water Heater Pipe Wrap - Single Family 13	620.11	$76
	TRUE		11	Water Heater Pipe Wrap - Single Family 14	826.81	$101
	TRUE		11	Water Heater Pipe Wrap - Single Family 15	413.41	$50
	FALSE		11	Water Heater Pipe Wrap - Single Family 16	-	$0
	FALSE		10	Low-Flow Showerhead - Mobile Home 6	-	$0
	FALSE		10	Low-Flow Showerhead - Mobile Home 8	-	$0
	FALSE		10	Low-Flow Showerhead - Mobile Home 9	-	$0
	TRUE		10	Low-Flow Showerhead - Mobile Home 10	551.06	$67
	FALSE		10	Low-Flow Showerhead - Mobile Home 13	-	$0
	TRUE		10	Low-Flow Showerhead - Mobile Home 14	826.58	$101
	TRUE		10	Low-Flow Showerhead - Mobile Home 15	551.06	$67
	FALSE		10	Low-Flow Showerhead - Mobile Home 16	-	$0
	TRUE		10	Low-Flow Showerhead - Multi Family 6	1,908.74	$233
	TRUE		10	Low-Flow Showerhead - Multi Family 8	3,393.32	$413
	TRUE		10	Low-Flow Showerhead - Multi Family 9	6,786.65	$827
	TRUE		10	Low-Flow Showerhead - Multi Family 10	5,302.07	$646
	TRUE		10	Low-Flow Showerhead - Multi Family 13	636.25	$78
	TRUE		10	Low-Flow Showerhead - Multi Family 14	2,757.07	$336
	TRUE		10	Low-Flow Showerhead - Multi Family 15	1,272.50	$155
	FALSE		10	Low-Flow Showerhead - Multi Family 16	-	$0
	TRUE		10	Low-Flow Showerhead - Single Family 6	1,786.05	$218
	TRUE		10	Low-Flow Showerhead - Single Family 8	1,530.90	$187
	TRUE		10	Low-Flow Showerhead - Single Family 9	1,786.05	$218
	TRUE		10	Low-Flow Showerhead - Single Family 10	2,296.35	$280
	TRUE		10	Low-Flow Showerhead - Single Family 13	3,827.25	$466
	TRUE		10	Low-Flow Showerhead - Single Family 14	5,103.00	$622
	TRUE		10	Low-Flow Showerhead - Single Family 15	2,041.20	$249
	TRUE		10	Low-Flow Showerhead - Single Family 16	255.15	$31
	FALSE		10	Faucet Aerators - Mobile Home 6	-	$0
	FALSE		10	Faucet Aerators - Mobile Home 8	-	$0

	FALSE		10	Faucet Aerators - Mobile Home 9	-	$0
	TRUE		10	Faucet Aerators - Mobile Home 10	980.29	$119
	FALSE		10	Faucet Aerators - Mobile Home 13	-	$0
	TRUE		10	Faucet Aerators - Mobile Home 14	1,470.44	$179
	TRUE		10	Faucet Aerators - Mobile Home 15	980.29	$119
	FALSE		10	Faucet Aerators - Mobile Home 16	-	$0
	TRUE		10	Faucet Aerators - Multi Family 6	2,876.85	$351
	TRUE		10	Faucet Aerators - Multi Family 8	5,114.40	$623
	TRUE		10	Faucet Aerators - Multi Family 9	10,228.80	$1,246
	TRUE		10	Faucet Aerators - Multi Family 10	7,991.25	$974
	TRUE		10	Faucet Aerators - Multi Family 13	958.95	$117
	TRUE		10	Faucet Aerators - Multi Family 14	4,155.45	$506
	TRUE		10	Faucet Aerators - Multi Family 15	1,917.90	$234
	FALSE		10	Faucet Aerators - Multi Family 16	-	$0
	TRUE		10	Faucet Aerators - Single Family 6	2,710.89	$330
	TRUE		10	Faucet Aerators - Single Family 8	2,323.62	$283
	TRUE		10	Faucet Aerators - Single Family 9	2,710.89	$330
	TRUE		10	Faucet Aerators - Single Family 10	3,485.43	$425
	TRUE		10	Faucet Aerators - Single Family 13	5,809.05	$708
	TRUE		10	Faucet Aerators - Single Family 14	7,745.39	$944
	TRUE		10	Faucet Aerators - Single Family 15	3,872.70	$472
	TRUE		10	Faucet Aerators - Single Family 16	387.27	$47
	TRUE		11	Envelope & Air Sealing - Mobile Home 6	28.97	$4
	TRUE		11	Envelope & Air Sealing - Mobile Home 8	181.06	$22
	FALSE		11	Envelope & Air Sealing - Mobile Home 9	-	$0
	TRUE		11	Envelope & Air Sealing - Mobile Home 10	524.27	$64
	FALSE		11	Envelope & Air Sealing - Mobile Home 13	-	$0
	TRUE		11	Envelope & Air Sealing - Mobile Home 14	1,066.83	$130
	TRUE		11	Envelope & Air Sealing - Mobile Home 15	651.83	$79
	FALSE		11	Envelope & Air Sealing - Mobile Home 16	-	$0
	TRUE		11	Envelope & Air Sealing - Multi Family 6	2,293.48	$279
	TRUE		11	Envelope & Air Sealing - Multi Family 8	984.70	$120
	TRUE		11	Envelope & Air Sealing - Multi Family 9	16,007.31	$1,950
	TRUE		11	Envelope & Air Sealing - Multi Family 10	2,630.29	$320
	TRUE		11	Envelope & Air Sealing - Multi Family 13	884.68	$108
	TRUE		11	Envelope & Air Sealing - Multi Family 14	4,551.48	$555
	TRUE			Envelope & Air Sealing - Multi Family 15	8,388.65	$1,022
	FALSE			Envelope & Air Sealing - Multi Family 16	-	$0
	TRUE			Envelope & Air Sealing - Single Family 6	1,834.79	$224
	TRUE			Envelope & Air Sealing - Single Family 8	318.48	$39
	TRUE			Envelope & Air Sealing - Single Family 9	4,988.21	$608
	TRUE			Envelope & Air Sealing - Single Family 10	1,796.76	$219
	TRUE		11	Envelope & Air Sealing - Single Family 13	6,514.99	$794
	TRUE		11	Envelope & Air Sealing - Single Family 14	3,731.96	$455
	TRUE		11	Envelope & Air Sealing - Single Family 15	18,121.01	$2,208
	TRUE		11	Envelope & Air Sealing - Single Family 16	11.39	$1
	TRUE		16	LEDs - Mobile Home 6	143,313.94	$17,461
	TRUE		16	LEDs - Mobile Home 8	234,205.79	$28,535
	TRUE		16	LEDs - Mobile Home 9	248,365.62	$30,260
	TRUE		16	LEDs - Mobile Home 10	1,223,024.18	$149,010
	TRUE		16	LEDs - Mobile Home 13	118,032.69	$14,381
	TRUE		16	LEDs - Mobile Home 14	462,968.66	$56,407
	TRUE		16	LEDs - Mobile Home 15	230,048.79	$28,029
	TRUE		16	LEDs - Mobile Home 16	17,426.32	$2,123
	TRUE		16	LEDs - Multi Family 6	675,659.67	$82,321
	TRUE		16	LEDs - Multi Family 8	2,550,429.97	$310,738
	TRUE		16	LEDs - Multi Family 9	1,361,119.13	$165,835
	TRUE		16	LEDs - Multi Family 10	1,180,081.05	$143,778
	TRUE		16	LEDs - Multi Family 13	123,582.71	$15,057
	TRUE		16	LEDs - Multi Family 14	639,439.75	$77,908
	TRUE		16	LEDs - Multi Family 15	359,053.06	$43,746
	TRUE		16	LEDs - Multi Family 16	693.61	$85
	TRUE		16	LEDs - Single Family 6	886,468.42	$108,005
	TRUE		16	LEDs - Single Family 8	5,658,992.86	$689,478
	TRUE		16	LEDs - Single Family 9	5,065,053.84	$617,114
	TRUE		16	LEDs - Single Family 10	9,391,578.44	$1,144,247
	TRUE		16	LEDs - Single Family 13	1,803,025.50	$219,676
	TRUE		16	LEDs - Single Family 14	4,861,235.22	$592,281
	TRUE		16	LEDs - Single Family 15	1,073,846.21	$130,835
	TRUE		16	LEDs - Single Family 16	45,833.99	$5,584
	TRUE		16	LED Reflector Lamp - Mobile Home 6	3,114.63	$379
	TRUE		16	LED Reflector Lamp - Mobile Home 8	5,068.40	$618
	TRUE		16	LED Reflector Lamp - Mobile Home 9	5,397.69	$658
	TRUE		16	LED Reflector Lamp - Mobile Home 10	26,675.72	$3,250
	TRUE		16	LED Reflector Lamp - Mobile Home 13	2,610.05	$318
	TRUE		16	LED Reflector Lamp - Mobile Home 14	10,154.69	$1,237
	TRUE		16	LED Reflector Lamp - Mobile Home 15	5,088.43	$620
	TRUE		16	LED Reflector Lamp - Mobile Home 16	383.00	$47
	TRUE		16	LED Reflector Lamp - Multi Family 6	14,734.34	$1,795
	TRUE		16	LED Reflector Lamp - Multi Family 8	55,332.77	$6,742
	TRUE		16	LED Reflector Lamp - Multi Family 9	29,625.87	$3,610
	TRUE		16	LED Reflector Lamp - Multi Family 10	25,715.57	$3,133
	TRUE		16	LED Reflector Lamp - Multi Family 13	2,727.29	$332
	TRUE		16	LED Reflector Lamp - Multi Family 14	14,006.87	$1,707
	TRUE		16	LED Reflector Lamp - Multi Family 15	8,025.98	$978
	FALSE		16	LED Reflector Lamp - Multi Family 16	-	$0
	TRUE		16	LED Reflector Lamp - Single Family 6	19,363.71	$2,359
	TRUE		16	LED Reflector Lamp - Single Family 8	122,791.10	$14,961
	TRUE		16	LED Reflector Lamp - Single Family 9	110,183.93	$13,425
	TRUE		16	LED Reflector Lamp - Single Family 10	204,975.55	$24,974
	TRUE		16	LED Reflector Lamp - Single Family 13	39,593.26	$4,824
	TRUE		16	LED Reflector Lamp - Single Family 14	106,689.41	$12,999
	TRUE		16	LED Reflector Lamp - Single Family 15	23,623.71	$2,878
	TRUE		16	LED Reflector Lamp - Single Family 16	976.13	$119
	TRUE		10	T-Stat Shower Water Valve - Mobile Home 6	118.74	$14
	TRUE		10	T-Stat Shower Water Valve - Mobile Home 8	118.74	$14
	FALSE		10	T-Stat Shower Water Valve - Mobile Home 9	-	$0
	TRUE		10	T-Stat Shower Water Valve - Mobile Home 10	474.98	$58
	FALSE		10	T-Stat Shower Water Valve - Mobile Home 13	-	$0
	TRUE		10	T-Stat Shower Water Valve - Mobile Home 14	1,068.69	$130
	TRUE		10	T-Stat Shower Water Valve - Mobile Home 15	593.72	$72
	FALSE		10	T-Stat Shower Water Valve - Mobile Home 16	-	$0
	TRUE		10	T-Stat Shower Water Valve - Multi Family 6	2,291.95	$279
	TRUE		10	T-Stat Shower Water Valve - Multi Family 8	4,033.84	$491
	TRUE		10	T-Stat Shower Water Valve - Multi Family 9	8,159.35	$994
	TRUE		10	T-Stat Shower Water Valve - Multi Family 10	6,325.79	$771
	TRUE		10	T-Stat Shower Water Valve - Multi Family 13	641.75	$78
	TRUE		10	T-Stat Shower Water Valve - Multi Family 14	3,117.05	$380
	TRUE		10	T-Stat Shower Water Valve - Multi Family 15	1,466.85	$179
	FALSE		10	T-Stat Shower Water Valve - Multi Family 16	-	$0
	TRUE		10	T-Stat Shower Water Valve - Single Family 6	2,916.64	$355
	TRUE		10	T-Stat Shower Water Valve - Single Family 8	2,479.15	$302
	TRUE		10	T-Stat Shower Water Valve - Single Family 9	2,916.64	$355
	TRUE		10	T-Stat Shower Water Valve - Single Family 10	3,645.80	$444
	TRUE		10	T-Stat Shower Water Valve - Single Family 13	5,979.12	$728
	TRUE		10	T-Stat Shower Water Valve - Single Family 14	8,312.43	$1,013
	TRUE		10	T-Stat Shower Water Valve - Single Family 15	3,062.47	$373
	TRUE		10	T-Stat Shower Water Valve - Single Family 16	583.33	$71
	TRUE		5	Efficient Fan Control - Mobile Home Zone 14	58,572.09	$7,136
	TRUE		5	Efficient Fan Control - Mobile Home Zone 15	51,529.42	$6,278
	TRUE		5	Efficient Fan Control - Multi-Family Zone 14	9,998.88	$1,218
	TRUE		5	Efficient Fan Control - Multi-Family Zone 15	5,262.33	$641
	FALSE		5	Efficient Fan Control - Single Family Zone 10	-	$0
	FALSE		5	Efficient Fan Control - Single Family Zone 13	-	$0
	TRUE		5	Efficient Fan Control - Single Family Zone 14	200,022.31	$24,370
	TRUE		5	Efficient Fan Control - Single Family Zone 15	113,504.12	$13,829
	TRUE		14	Refrigerators - Mobile Home 6	157,656.07	$19,208
	TRUE		14	Refrigerators - Mobile Home 8	170,904.48	$20,823
	TRUE		14	Refrigerators - Mobile Home 9	169,579.64	$20,661
	TRUE		14	Refrigerators - Mobile Home 10	662,420.45	$80,708
	TRUE		14	Refrigerators - Mobile Home 13	113,936.32	$13,882
	TRUE		14	Refrigerators - Mobile Home 14	283,515.95	$34,543
	TRUE		14	Refrigerators - Mobile Home 15	87,439.50	$10,653
	TRUE		14	Refrigerators - Mobile Home 16	21,197.45	$2,583
	TRUE		14	Refrigerators - Multi Family 6	924,738.95	$112,668
	TRUE		14	Refrigerators - Multi Family 8	2,474,802.81	$301,524
	TRUE		14	Refrigerators - Multi Family 9	1,302,318.61	$158,671
	TRUE		14	Refrigerators - Multi Family 10	1,022,777.18	$124,613

TRUE			14	Refrigerators - Multi Family 13	107,312.11	$13,075
TRUE			14	Refrigerators - Multi Family 14	466,344.00	$56,818
TRUE			14	Refrigerators - Multi Family 15	147,057.34	$17,917
TRUE			14	Refrigerators - Multi Family 16	1,324.84	$161
TRUE			14	Refrigerators - Single Family 6	1,070,471.45	$130,424
TRUE			14	Refrigerators - Single Family 8	3,460,484.44	$421,617
TRUE			14	Refrigerators - Single Family 9	3,596,943.06	$438,243
TRUE			14	Refrigerators - Single Family 10	4,466,038.69	$544,131
TRUE			14	Refrigerators - Single Family 13	1,547,414.18	$188,533
TRUE			14	Refrigerators - Single Family 14	2,825,885.65	$344,299
TRUE			14	Refrigerators - Single Family 15	373,605.14	$45,519
TRUE			14	Refrigerators - Single Family 16	47,694.27	$5,811
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[2] Elec = Electric appliance measure, Gas = Gas Appliance Measure, Weath = Weatherization measure.

$89,174,685	**$10,864,822**
Energy Savings	NEBs

Ratio, including NEBs
NEB C/B ratio for each measure. Each populated cell
o "0" is entered when the energy efficient measure

	Utility / Ratepayer Benefits																													
Energy Efficient Measure	7A. Reduced Carrying Cost on Arrearages		Dollar amount of total benefit	7B. Lower Bad Debt Write-Offs		7C. Fewer Shut-offs		7D. Fewer Reconnects		7E. Fewer Notices		7F. Fewer Customer Calls		7G. Lower Collection Costs		7H. Red'n in emergency gas service calls		7I. Utility Health & Safety - Insurance savings only		7J. Transmission and /or distribution savings (distribution only)		7K. Utility Rate Subsidies Avoided (CARE) payments		Space for other entries		Space for other entries	
CFLs - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
CFLs - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 6	1	$163	1	$18	1	$2	1	$1	1	$57	1	$68	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 8	1	$213	1	$24	1	$3	1	$1	1	$74	1	$89	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 9	1	$411	1	$46	1	$5	1	$2	1	$143	1	$171	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 10	1	$1,156	1	$130	1	$14	1	$5	1	$403	1	$481	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 13	1	$99	1	$11	1	$1	1	$0	1	$35	1	$41	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 14	1	$426	1	$48	1	$5	1	$2	1	$148	1	$177	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 15	1	$121	1	$14	1	$1	1	$1	1	$42	1	$50	1	$0	0	$0	0	$0	1	$0	1	$0					
Exterior Fixtures - Single Family 16	1	$7	1	$1	1	$0	1	$0	1	$2	1	$3	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 6	1	$272	1	$30	1	$3	1	$1	1	$95	1	$113	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 8	1	$155	1	$17	1	$2	1	$1	1	$54	1	$65	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 9	1	$233	1	$26	1	$3	1	$1	1	$81	1	$97	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 10	1	$893	1	$100	1	$11	1	$4	1	$311	1	$371	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 13	1	$19	1	$2	1	$0	1	$0	1	$7	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 14	1	$291	1	$33	1	$4	1	$1	1	$102	1	$121	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 15	1	$466	1	$52	1	$6	1	$2	1	$162	1	$194	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 6	1	$3,318	1	$372	1	$41	1	$15	1	$1,157	1	$1,381	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 8	1	$9,663	1	$1,085	1	$120	1	$42	1	$3,371	1	$4,021	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 9	1	$6,131	1	$688	1	$76	1	$27	1	$2,139	1	$2,551	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 10	1	$2,639	1	$296	1	$33	1	$12	1	$921	1	$1,098	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 13	1	$19	1	$2	1	$0	1	$0	1	$7	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 14	1	$776	1	$87	1	$10	1	$3	1	$271	1	$323	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 15	1	$602	1	$68	1	$7	1	$3	1	$210	1	$250	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Multi Family 16	1	$19	1	$2	1	$0	1	$0	1	$7	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 6	1	$2,639	1	$296	1	$33	1	$12	1	$921	1	$1,098	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 8	1	$6,963	1	$782	1	$87	1	$30	1	$2,429	1	$2,897	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 9	1	$7,085	1	$795	1	$88	1	$31	1	$2,472	1	$2,948	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 10	1	$7,623	1	$856	1	$95	1	$33	1	$2,659	1	$3,172	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 13	1	$313	1	$35	1	$4	1	$1	1	$109	1	$130	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 14	1	$4,202	1	$472	1	$52	1	$18	1	$1,466	1	$1,749	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 15	1	$2,692	1	$302	1	$33	1	$12	1	$939	1	$1,120	1	$0	0	$0	0	$0	1	$0	1	$0					
Torchiere - Single Family 16	1	$17	1	$2	1	$0	1	$0	1	$6	1	$7	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Refrigerators - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$7,042	1	$791	1	$88	1	$31	1	$2,456	1	$2,930	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$26,909	1	$3,021	1	$335	1	$118	1	$9,387	1	$11,197	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$56,836	1	$6,381	1	$707	1	$249	1	$19,827	1	$23,650	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$194,651	1	$21,852	1	$2,421	1	$851	1	$67,905	1	$80,995	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$46,777	1	$5,251	1	$582	1	$205	1	$16,318	1	$19,464	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$76,955	1	$8,639	1	$957	1	$337	1	$26,846	1	$32,021	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$34,999	1	$3,929	1	$435	1	$153	1	$12,210	1	$14,563	1	$0	0	$0	0	$0	1	$0	1	$0					
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Mobile Home Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Multi Family Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 14	1	$5,508	1	$618	1	$69	1	$24	1	$1,921	1	$2,292	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 15	1	$1,731	1	$194	1	$22	1	$8	1	$604	1	$720	1	$0	0	$0	0	$0	1	$0	1	$0					
Duct Sealing - Single Family Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Mobile Home Zone 10	1	$31,706	1	$3,559	1	$394	1	$139	1	$11,061	1	$13,193	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Mobile Home Zone 13	1	$5,523	1	$620	1	$69	1	$24	1	$1,927	1	$2,298	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Mobile Home Zone 14	1	$11,449	1	$1,285	1	$142	1	$50	1	$3,994	1	$4,764	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Mobile Home Zone 15	1	$14,351	1	$1,611	1	$178	1	$63	1	$5,006	1	$5,971	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Mobile Home Zone 16	1	$160	1	$18	1	$2	1	$1	1	$56	1	$66	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Single Family Zone 10	1	$379,680	1	$42,624	1	$4,722	1	$1,660	1	$132,453	1	$157,987	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Single Family Zone 13	1	$82,406	1	$9,251	1	$1,025	1	$360	1	$28,748	1	$34,290	1	$0	0	$0	0	$0	1	$0	1	$0					
Evap Install - Single Family Zone 14	1	$254,897	1	$28,615	1	$3,170	1	$1,115	1	$88,922	1	$106,064	1	$0	0	$0	0	$0	1	$0	1	$0					

Evap Install - Single Family Zone 15	1	$75,668	1	$8,495	1	$941	1	$331	1	$26,397	1	$31,486	1	$0	0	$0	0	$0	1	$0	1	$0
Evap Install - Single Family Zone 16	1	$95	1	$11	1	$1	1	$0	1	$33	1	$40	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Multi Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Multi Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Multi Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Single Family Zone 14	1	$9,008	1	$1,011	1	$112	1	$39	1	$3,142	1	$3,748	1	$0	0	$0	0	$0	1	$0	1	$0
Ht Pmp Replace - Single Family Zone 15	1	$2,279	1	$256	1	$28	1	$10	1	$795	1	$948	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Mobile Home Zone 14	1	$9,299	1	$1,044	1	$116	1	$41	1	$3,244	1	$3,869	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Mobile Home Zone 15	1	$14,652	1	$1,645	1	$182	1	$64	1	$5,112	1	$6,097	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Multi-Family Zone 14	1	$2,128	1	$239	1	$26	1	$9	1	$742	1	$885	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Multi-Family Zone 15	1	$1,851	1	$208	1	$23	1	$8	1	$646	1	$770	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Single Family Zone 14	1	$27,060	1	$3,038	1	$337	1	$118	1	$9,440	1	$11,260	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Replace - Single Family Zone 15	1	$30,502	1	$3,424	1	$379	1	$133	1	$10,641	1	$12,692	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Mobile Home Zone 10	1	$250	1	$28	1	$3	1	$1	1	$87	1	$104	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Mobile Home Zone 13	1	$117	1	$13	1	$1	1	$1	1	$41	1	$49	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Mobile Home Zone 14	1	$183	1	$21	1	$2	1	$1	1	$64	1	$76	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Mobile Home Zone 15	1	$264	1	$30	1	$3	1	$1	1	$92	1	$110	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Multi-Family Zone 10	1	$52	1	$6	1	$1	1	$0	1	$18	1	$22	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Multi-Family Zone 13	1	$8	1	$1	1	$0	1	$0	1	$3	1	$3	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Multi-Family Zone 14	1	$41	1	$5	1	$1	1	$0	1	$14	1	$17	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Multi-Family Zone 15	1	$33	1	$4	1	$0	1	$0	1	$12	1	$14	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Single Family Zone 10	1	$1,179	1	$132	1	$15	1	$5	1	$411	1	$490	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Single Family Zone 13	1	$878	1	$99	1	$11	1	$4	1	$306	1	$365	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Single Family Zone 14	1	$534	1	$60	1	$7	1	$2	1	$186	1	$222	1	$0	0	$0	0	$0	1	$0	1	$0
RAC - Single Family Zone 15	1	$530	1	$60	1	$7	1	$2	1	$185	1	$221	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 6	1	$134	1	$15	1	$2	1	$1	1	$47	1	$56	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 8	1	$289	1	$32	1	$4	1	$1	1	$101	1	$120	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 9	1	$500	1	$56	1	$6	1	$2	1	$174	1	$208	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 10	1	$1,377	1	$155	1	$17	1	$6	1	$480	1	$573	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 13	1	$157	1	$18	1	$2	1	$1	1	$55	1	$65	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 14	1	$627	1	$70	1	$8	1	$3	1	$219	1	$261	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 15	1	$155	1	$17	1	$2	1	$1	1	$54	1	$65	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 16	1	$12	1	$1	1	$0	1	$0	1	$4	1	$5	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 6	1	$1,790	1	$201	1	$22	1	$8	1	$624	1	$745	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 8	1	$5,856	1	$657	1	$73	1	$26	1	$2,043	1	$2,437	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 9	1	$2,341	1	$263	1	$29	1	$10	1	$817	1	$974	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 10	1	$2,701	1	$303	1	$34	1	$12	1	$942	1	$1,124	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 13	1	$189	1	$21	1	$2	1	$1	1	$66	1	$79	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 14	1	$1,719	1	$193	1	$21	1	$8	1	$600	1	$715	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 15	1	$350	1	$39	1	$4	1	$2	1	$122	1	$146	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 6	1	$1,892	1	$212	1	$24	1	$8	1	$660	1	$787	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 8	1	$8,068	1	$906	1	$100	1	$35	1	$2,815	1	$3,357	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 9	1	$6,088	1	$683	1	$76	1	$27	1	$2,124	1	$2,533	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 10	1	$13,116	1	$1,472	1	$163	1	$57	1	$4,575	1	$5,457	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 13	1	$2,046	1	$230	1	$25	1	$9	1	$714	1	$851	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 14	1	$4,681	1	$526	1	$58	1	$20	1	$1,633	1	$1,948	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 15	1	$1,255	1	$141	1	$16	1	$5	1	$438	1	$522	1	$0	0	$0	0	$0	1	$0	1	$0
Smart Power Strips - Single Family 16	1	$69	1	$8	1	$1	1	$0	1	$24	1	$29	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Mobile Home Zone 14	1	$210	1	$24	1	$3	1	$1	1	$73	1	$88	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Mobile Home Zone 15	1	$93	1	$10	1	$1	1	$0	1	$32	1	$39	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Multi-Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Multi-Family Zone 14	1	$57	1	$6	1	$1	1	$0	1	$20	1	$24	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Multi-Family Zone 15	1	$13	1	$1	1	$0	1	$0	1	$5	1	$5	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Single Family Zone 14	1	$5,218	1	$586	1	$65	1	$23	1	$1,820	1	$2,171	1	$0	0	$0	0	$0	1	$0	1	$0
CAC Service - Single Family Zone 15	1	$1,486	1	$167	1	$18	1	$6	1	$518	1	$618	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 6	1	$9	1	$1	1	$0	1	$0	1	$3	1	$4	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 8	1	$18	1	$2	1	$0	1	$0	1	$6	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 9	1	$45	1	$5	1	$1	1	$0	1	$16	1	$19	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 10	1	$36	1	$4	1	$0	1	$0	1	$13	1	$15	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 13	1	$9	1	$1	1	$0	1	$0	1	$3	1	$4	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 14	1	$18	1	$2	1	$0	1	$0	1	$6	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 15	1	$9	1	$1	1	$0	1	$0	1	$3	1	$4	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 6	1	$9	1	$1	1	$0	1	$0	1	$3	1	$4	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 8	1	$9	1	$1	1	$0	1	$0	1	$3	1	$4	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 9	1	$9	1	$1	1	$0	1	$0	1	$3	1	$4	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 10	1	$19	1	$2	1	$0	1	$0	1	$7	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 13	1	$19	1	$2	1	$0	1	$0	1	$7	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 14	1	$28	1	$3	1	$0	1	$0	1	$10	1	$12	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 15	1	$19	1	$2	1	$0	1	$0	1	$7	1	$8	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Blanket - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 14	1	$13	1	$1	1	$0	1	$0	1	$5	1	$5	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 6	1	$26	1	$3	1	$0	1	$0	1	$9	1	$11	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 8	1	$39	1	$4	1	$0	1	$0	1	$14	1	$16	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 9	1	$91	1	$10	1	$1	1	$0	1	$32	1	$38	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 10	1	$65	1	$7	1	$1	1	$0	1	$23	1	$27	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 13	1	$13	1	$1	1	$0	1	$0	1	$5	1	$5	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 14	1	$39	1	$4	1	$0	1	$0	1	$14	1	$16	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 15	1	$13	1	$1	1	$0	1	$0	1	$5	1	$5	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 6	1	$27	1	$3	1	$0	1	$0	1	$9	1	$11	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 8	1	$13	1	$1	1	$0	1	$0	1	$5	1	$6	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 9	1	$27	1	$3	1	$0	1	$0	1	$9	1	$11	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 10	1	$27	1	$3	1	$0	1	$0	1	$9	1	$11	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 13	1	$40	1	$4	1	$0	1	$0	1	$14	1	$17	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 14	1	$53	1	$6	1	$1	1	$0	1	$19	1	$22	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 15	1	$27	1	$3	1	$0	1	$0	1	$9	1	$11	1	$0	0	$0	0	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 10	1	$35	1	$4	1	$0	1	$0	1	$12	1	$15	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 14	1	$53	1	$6	1	$1	1	$0	1	$19	1	$22	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 15	1	$35	1	$4	1	$0	1	$0	1	$12	1	$15	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 6	1	$123	1	$14	1	$2	1	$1	1	$43	1	$51	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 8	1	$218	1	$25	1	$3	1	$1	1	$76	1	$91	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 9	1	$437	1	$49	1	$5	1	$2	1	$152	1	$182	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 10	1	$341	1	$38	1	$4	1	$1	1	$119	1	$142	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 13	1	$41	1	$5	1	$1	1	$0	1	$14	1	$17	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 14	1	$177	1	$20	1	$2	1	$1	1	$62	1	$74	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 15	1	$82	1	$9	1	$1	1	$0	1	$29	1	$34	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 6	1	$115	1	$13	1	$1	1	$1	1	$40	1	$48	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 8	1	$98	1	$11	1	$1	1	$0	1	$34	1	$41	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 9	1	$115	1	$13	1	$1	1	$1	1	$40	1	$48	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 10	1	$148	1	$17	1	$2	1	$1	1	$52	1	$61	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 13	1	$246	1	$28	1	$3	1	$1	1	$86	1	$102	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 14	1	$328	1	$37	1	$4	1	$1	1	$115	1	$137	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 15	1	$131	1	$15	1	$2	1	$1	1	$46	1	$55	1	$0	0	$0	0	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 16	1	$16	1	$2	1	$0	1	$0	1	$6	1	$7	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0

Faucet Aerators - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 10	1	$63	1	$7	1	$1	1	$0	1	$22	1	$26	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 14	1	$95	1	$11	1	$1	1	$0	1	$33	1	$39	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 15	1	$63	1	$7	1	$1	1	$0	1	$22	1	$26	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 6	1	$185	1	$21	1	$2	1	$1	1	$65	1	$77	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 8	1	$329	1	$37	1	$4	1	$1	1	$115	1	$137	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 9	1	$658	1	$74	1	$8	1	$3	1	$230	1	$274	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 10	1	$514	1	$58	1	$6	1	$2	1	$179	1	$214	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 13	1	$62	1	$7	1	$1	1	$0	1	$22	1	$26	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 14	1	$267	1	$30	1	$3	1	$1	1	$93	1	$111	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 15	1	$123	1	$14	1	$2	1	$1	1	$43	1	$51	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 6	1	$174	1	$20	1	$2	1	$1	1	$61	1	$73	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 8	1	$149	1	$17	1	$2	1	$1	1	$52	1	$62	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 9	1	$174	1	$20	1	$2	1	$1	1	$61	1	$73	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 10	1	$224	1	$25	1	$3	1	$1	1	$78	1	$93	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 13	1	$374	1	$42	1	$5	1	$2	1	$130	1	$155	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 14	1	$498	1	$56	1	$6	1	$2	1	$174	1	$207	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 15	1	$249	1	$28	1	$3	1	$1	1	$87	1	$104	1	$0	0	$0	0	$0	1	$0	1	$0
Faucet Aerators - Single Family 16	1	$25	1	$3	1	$0	1	$0	1	$9	1	$10	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 6	1	$2	1	$0	1	$0	1	$0	1	$1	1	$1	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 8	1	$12	1	$1	1	$0	1	$0	1	$4	1	$5	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 10	1	$34	1	$4	1	$0	1	$0	1	$12	1	$14	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 14	1	$69	1	$8	1	$1	1	$0	1	$24	1	$29	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 15	1	$42	1	$5	1	$1	1	$0	1	$15	1	$17	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 6	1	$148	1	$17	1	$2	1	$1	1	$51	1	$61	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 8	1	$63	1	$7	1	$1	1	$0	1	$22	1	$26	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 9	1	$1,030	1	$116	1	$13	1	$5	1	$359	1	$428	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 10	1	$169	1	$19	1	$2	1	$1	1	$59	1	$70	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 13	1	$57	1	$6	1	$1	1	$0	1	$20	1	$24	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 14	1	$293	1	$33	1	$4	1	$1	1	$102	1	$122	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 15	1	$540	1	$61	1	$7	1	$2	1	$188	1	$225	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 6	1	$118	1	$13	1	$1	1	$1	1	$41	1	$49	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 8	1	$20	1	$2	1	$0	1	$0	1	$7	1	$9	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 9	1	$321	1	$36	1	$4	1	$1	1	$112	1	$134	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 10	1	$116	1	$13	1	$1	1	$1	1	$40	1	$48	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 13	1	$419	1	$47	1	$5	1	$2	1	$146	1	$174	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 14	1	$240	1	$27	1	$3	1	$1	1	$84	1	$100	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 15	1	$1,166	1	$131	1	$14	1	$5	1	$407	1	$485	1	$0	0	$0	0	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 16	1	$1	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 6	1	$9,219	1	$1,035	1	$115	1	$40	1	$3,216	1	$3,836	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 8	1	$15,066	1	$1,691	1	$187	1	$66	1	$5,256	1	$6,269	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 9	1	$15,977	1	$1,794	1	$199	1	$70	1	$5,573	1	$6,648	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 10	1	$78,674	1	$8,832	1	$979	1	$344	1	$27,446	1	$32,737	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 13	1	$7,593	1	$852	1	$94	1	$33	1	$2,649	1	$3,159	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 14	1	$29,781	1	$3,343	1	$370	1	$130	1	$10,389	1	$12,392	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 15	1	$14,798	1	$1,661	1	$184	1	$65	1	$5,162	1	$6,158	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Mobile Home 16	1	$1,121	1	$126	1	$14	1	$5	1	$391	1	$466	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 6	1	$43,463	1	$4,879	1	$541	1	$190	1	$15,162	1	$18,085	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 8	1	$164,062	1	$18,418	1	$2,041	1	$718	1	$57,233	1	$68,267	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 9	1	$87,557	1	$9,829	1	$1,089	1	$383	1	$30,544	1	$36,433	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 10	1	$75,911	1	$8,522	1	$944	1	$332	1	$26,482	1	$31,587	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 13	1	$7,950	1	$892	1	$99	1	$35	1	$2,773	1	$3,308	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 14	1	$41,133	1	$4,618	1	$512	1	$180	1	$14,349	1	$17,116	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 15	1	$23,097	1	$2,593	1	$287	1	$101	1	$8,057	1	$9,611	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Multi Family 16	1	$45	1	$5	1	$1	1	$0	1	$16	1	$19	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 6	1	$57,024	1	$6,402	1	$709	1	$249	1	$19,893	1	$23,728	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 8	1	$364,026	1	$40,866	1	$4,528	1	$1,592	1	$126,992	1	$151,474	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 9	1	$325,820	1	$36,577	1	$4,052	1	$1,425	1	$113,663	1	$135,576	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 10	1	$604,133	1	$67,821	1	$7,514	1	$2,642	1	$210,754	1	$251,383	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 13	1	$115,983	1	$13,020	1	$1,443	1	$507	1	$40,461	1	$48,261	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 14	1	$312,709	1	$35,105	1	$3,889	1	$1,368	1	$109,090	1	$130,120	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 15	1	$69,077	1	$7,755	1	$859	1	$302	1	$24,098	1	$28,744	1	$0	0	$0	0	$0	1	$0	1	$0
LEDs - Single Family 16	1	$2,948	1	$331	1	$37	1	$13	1	$1,029	1	$1,227	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 6	1	$200	1	$22	1	$2	1	$1	1	$70	1	$83	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 8	1	$326	1	$37	1	$4	1	$1	1	$114	1	$136	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 9	1	$347	1	$39	1	$4	1	$2	1	$121	1	$144	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 10	1	$1,716	1	$193	1	$21	1	$8	1	$599	1	$714	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 13	1	$168	1	$19	1	$2	1	$1	1	$59	1	$70	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 14	1	$653	1	$73	1	$8	1	$3	1	$228	1	$272	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 15	1	$327	1	$37	1	$4	1	$1	1	$114	1	$136	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 16	1	$25	1	$3	1	$0	1	$0	1	$9	1	$10	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 6	1	$948	1	$106	1	$12	1	$4	1	$331	1	$394	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 8	1	$3,559	1	$400	1	$44	1	$16	1	$1,242	1	$1,481	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 9	1	$1,906	1	$214	1	$24	1	$8	1	$665	1	$793	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 10	1	$1,654	1	$186	1	$21	1	$7	1	$577	1	$688	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 13	1	$175	1	$20	1	$2	1	$1	1	$61	1	$73	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 14	1	$901	1	$101	1	$11	1	$4	1	$314	1	$375	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 15	1	$516	1	$58	1	$6	1	$2	1	$180	1	$215	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 6	1	$1,246	1	$140	1	$15	1	$5	1	$435	1	$518	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 8	1	$7,899	1	$887	1	$98	1	$35	1	$2,756	1	$3,287	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 9	1	$7,088	1	$796	1	$88	1	$31	1	$2,473	1	$2,949	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 10	1	$13,185	1	$1,480	1	$164	1	$58	1	$4,600	1	$5,487	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 13	1	$2,547	1	$286	1	$32	1	$11	1	$889	1	$1,060	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 14	1	$6,863	1	$770	1	$85	1	$30	1	$2,394	1	$2,856	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 15	1	$1,520	1	$171	1	$19	1	$7	1	$530	1	$632	1	$0	0	$0	0	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 16	1	$63	1	$7	1	$1	1	$0	1	$22	1	$26	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 6	1	$8	1	$1	1	$0	1	$0	1	$3	1	$3	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 8	1	$8	1	$1	1	$0	1	$0	1	$3	1	$3	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 10	1	$31	1	$3	1	$0	1	$0	1	$11	1	$13	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 14	1	$69	1	$8	1	$1	1	$0	1	$24	1	$29	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 15	1	$38	1	$4	1	$0	1	$0	1	$13	1	$16	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 6	1	$147	1	$17	1	$2	1	$1	1	$51	1	$61	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 8	1	$259	1	$29	1	$3	1	$1	1	$91	1	$108	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 9	1	$525	1	$59	1	$7	1	$2	1	$183	1	$218	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 10	1	$407	1	$46	1	$5	1	$2	1	$142	1	$169	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 13	1	$41	1	$5	1	$1	1	$0	1	$14	1	$17	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 14	1	$201	1	$23	1	$2	1	$1	1	$70	1	$83	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 15	1	$94	1	$11	1	$1	1	$0	1	$33	1	$39	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 6	1	$188	1	$21	1	$2	1	$1	1	$65	1	$78	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 8	1	$159	1	$18	1	$2	1	$1	1	$56	1	$66	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 9	1	$188	1	$21	1	$2	1	$1	1	$65	1	$78	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 10	1	$235	1	$26	1	$3	1	$1	1	$82	1	$98	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 13	1	$385	1	$43	1	$5	1	$2	1	$134	1	$160	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 14	1	$535	1	$60	1	$7	1	$2	1	$187	1	$222	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 15	1	$197	1	$22	1	$2	1	$1	1	$69	1	$82	1	$0	0	$0	0	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 16	1	$38	1	$4	1	$0	1	$0	1	$13	1	$16	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Mobile Home Zone 14	1	$3,768	1	$423	1	$47	1	$16	1	$1,314	1	$1,568	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Mobile Home Zone 15	1	$3,315	1	$372	1	$41	1	$14	1	$1,156	1	$1,379	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Multi-Family Zone 14	1	$643	1	$72	1	$8	1	$3	1	$224	1	$268	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Multi-Family Zone 15	1	$339	1	$38	1	$4	1	$1	1	$118	1	$141	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 14	1	$12,867	1	$1,444	1	$160	1	$56	1	$4,489	1	$5,354	1	$0	0	$0	0	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 15	1	$7,301	1	$820	1	$91	1	$32	1	$2,547	1	$3,038	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 6	1	$10,142	1	$1,139	1	$126	1	$44	1	$3,538	1	$4,220	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 8	1	$10,994	1	$1,234	1	$137	1	$48	1	$3,835	1	$4,575	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 9	1	$10,909	1	$1,225	1	$136	1	$48	1	$3,805	1	$4,539	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 10	1	$42,612	1	$4,784	1	$530	1	$186	1	$14,865	1	$17,731	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 13	1	$7,329	1	$823	1	$91	1	$32	1	$2,557	1	$3,050	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 14	1	$18,238	1	$2,047	1	$227	1	$80	1	$6,362	1	$7,589	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 15	1	$5,625	1	$631	1	$70	1	$25	1	$1,962	1	$2,340	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Mobile Home 16	1	$1,364	1	$153	1	$17	1	$6	1	$476	1	$567	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 6	1	$59,486	1	$6,678	1	$740	1	$260	1	$20,752	1	$24,752	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 8	1	$159,197	1	$17,872	1	$1,980	1	$696	1	$55,536	1	$66,243	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 9	1	$83,774	1	$9,405	1	$1,042	1	$366	1	$29,225	1	$34,859	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 10	1	$65,792	1	$7,386	1	$818	1	$288	1	$22,952	1	$27,377	1	$0	0	$0	0	$0	1	$0	1	$0

Refrigerators - Multi Family 13	1	$6,903	1	$775	1	$86	1	$30	1	$2,408	1	$2,872	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 14	1	$29,999	1	$3,368	1	$373	1	$131	1	$10,465	1	$12,483	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 15	1	$9,460	1	$1,062	1	$118	1	$41	1	$3,300	1	$3,936	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Multi Family 16	1	$85	1	$10	1	$1	1	$0	1	$30	1	$35	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 6	1	$68,860	1	$7,730	1	$856	1	$301	1	$24,022	1	$28,653	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 8	1	$222,603	1	$24,990	1	$2,769	1	$974	1	$77,656	1	$92,626	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 9	1	$231,381	1	$25,975	1	$2,878	1	$1,012	1	$80,718	1	$96,279	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 10	1	$287,287	1	$32,251	1	$3,573	1	$1,256	1	$100,221	1	$119,542	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 13	1	$99,541	1	$11,175	1	$1,238	1	$435	1	$34,725	1	$41,419	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 14	1	$181,781	1	$20,407	1	$2,261	1	$795	1	$63,415	1	$75,640	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 15	1	$24,033	1	$2,698	1	$299	1	$105	1	$8,384	1	$10,000	1	$0	0	$0	0	$0	1	$0	1	$0
Refrigerators - Single Family 16	1	$3,068	1	$344	1	$38	1	$13	1	$1,070	1	$1,277	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0

Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0			

, Gas = Gas Appliance Measure, Weath = Weatherization me

$5,736,345	$5,736,345	$643,972	$643,972	$71,348	$71,348	$25,087	$25,087	$2,001,143	$2,001,143	$2,386,927	$2,386,927	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Ratio, including NEBs

NEB C/B ratio for each measure. Each populated cell
o "0" is entered when the energy efficient measure

	Societal Benefits						
Energy Efficient Measure	8A. Unemployment Payment Reductions	8B. Emissions / Environment	8C. Health and Safety Equipment (CO and Other H&S)	8D. Water and Wastewater Savings	Space for other entries	Space for other entries	Program Rebate
CFLs - Mobile Home 6							
CFLs - Mobile Home 8							
CFLs - Mobile Home 9							
CFLs - Mobile Home 10							
CFLs - Mobile Home 13							
CFLs - Mobile Home 14							
CFLs - Mobile Home 15							
CFLs - Mobile Home 16							
CFLs - Multi Family 6							
CFLs - Multi Family 8							
CFLs - Multi Family 9							
CFLs - Multi Family 10							
CFLs - Multi Family 13							
CFLs - Multi Family 14							
CFLs - Multi Family 15							
CFLs - Multi Family 16							
CFLs - Single Family 6							
CFLs - Single Family 8							
CFLs - Single Family 9							
CFLs - Single Family 10							
CFLs - Single Family 13							
CFLs - Single Family 14							
CFLs - Single Family 15							
CFLs - Single Family 16							
Exterior Fixtures - Single Family 6							
Exterior Fixtures - Single Family 8							
Exterior Fixtures - Single Family 9							
Exterior Fixtures - Single Family 10							
Exterior Fixtures - Single Family 13							
Exterior Fixtures - Single Family 14							
Exterior Fixtures - Single Family 15							
Exterior Fixtures - Single Family 16							
Torchiere - Mobile Home 6							
Torchiere - Mobile Home 8							
Torchiere - Mobile Home 9							
Torchiere - Mobile Home 10							
Torchiere - Mobile Home 13							
Torchiere - Mobile Home 14							
Torchiere - Mobile Home 15							
Torchiere - Mobile Home 16							
Torchiere - Multi Family 6							
Torchiere - Multi Family 8							
Torchiere - Multi Family 9							
Torchiere - Multi Family 10							
Torchiere - Multi Family 13							
Torchiere - Multi Family 14							
Torchiere - Multi Family 15							
Torchiere - Multi Family 16							
Torchiere - Single Family 6							
Torchiere - Single Family 8							
Torchiere - Single Family 9							
Torchiere - Single Family 10							
Torchiere - Single Family 13							
Torchiere - Single Family 14							
Torchiere - Single Family 15							
Torchiere - Single Family 16							
Refrigerators - Mobile Home 6							
Refrigerators - Mobile Home 8							
Refrigerators - Mobile Home 9							
Refrigerators - Mobile Home 10							
Refrigerators - Mobile Home 13							
Refrigerators - Mobile Home 14							
Refrigerators - Mobile Home 15							
Refrigerators - Mobile Home 16							
Refrigerators - Multi Family 6							
Refrigerators - Multi Family 8							
Refrigerators - Multi Family 9							
Refrigerators - Multi Family 10							
Refrigerators - Multi Family 13							
Refrigerators - Multi Family 14							
Refrigerators - Multi Family 15							
Refrigerators - Multi Family 16							
Refrigerators - Single Family 6							
Refrigerators - Single Family 8							
Refrigerators - Single Family 9							
Refrigerators - Single Family 10							
Refrigerators - Single Family 13							
Refrigerators - Single Family 14							
Refrigerators - Single Family 15							
Refrigerators - Single Family 16							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Famil							
Duct Sealing - Mobile Home Zone 6							
Duct Sealing - Mobile Home Zone 8							
Duct Sealing - Mobile Home Zone 9							
Duct Sealing - Mobile Home Zone 10							
Duct Sealing - Mobile Home Zone 13							
Duct Sealing - Mobile Home Zone 14							
Duct Sealing - Mobile Home Zone 15							
Duct Sealing - Mobile Home Zone 16							
Duct Sealing - Multi Family Zone 6							
Duct Sealing - Multi Family Zone 8							
Duct Sealing - Multi Family Zone 9							
Duct Sealing - Multi Family Zone 10							
Duct Sealing - Multi Family Zone 13							
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			$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Ratio, including NEBs

NEB C/B ratio for each measure. Each populated cell
o "0" is entered when the energy efficient measure

Participant Benefits

Energy Efficient Measure	9A. Water / Sewer Savings		9B. Fewer Shut-offs		9C. Fewer Calls to the Utility		9D. Fewer Reconnect s		9E. Property Value Benefits		9F. Fewer fires		9G. Indoor Air Quality (CO related)		9H. Moving Costs / Mobility		9I. Fewer illnesses and lost days from work/scho ol		9J. Reduced Transactio ns Costs (limited measures)		9K. Net Household Benefits from Comfort, Noise, net negatives		9K. Net Household Benefits from additional Hardship Benefits	Space for other entries
CFLs - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
CFLs - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Exterior Fixtures - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Torchiere - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Pool Pumps - Variable Speed (Programmed Var Spd)- Single Family	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Mobile Home Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Multi Family Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Duct Sealing - Single Family Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Mobile Home Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Mobile Home Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0

Evap Install - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Evap Install - Single Family Zone 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Multi Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Multi Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Multi Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Ht Pmp Replace - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Multi-Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Multi-Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Replace - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Mobile Home Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Multi-Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Multi-Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Multi-Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Multi-Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
RAC - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips -Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Smart Power Strips - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Mobile Home Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Multi-Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Multi-Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Multi-Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
CAC Service - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Blanket - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Water Heater Pipe Wrap - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Low-Flow Showerhead - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0

Faucet Aerators - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Faucet Aerators - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Envelope & Air Sealing - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Envelope & Air Sealing - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Envelope & Air Sealing - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Envelope & Air Sealing - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Envelope & Air Sealing - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Envelope & Air Sealing - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Envelope & Air Sealing - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LEDs - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
LED Reflector Lamp - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
T-Stat Shower Water Valve - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Mobile Home Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Mobile Home Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Multi-Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Multi-Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Efficient Fan Control - Single Family Zone 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Mobile Home 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0

Refrigerators - Multi Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Multi Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 6	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 8	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 9	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 10	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 13	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 14	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 15	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Refrigerators - Single Family 16	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	0	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
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Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	1	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0
Measure TBD	1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0

Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			
Measure TBD		1	$0	1	$0	1	$0	1	$0	1	$0	0	$0	0	$0	1	$0	0	$0	1	$0	1	$0	1	$0			

, Gas = Gas Appliance Measure, Weath = Weatherization me

$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	**$10,864,822**

NEBs

LIEE Program 2015-2017 Budget

Input fields (hard coded) in white cell

					ROUNDED	ROUNDED	ROUNDED	ROUNDED	ROUNDED	ROUNDED	ROUNDED	ROUNDED			
					NON-LABOR	NON-LABOR	NON-LABOR	NON-LABOR	LABOR - LOADED			PROGRAM BUDGET	LABOR + NON-LABOR: LOADED		
Total	$3,297,827	$9,430,936	$7,657,708	67.1 / 66.6 / 66.9	$3,141,000	$9,236,000	$7,460,000	$19,837,000	$8,655,000	$8,983,000	$9,303,000	$46,778,000	$12,663,000	$19,145,000	$17,716,000

ORG	PCC	Department	Sub-group	Budget Contact	Approver	Internal Cost Category	CPUC Budget Category	Type	Description	Charges In ?	Comments	Non-Labor Escalation?	2015	2016	2017	2015-2017 Non Labor	2015	2016	2017	Estimated Base Salary 1 2015		2015	2016	2017	2015-17	2015	2016	2017	2015-17	2015	2016	2017
Customer Service																																
Customer E **Solutions Marketing**																					x	$ 1,498,000	$ 2,603,000	$ 2,754,000	$ 6,855,000	$ 347,000	$ 693,000	$ 763,000	$ 8,658,000	$ 1,845,000	$ 3,296,000	$ 3,517,000
Enabling Technologies	14197	Solutions Marketing		Lisa Long	Allen Fernan	Marketing &	Marketing ar	FTE	Labor	Charges In	Solutions Marketing					$ -	1.53	4.17	4.5	$125,000		$ -	$ -	$ -	$ -	$ 247,000	$ 693,000	$ 763,000	$1,703,000	$247,000	$693,000	$763,000
Enabling Technologies	14197	Solutions Marketing		Lisa Long	Allen Fernan	Marketing &	Marketing ar	FTE	Labor - Staff	Charges In	Solutions Marketing						0.8			$125,000		$ -	$ -	$ -	$ -	$ 100,000	$ -	$ -	$100,000	$100,000	$0	$0
Enabling Technologies	14197	Solutions Marketing		Lisa Long	Allen Fernan	Marketing &	Marketing ar	Other/Non-l	Contracts		Solutions Marketing - ESA 2020		$1,497,813	$ 1,821,500	$ 1,894,750	$ 5,214,063						$ 1,498,000	$ 1,822,000	$ 1,895,000	$ 5,215,000	$ -	$ -	$ -	$5,215,000	$1,498,000	$1,822,000	$1,895,000
Enabling Technologies	14197	Solutions Marketing		Lisa Long	Allen Fernan	Marketing &	Marketing ar	Other/Non-l	Contracts		Solutions Marketing - ESA II			$ 781,225	$ 859,348	$ 1,640,573						$ -	$ 781,000	$ 859,000	$ 1,640,000	$ -	$ -	$ -	$1,640,000	$0	$781,000	$859,000
Channel of Choice																																
Customer E **Customer Insight**																					x	$ -	$ -	$ -	$ -	$ 14,000	$ 21,000	$ 22,000	$ 57,000	$ 125,000	$ 171,000	$ 177,000
Customer Insight	13775			Darleen DeR	Allen Fernandez Smith		General Adm	Other/Non-l	Contracts	Charges In	CIS		111,000	150,000	154,500							$ 111,000	$ 150,000	$ 155,000	$ 416,000	$ -	$ -	$ -	$416,000	$111,000	$150,000	$155,000
Customer Insight	13775	CIS		Darleen DeR	Allen Fernandez Smith		General Adm	FTE	Labor	Charges In	CIS						0.10	0.15	0.15	$125,000		$ -	$ -	$ -	$ -	$ 14,000	$ 21,000	$ 22,000	$57,000	$14,000	$21,000	$22,000
Pricing Product																																
IDSM Produ **Pricing Product**																					x	$ 283,000	$ 5,047,000	$ 3,120,000	$ 8,450,000	$ 1,508,000	$ 1,739,000	$ 1,791,000	$ 13,488,000	$2,501,000	$7,517,000	$5,664,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	FTE	Labor	Charges In	Smart Energy Line (SEL)						5	5	5	$ 110,000		$ -	$ -	$ -	$ -	$ 710,000	$ 731,000	$ 753,000	$2,194,000	$710,000	$731,000	$753,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	FTE	Labor		PP labor						7.65	8	8	$ 125,532		$ -	$ -	$ -	$ -	$ 1,239,000	$ 1,334,000	$ 1,374,000	$3,947,000	$1,239,000	$1,334,000	$1,374,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Labor	Labor - Staff								0.5	1	1	$ 150,000		$ -	$ -	$ -	$ -	$ 75,000	$ 155,000	$ 159,000	$389,000	$75,000	$155,000	$159,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Regulatory C	FTE	Labor		PP labor						1.2	1.5	1.5	$ 125,532		$ -	$ -	$ -	$ -	$ 194,000	$ 250,000	$ 258,000	$702,000	$194,000	$250,000	$258,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Appliances	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Domestic Hc	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Enclosure	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		HVAC	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Lighting	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Miscellaneou	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Customer Er	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		In Home Edu	Other/Non-l	Contracts							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Contracts		RHA/Chico Technical		$ 150,000	$ 154,500	$ 159,135	$ 463,635						$ 150,000	$ 155,000	$ 159,000	$ 464,000	$ -	$ -	$ -	$464,000	$150,000	$155,000	$159,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Contracts		Customer Research			$ 200,000	$ 200,000	$ 400,000						$ -	$ 200,000	$ 200,000	$ 400,000	$ -	$ -	$ -	$400,000	$0	$200,000	$200,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Other Cost		Postage for Inspection		$ 20,000	$ 21,000	$ 22,050	$ 63,050						$ 20,000	$ 21,000	$ 22,000	$ 63,000	$ -	$ -	$ -	$63,000	$20,000	$21,000	$22,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Other Cost		New EPO - Design, Build, Test, Training		$ -	$ 3,000,000	$ 1,500,000	$ 4,500,000						$ -	$ 3,000,000	$ 1,500,000	$ 4,500,000	$ -	$ -	$ -	$4,500,000	$0	$3,000,000	$1,500,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Other Cost		New EPO - Licensing		$ -	$ -	$ 350,000	$ 350,000						$ -	$ -	$ 350,000	$ 350,000	$ -	$ -	$ -	$350,000	$0	$0	$350,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Other Cost		New EPO - O&M & Minor Enhancements		$ -	$ -	$ 250,000	$ 250,000						$ -	$ -	$ 250,000	$ 250,000	$ -	$ -	$ -	$250,000	$0	$0	$250,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Other Cost		New EPO - Support EPO in Transition		$ -	$ 600,000	$ -	$ 600,000						$ -	$ 600,000	$ -	$ 600,000	$ -	$ -	$ -	$600,000	$0	$600,000	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		General Adm	Other/Non-l	Other Cost		Travel & Misc.		$ 47,250	$ 50,000	$ 55,000	$ 152,250						$ 47,000	$ 50,000	$ 55,000	$ 152,000	$ -	$ -	$ -	$152,000	$47,000	$50,000	$55,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Regulatory C	Other/Non-l	Other Cost		Travel & Misc.		$ 11,200	$ 11,536	$ 12,600	$ 35,336						$ 11,000	$ 12,000	$ 13,000	$ 36,000	$ -	$ -	$ -	$36,000	$11,000	$12,000	$13,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		M&E Studies	Other/Non-l	Contracts		Impact Evaluation		$ -	$ 107,250	$ 57,750	$ 165,000						$ -	$ 107,000	$ 58,000	$ 165,000	$ -	$ -	$ -	$165,000	$0	$107,000	$58,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		M&E Studies	Other/Non-l	Contracts		Low Income Needs Assessment		$ -	$ 97,500	$ 52,500	$ 150,000						$ -	$ 98,000	$ 53,000	$ 151,000	$ -	$ -	$ -	$151,000	$0	$98,000	$53,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		M&E Studies	Other/Non-l	Contracts		Energy Education (Phase 2)		$ -	$ 68,250	$ 36,750	$ 105,000						$ -	$ 68,000	$ 37,000	$ 105,000	$ -	$ -	$ -	$105,000	$0	$68,000	$37,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		M&E Studies	Other/Non-l	Contracts		Non Energy Benefits and Equity Criteri		$ -	$ 29,250	$ 15,750	$ 45,000						$ -	$ 29,000	$ 16,000	$ 45,000	$ -	$ -	$ -	$45,000	$0	$29,000	$16,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		M&E Studies	Other/Non-l	Other Cost							$ -						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Pilots	Other/Non-l	Contracts		HAN Component of Energy Education			$ 81,250	$ 43,750	$ 125,000						$ -	$ 81,000	$ 44,000	$ 125,000	$ -	$ -	$ -	$125,000	$0	$81,000	$44,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Pilots	Other/Non-l	Contracts		Energy-Water Leveraged Pilot			$ 88,400	$ 47,600	$ 136,000						$ -	$ 88,000	$ 48,000	$ 136,000	$ -	$ -	$ -	$136,000	$0	$88,000	$48,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Pilots	Other/Non-l	Contracts		CSD Geographic Coordination - Phase II			$ 218,075	$ 117,425	$ 335,500						$ -	$ 218,000	$ 117,000	$ 335,000	$ -	$ -	$ -	$335,000	$0	$218,000	$117,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		Pilots	Other/Non-l	Contracts		Consumption Driven Weatherization Pi			$ 265,200	$ 142,800	$ 408,000						$ -	$ 265,000	$ 143,000	$ 408,000	$ -	$ -	$ -	$408,000	$0	$265,000	$143,000
Products	14711	Low Income Program and		Tina Nguyen	Allen Fernandez Smith		CPUC Energy	Other/Non-l	Other Cost				$ 55,000	$ 55,000	$ 55,000	$ 165,000						$ 55,000	$ 55,000	$ 55,000	$ 165,000	$ -	$ -	$ -	$165,000	$55,000	$55,000	$55,000
Energy Efficiency																																
Operations **Energy Efficiency Operations**																					x	$ 1,075,000	$ 1,011,000	$ 1,011,000	$ 3,097,000	$ 6,196,000	$ 5,882,000	$ 6,059,000	$ 21,234,000	$ 7,271,000	$ 6,893,000	$ 7,070,000
Energy Efficiency Operations	13973	Business System Administ		Vici Pars	Vici Pars		General Adm	FTE	Labor								1.79	2	2	$ 115,142		$ -	$ -	$ -	$ -	$ 266,000	$ 306,000	$ 315,000	$887,000	$266,000	$306,000	$315,000
Energy Efficiency Operations	13973	Business System Administ		Vici Pars	Vici Pars		General Adm	Other/Non-l	Contracts				$ 700,000	$ 700,000	$ 700,000	$ 2,100,000						$ 700,000	$ 700,000	$ 700,000	$ 2,100,000	$ -	$ -	$ -	$2,100,000	$700,000	$700,000	$700,000
Energy Efficiency Operations	13636	Enrollment & Incentive Mı		Michael Burı	Michael Burger		General Adm	FTE	Labor								1.09	1.09	1.09	$ 121,326		$ -	$ -	$ -	$ -	$ 171,000	$ 176,000	$ 181,000	$528,000	$171,000	$176,000	$181,000
Energy Efficiency Operations	13636			Michael Burı	Michael Burger		Regulatory C	FTE	Labor								0.18	0.18	0.18	$ 121,326		$ -	$ -	$ -	$ -	$ 28,000	$ 29,000	$ 30,000	$87,000	$28,000	$29,000	$30,000
Energy Efficiency Operations	13636	Financial Reporting and G		Michael Burı	Michael Burger		General Adm	FTE	Labor	Charges In	Business Finance						0.46	0.46	0.46	$ 121,326		$ -	$ -	$ -	$ -	$ 72,000	$ 74,000	$ 76,000	$222,000	$72,000	$74,000	$76,000
Energy Efficiency Operations	13636	Financial Reporting and G		Michael Burı	Michael Burger		General Adm	FTE	Labor - Staff	Charges In	Business Finance									$ 121,326		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Energy Efficiency Operations	13636	Financial Reporting and G		Michael Burı	Michael Burger		General Adm	FTE	Labor	Charges In	Sourcing						1.2	1.2	1.2	$ 121,326		$ -	$ -	$ -	$ -	$ 188,000	$ 193,000	$ 199,000	$580,000	$188,000	$193,000	$199,000
Energy Efficiency Operations	14714			Mike Boggs	Mike Boggs		Inspections	FTE	FTE		External Verification Admin						2.02	2.02	2.02	$ 112,141		$ -	$ -	$ -	$ -	$ 292,000	$ 301,000	$ 310,000	$903,000	$292,000	$301,000	$310,000
Energy Efficiency Operations	14714			Mike Boggs	Mike Boggs		Inspections	FTE	Labor	Charges In	Central Inspection						40	36	36	$ 100,000		$ -	$ -	$ -	$ -	$ 5,160,000	$ 4,783,000	$ 4,927,000	$14,870,000	$5,160,000	$4,783,000	$4,927,000
Energy Efficiency Operations	14714			Mike Boggs	Mike Boggs		Inspections	FTE	Labor - Cons	Charges In	Central Inspection						0.15	0.15	0.15	$ 100,000		$ -	$ -	$ -	$ -	$ 19,000	$ 20,000	$ 21,000	$60,000	$19,000	$20,000	$21,000
Energy Efficiency Operations	14714			Mike Boggs	Mike Boggs		Inspections	FTE	Labor - Staff	Charges In	Central Inspection									$ 112,141		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Energy Efficiency Operations	14714			Mike Boggs	Mike Boggs		Inspections	Other/Non-l	Other Cost	Charges In	Central Inspection		$ 375,000	$ 311,000	$ 311,000							$ 375,000	$ 311,000	$ 311,000	$ 997,000	$ -	$ -	$ -	$997,000	$375,000	$311,000	$311,000
Energy Efficiency Operations	14714			Mike Boggs	Mike Boggs		Inspections	Other/Non-l	Other Cost													$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Energy Products and Programs																																
Retail Distributor & Trade Alliances																					x	$ 285,000	$ 575,000	$ 575,000	$ 1,435,000	$ 351,000	$ 402,000	$ 414,000	$ 2,602,000	$ 682,000	$ 1,022,000	$ 1,034,000
Energy Training Center	13772			Paola Benas:	Paola Benassi		General Adm	Other/Non-l	Other Cost				$ 45,564	$ 45,000	$ 45,000	$ 135,564						$ 46,000	$ 45,000	$ 45,000	$ 136,000	$ -	$ -	$ -	$136,000	$46,000	$45,000	$45,000
Energy Training Center	13772			Paola Benas:	Paola Benassi		Training Cer	FTE	Labor								1.8	2	2	$ 151,309		$ -	$ -	$ -	$ -	$ 351,000	$ 402,000	$ 414,000	$1,167,000	$351,000	$402,000	$414,000
Energy Training Center	13772			Paola Benas:	Paola Benassi		Training Cer	Other/Non-l	Contracts				$ 285,000	$ 575,000	$ 575,000	$ 1,435,000						$ 285,000	$ 575,000	$ 575,000	$ 1,435,000	$ -	$ -	$ -	$1,435,000	$285,000	$575,000	$575,000
CES																																
Business Operations																					x	$ -	$ -	$ -	$ -	$ 239,000	$ 246,000	$ 254,000	$ 739,000	$ 239,000	$ 246,000	$ 254,000
Business Operations	14195			Jeremy Donr	Jeremy Donnell		General Adm	FTE	Labor								0.04	0.04	0.04	$ 110,012		$ -	$ -	$ -	$ -	$ 6,000	$ 6,000	$ 6,000	$18,000	$6,000	$6,000	$6,000
Business Operations	14195			Jeremy Donr	Jeremy Donnell		Regulatory C	FTE	Labor								0.72	0.72	0.72	$ 110,012		$ -	$ -	$ -	$ -	$ 102,000	$ 105,000	$ 108,000	$315,000	$102,000	$105,000	$108,000
Business Operations	14195			Jeremy Donr	Jeremy Donnell		General Adm	FTE	Labor - Staff											$ 110,012		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0
Business Operations	11070	Risk Compliance and Impr		Gita Mondal	Gita Mondal		General Adm	FTE	Labor								0.86	0.86	0.86	$ 111,846		$ -	$ -	$ -	$ -	$ 124,000	$ 128,000	$ 132,000	$384,000	$124,000	$128,000	$132,000
Business Operations	11070	Risk Compliance and Impr		Gita Mondal	Gita Mondal		Regulatory C	FTE	Labor								0.05	0.05	0.05	$ 111,846		$ -	$ -	$ -	$ -	$ 7,000	$ 7,000	$ 8,000	$22,000	$7,000	$7,000	$8,000

Footnotes

[1] Estimated Annual base salaries are estimated and calculated by Business Finance. Labor cost calculations included S&M, overhead cost (see PCC tabs)

2 Labor reflects Activity Type Cost ONLY - (Benefits Burden Offset NOT included)

Key Assumptions for Labor

PCC Standard Rate	20%
Payroll Taxes	9%
Labor Escalation	3%
All overhead costs are included in total labor.	

	Project Name	Order Number & Description	Description
ESA 2020	**Acquisition: DM/EM**	**8149037 ESA Direct Outreach**	**TOTAL:**
ESA 2020	Acquisition: Direct Outreach	8149037 ESA Direct Outreach	Direct mail and/or email to drive awareness and acquisition
ESA 2020	Acquisition: Bill Insert	8149037 ESA Direct Outreach	Bill Insert to drive awareness and acquisition
ESA 2020	Acquisition: Digital	8149043 ESA Media	Digital advertising, search and radio campaign to drive awareness and acquisition
ESA 2020	Acqusition: IVR, SMS,	8149037 ESA Direct Outreach	Automated call, text messages to drive awareness and acquisition
ESA 2020	Acqusition:Telemarketing	8149037 ESA Direct Outreach	Telemarketing calls
ESA 2020	Acquisition: Partnerships - Saber es Poder	8149037 ESA Direct Outreach	Partnership to drive awareness and acquisition
ESA 2020	**Acquisition: Newsletter**	**8149041 ESA Online/Web**	**TOTAL:**
ESA 2020	Acquisition: Newsletter - Residential	8149041 ESA Online/Web	CARE and ESA co-fund monthly email newsletter to low-income residential customers; supports awareness and acquisition
ESA 2020	Acquisition: Newsletter - Home Energy Report	8149041 ESA Online/Web	Part of the existing Home Energy Report
ESA 2020	Acquisition: Contractor Collateral	8149038 ESA Collateral	Contractor educational materials every year (does not include printed forms)
ESA 2020	Acquisition: Contractor Tools	8149038 ESA Collateral	Provide marketing templates for contractors to drive awareness and referrals
ESA 2020	Data / Analytics - Targetbase Lists	8149042 ESA Data Management	Customer list pulls
ESA 2020	Customer insights research	8149040 ESA Research	Research related to outreach and messaging for re-treating ESA homes after 10 years
ESA 2020	Labor - Marketing Strategy	8149039 ESA Labor	

ESA 2020	Labor - Mar Comm	8149400 ESA Labor (Mar Comm)	
ESA 2020	Labor - Bus Ops	8149045 ESA Labor (Bus Ops)	
ESA 2020	Labor - Customer Insights	Labor Associated with customer research planned	
	TOTAL	**ESA 2020 Total**	
			Target 2015 % Increase
			Target 2015 ESA 2020 Budget

ESA II	Acquisition: Direct Outreach	8149037 ESA Direct Outreach	Direct mail and/or email to customers who participated 10+ years ago.
ESA II	Acqusition: IVR, SMS, Telemarketing	8149037 ESA Direct Outreach	Automated call, text messages to drive awareness and acquisition
ESA II	Acquisition: Contractor Collateral	Contractor collateral or contractor tools?	Contractor educational materials every year (does not include printed forms)
ESA II	Data / Analytics - Targetbase Lists	8149042 ESA Data Management	Customer list pulls
ESA II	Customer insights research	8149040 ESA Research	Research related to outreach and messaging for re-treating ESA homes after 10 years
	TOTAL	**ESA II Total**	

2014 Budget

			2016 Est
Customer Count	**Cost Per Unit**	**Qty**	**Cost Estimate**
How many customers will be targeted	Cost per unit	Repeated how many times	Forumla to calculate costs based on Col U, V, W.
300,000	$ 0.65	4	$ 780,000
	$ 9,000.00	**1**	$ 9,000
n/a	$ 300,000.00	ongoing	$ 300,000
180,000	$ 0.25	**1**	$ 45,000
15,000	$ 6.60	1	$ 99,000
1,500	$ 45.00	1	$ 67,500
n/a	$ 7,500	12	$ 90,000
n/a	$ 5,000	3	$ 15,000
n/a	$ 150,000	1	$ 150,000
n/a	$ 70,000	1	$ 77,000
n/a	$ 150,000	1	$ 150,000
n/a	$ 39,000.00	1	$ 39,000
n/a	$ 368,960	1	$ 368,960

n/a	$ 262,236.00	1	$ 288,460
n/a	$ 12,196.00	1	$ 13,416
n/a	$ 22,500.00	1	$ 22,500
			$ 2,514,835
		Increase By	**34%**
224,000	$ 0.65	4	$ 582,400
134,400	$ 0.25	2	$ 67,200
n/a	$ 18,750	1	$ 20,625
n/a	$ 72,000.00	1	$ 72,000
n/a	$ 39,000.00	1	$ 39,000
			$ 781,225

	2016 Budget to include ESA 2020 and ESA II	**$ 3,296,060**
Total Percent Change	**43%**	

Target 2015 ESA 2020 Budget (20% increase)	**$**	**2,255,820**
Current 2015 ESA 2020 Budget	**$**	**2,514,835**
Current 2015 ESA II budget	**$**	**781,225**

imates	
Assumptions	**Cost Estimate**
List any assumptions made on customer counts,or details on where the estimates are from. Note what is included in the estimate: Design, graphics, IT, translation, etc. This helps us to explain or justify costs or changes later.	
300k willing and eligigle customers remain to be treated. Cost aligns with CARE budget. Translation costs included.	$ 858,000.00
Based on 2014 customer count and cost. Translation costs included. 1 bill inserts per year. 1 Insert will be funded by ESA 2020 and ESA II. Both inserts will include details for both programs	$ 9,900.00
Based on 2014 cost with 10% yearly increase to cover inflation.	$ 330,000.00
Based on 2014 customer count and CARE costs. Text is a new channel w/ no costs avaialble but most likely similar to IVR. Assumes we have phone numbers for 60% of the 300,000 remaining to be treated	$ 49,500.00
Cost per call based on based on vendor estimate (Nexant). Assumes we will utilize telemarketing 5%the total customers left to be treated . Testing to see effectiveness. Will increase if deemed effective at overcoming barriers to participation	
Most likely similar to Allconnect cost.	$ 74,250.00
	$ -
Low Income Co-funded newsletter. CARE contributes 1/2 ($90k). ESA contributes 1/2 ($90k) Previously in 2014 ESA and CARE sponsored several issues of the residential newsletter and had low income content. Current strategy being tested is a separate individiual low income newsletter developed specifically for low income customers and delivered monthly	$ 99,000.00
Participation in 3 waves.	$ 16,500.00
reduced from 2014 costs. Printed forms will no longer be done. This cost is associated with educational materials only.	$ 165,000.00
Based on 2014 cost with 10% yearly increase to cover inflation.	$ 84,700.00
Based on 2014 cost. Pull approximately 2 list pulls per month. Aprox total for lists	$ 165,000.00
Based on Customer Insights estimates for Low Income recommended research. Split between CARE and ESA. ESA research of 78k will be divided by ESA 2020 and ESA II (each paying 39,000)	$ 42,900.00
Based on 2014 cost with 10% yearly increase to cover inflation. Labor for ESA 2020 and ESA II	$ 405,856.00

Based on 2014 cost with 10% yearly increase to cover inflation. Labor for ESA 2020 and ESA II	$	317,305.56
Based on 2014 cost with 10% yearly increase to cover inflation. Labor for ESA 2020 and ESA II	$	14,757.16
Based on Customer Insights estimates for Low Income recommended research. 1/2 split with CARE. Work papers include details. Labor for ESA 2020 and ESA II	$	24,750.00
	$	**2,657,419**
Based on 224,100 homes being treated in 2002 to 2005 (over 10 years). Cost aligns with CARE budget. Translation costs included.	$	640,640.00
Based on CARE costs. Text is a new channel so no costs avaialble but most likely similar to IVR. Customer count based on contacting 60% of the 224keligible customers through text/IVR. 226k*0.6=134,000	$	73,920.00
Factors contract materials needed. 1/8 of the cost of materials created for ESA 2020	$	22,687.50
Necessary for separate list pulls to target the homes treated over 10 years ago. ESA II needs aprox 1 per month at $6 per pull.	$	79,200.00
Based on Customer Insights estimates for Low Income recommended research. Split between CARE and ESA. ESA research of 78k will be divided by ESA 2020 and ESA II (each paying 39,000)	$	42,900.00
	$	**859,348**

	$	**3,516,766.22**

Targeting 300k homes (Carries all labor costs for ESA 2020 and ESA II)
Targeting 224k homes for retreatment)

2017 Estimates
Assumptions
2017 adds 10% to the amount in 2016 to account for increased costs (production/mailing/etc) inflation, etc)
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5
Same as Z5

Same as Z5
Same as Z5
Same as Z5
2017 adds 10% to the amount in 2016 to account for increased costs (production/mailing/etc) inflation, etc)

2017 Budget

PACIFIC GAS AND ELECTRIC COMPANY
Low Income Program – Project Year 2015-2017
Application 14-11-010
Data Response

PG&E Data Request No.:	ORA_009-01-03		
PG&E File Name:	LowIncomeProgramPY15-17_DR_ORA_009-Q01-03		
Request Date:	March 5, 2015	Requester DR No.:	012
Date Sent:	March 19, 2015	Requesting Party:	Office of Ratepayer Advocates
PG&E Witness:	Mary O'Drain	Requester:	Camille Watts-Zagha

QUESTION 1

Regarding the ESA administrative budget proposed for 2016, please provide all workpapers supporting Table A-1 "ESA Budget," for the following line items:

Training Center
Inspections
Marketing and Outreach
Statewide Marketing Education and Outreach [2]
Measurement and Evaluation Studies
Regulatory Compliance
General Administration
CPUC Energy Division

Workpapers should include quantitative support for the final amount requested, and may include cost of employee, by employee title, cost of activity, by specific activity, assumptions

a. For each line item, explain the difference in cost between 2016, and the annual average of costs in 2013 & 2014. Specifically identify the drivers of the cost increase or decrease, including but not limited to

a. Greater or fewer number of the same activities performed in previous years,

b. The addition or subtraction of an activity in the program,

c. staff additions or subtractions,

d. cost increases or decreases in materials,

e. efficiencies gained or lost.

ANSWER 1

PG&E's work papers supporting the ESA Program's administrative proposed budget for 2016 for the line items: Training Center, Inspections, Marketing and Outreach, Statewide Marketing Education and Outreach, Measurement and Evaluation Studies, Regulatory Compliance, General Administration, and CPUC Energy Division are attached as:

LIPPY15-17_DR_ORA 009_Q01Atch01_2016Budget

a. The table below provides a comparison of 2013 and 2014 actual expenses to the 2016 proposed budget by the requested line items.

ESA Program	PY2013 Expenses [1]	PY 2014 Expenses [2]	PY 2016 Proposed
Training Center	$654,789	$697,140	$977,000
Inspections	$5,028,005	$5,952,075	$5,415,000
Marketing and Outreach	$1,113,801	$1,806,012	$3,296,000
Statewide Marketing Education and Outreach	$0	$0	$0
Measurement and Evaluation Studies	$543,408	$0	$302,000
Regulatory Compliance	$207,725	$322,282	$403,000
General Administration	$3,384,888	$4,079,410	$8,045,000
CPUC Energy Division	$20,057	$20,499	$55,000

[1] 2013 expenses did not include $1.5 million in employee benefits that was allocated to the ESA Program beginning in 2014 due to D.14-08-032-PG&E's 2014 GRC.
[2] Expenses are through December 31, 2014. Final expenses will be reported in PG&E's 2014 Annual Report to be filed on May 1, 2015.

- Training Center: PG&E's labor costs to provide ESA Program's contractors with training and education have remained constant at $350,000 - $400,000 annually. The increase in the 2016 proposed budget is due to new training curriculums and materials for new measures.
- Inspections: The decrease in the 2016 proposed budget reflects the lower homes treated goal proposed in 2016.
- Marketing and Outreach: The increase in the 2016 proposed budget is due to: 1) marketing costs to outreach to new customers to meet the ESA 2020 goal, and 2) Additional outreach costs for the ESA II initiative.
- Statewide Marketing Education and Outreach: PG&E is not requesting any budget for this line item in 2016, and has requested this line item be deleted
- Measurement and Evaluation Studies: The 2016 proposed budget is specific for four Joint Utility ESA studies in 2015-2017 as described in PG&E's ESA Testimony, Attachment D, 1-4.
- Regulatory Compliance: The increase in the 2016 proposed budget is due to labor cost increases that were escalated annually at 3%.
- General Administration: The increase in the 2016 proposed budget is due to: 1) an additional $200,000 to fund any additional rapid feedback research required by the CPUC, and 2) New funding of $3,600,000 to move the outdated Energy Partners Online (EPO) customer management database to a new system, Energy Insight.
- CPUC Energy Division (ED): The 2016 proposed budget is the same as the 2012--2014 budget authorized in D.12-08-44. PG&E had requested an updated

cost budget from ED for this line item but did not receive a response from them for the application filing in November.

QUESTION 2

Regarding the ESA administrative budget proposed for 2016, please describe the process by which the budget was developed. Include the date the first draft of the budget was presented, by whom and to whom. Include position names, titles, and names of organization branches or divisions. Identify each successive draft of the budget and list of those approving the budget.

ANSWER 2

PG&E followed the following process in developing the ESA administrative budget proposed for 2016:

- Developed a budget template around March-April 2014 (shown in answer 1).
- The ESA Program supervisor reached out to internal department stakeholders to provide their proposed budgets to enter into the budget template. Due to the delay in issuing the Application Guidance Document (provided as Attachment Q in D.14-08-030), a draft proposed budget was not available until early October 2014.
- The first draft of the budget was reviewed by the ESA Program supervisor and manager in October 2014.
- PG&E presented a draft budget at the PG&E Application Public Meeting held in San Francisco on October 7, 2014.
- The Low Income Manager and the Low Income Expert presented the budget in October to PG&E Customer Care management (to the Director of Pricing Products). The Director of Pricing Products presented an overview of the ESA budget to the Senior Director of Customer Programs/Acting VP of Customer Care.

QUESTION 3

Regarding PG&E's response to ORA-4, Question 3 h, regarding administrative costs in the ESACET calculation, please identify by category and amount, the costs not included in PG&E's administrative section of the budget in Table A-1 "ESA Budget". Provide the cell(s) in the E3 calculator that links to each category of administrative cost not included in the administrative section of Table A-1. If there is no cell(s) in the E3 calculator to link to, provide workpapers for this category of costs.

ANSWER 3

The installation value used in the PG&E's ESA Cost Effectiveness Test was $310,575 more than that in the budget tables filed. The enclosure installation budget was

incorrectly stated in the filed budget tables. PG&E will file an errata to correct this discrepancy.

The input worksheet of the 2016 E3 calculator that links to the category not included in the administrative section of Table A-1 is shown below.

a.i. Overhead and G&A	$	21,654,113
a.ii. Other Admin costs	$	7,556,867
b. Marketing/Outreach	$	3,296,000
c. Direct Implementation (non incentive)		
c.i. Activity		
c.ii. Installation	$	23,295,000
c.iii. Hardware & Materials		
c.iv. Rebate Processing and Inspection		
d. Total Incentives and Rebates	$	99,036,595
e. EM&V		
Total	**$**	**154,838,575**

PACIFIC GAS AND ELECTRIC COMPANY
Low Income Program – Project Year 2015-2017
Application 14-11-010
Data Response

PG&E Data Request No.:	ORA_009-01-03		
PG&E File Name:	LowIncomeProgramPY15-17_DR_ORA_009-Q01-03		
Request Date:	March 5, 2015	Requester DR No.:	012
Date Sent:	March 19, 2015	Requesting Party:	Office of Ratepayer Advocates
PG&E Witness:	Mary O'Drain	Requester:	Camille Watts-Zagha

QUESTION 1

Regarding the ESA administrative budget proposed for 2016, please provide all workpapers supporting Table A-1 "ESA Budget," for the following line items:

Training Center
Inspections
Marketing and Outreach
Statewide Marketing Education and Outreach [2]
Measurement and Evaluation Studies
Regulatory Compliance
General Administration
CPUC Energy Division

Workpapers should include quantitative support for the final amount requested, and may include cost of employee, by employee title, cost of activity, by specific activity, assumptions

a. For each line item, explain the difference in cost between 2016, and the annual average of costs in 2013 & 2014. Specifically identify the drivers of the cost increase or decrease, including but not limited to

a. Greater or fewer number of the same activities performed in previous years,

b. The addition or subtraction of an activity in the program,

c. staff additions or subtractions,

d. cost increases or decreases in materials,

e. efficiencies gained or lost.

ANSWER 1

PG&E's work papers supporting the ESA Program's administrative proposed budget for 2016 for the line items: Training Center, Inspections, Marketing and Outreach, Statewide Marketing Education and Outreach, Measurement and Evaluation Studies, Regulatory Compliance, General Administration, and CPUC Energy Division are attached as:

LIPPY15-17_DR_ORA 009_Q01Atch01_2016Budget

a. The table below provides a comparison of 2013 and 2014 actual expenses to the 2016 proposed budget by the requested line items.

ESA Program	PY2013 Expenses [1]	PY 2014 Expenses [2]	PY 2016 Proposed
Training Center	$654,789	$697,140	$977,000
Inspections	$5,028,005	$5,952,075	$5,415,000
Marketing and Outreach	$1,113,801	$1,806,012	$3,296,000
Statewide Marketing Education and Outreach	$0	$0	$0
Measurement and Evaluation Studies	$543,408	$0	$302,000
Regulatory Compliance	$207,725	$322,282	$403,000
General Administration	$3,384,888	$4,079,410	$8,045,000
CPUC Energy Division	$20,057	$20,499	$55,000

[1] 2013 expenses did not include $1.5 million in employee benefits that was allocated to the ESA Program beginning in 2014 due to D.14-08-032-PG&E's 2014 GRC.
[2] Expenses are through December 31, 2014. Final expenses will be reported in PG&E's 2014 Annual Report to be filed on May 1, 2015.

- Training Center: PG&E's labor costs to provide ESA Program's contractors with training and education have remained constant at $350,000 - $400,000 annually. The increase in the 2016 proposed budget is due to new training curriculums and materials for new measures.
- Inspections: The decrease in the 2016 proposed budget reflects the lower homes treated goal proposed in 2016.
- Marketing and Outreach: The increase in the 2016 proposed budget is due to: 1) marketing costs to outreach to new customers to meet the ESA 2020 goal, and 2) Additional outreach costs for the ESA II initiative.
- Statewide Marketing Education and Outreach: PG&E is not requesting any budget for this line item in 2016, and has requested this line item be deleted
- Measurement and Evaluation Studies: The 2016 proposed budget is specific for four Joint Utility ESA studies in 2015-2017 as described in PG&E's ESA Testimony, Attachment D, 1-4.
- Regulatory Compliance: The increase in the 2016 proposed budget is due to labor cost increases that were escalated annually at 3%.
- General Administration: The increase in the 2016 proposed budget is due to: 1) an additional $200,000 to fund any additional rapid feedback research required by the CPUC, and 2) New funding of $3,600,000 to move the outdated Energy Partners Online (EPO) customer management database to a new system, Energy Insight.
- CPUC Energy Division (ED): The 2016 proposed budget is the same as the 2012--2014 budget authorized in D.12-08-44. PG&E had requested an updated

cost budget from ED for this line item but did not receive a response from them for the application filing in November.

QUESTION 2

Regarding the ESA administrative budget proposed for 2016, please describe the process by which the budget was developed. Include the date the first draft of the budget was presented, by whom and to whom. Include position names, titles, and names of organization branches or divisions. Identify each successive draft of the budget and list of those approving the budget.

ANSWER 2

PG&E followed the following process in developing the ESA administrative budget proposed for 2016:

- Developed a budget template around March-April 2014 (shown in answer 1).
- The ESA Program supervisor reached out to internal department stakeholders to provide their proposed budgets to enter into the budget template. Due to the delay in issuing the Application Guidance Document (provided as Attachment Q in D.14-08-030), a draft proposed budget was not available until early October 2014.
- The first draft of the budget was reviewed by the ESA Program supervisor and manager in October 2014.
- PG&E presented a draft budget at the PG&E Application Public Meeting held in San Francisco on October 7, 2014.
- The Low Income Manager and the Low Income Expert presented the budget in October to PG&E Customer Care management (to the Director of Pricing Products). The Director of Pricing Products presented an overview of the ESA budget to the Senior Director of Customer Programs/Acting VP of Customer Care.

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c.i. Activity		
c.ii. Installation	$	23,295,000
c.iii. Hardware & Materials		
c.iv. Rebate Processing and Inspection		
d. Total Incentives and Rebates	$	99,036,595
e. EM&V		
Total	**$**	**154,838,575**

Work Paper PGECOHVC145
95 AFUE Furnace - Res
Revision # 0

Pacific Gas & Electric Company

Customer Energy Solutions

High Efficiency Furnace 95 AFUE (1.04 HIR) – Residential

Measure Codes: XXXX, XXXX

DRAFT

Last revised 6/19/2012

At-a-Glance Summary

Applicable Measure Codes:	H##1		
Measure Description:	This measure applies to the installation of a 95% AFUE high efficiency central natural gas furnace with and without variable speed motor in a residential dwelling.		
Energy Impact Common Units:	per household		
Base Case Description:	Source: Federal Standard. Base Case gas furnace meeting federal standard requirements of 80% AFUE for units less than 225,000 Btu/h.		
Base Case Energy Consumption:	DEER2011 does not yet provide the base case energy consumption.		
Measure Energy Consumption:	DEER2011 does not yet provide the base case energy consumption.		
Energy Savings (Base Case – Measure):	Source: DEER 2011 and Engineering Calculation. Varies by climate zones, dwelling types, and vintages.		
Costs Common Units:	$ per furnace, $/furnace		
Base Case Equipment Cost ($/unit):	Source: DEER2008 and Engineering Calculation. $9.35/mBtuh, Total equipment cost varies, see At-A-Glance Measure List.		
Measure Equipment Cost ($/unit):	Source: DEER2008 and Engineering Calculation. $17.23/mBtuh. Total equipment cost varies, see At-A-Glance Measure List		
Gross Measure Cost ($/unit)	See Section 4		
Measure Incremental Cost ($/unit):	Source: DEER2008 and Engineering Calculation. Varies, see At-A-Glance Measure List		
Effective Useful Life (years):	Source: DEER2011 20 years		
Measure Application Type:	Replace on Burnout (ROB) and New Construction (NC).		
Net-to-Gross Ratios:	Source: DEER2011 0.55 NTGR, Res-Default>2.		
Important Comments:	Impact savings are assumed the residential dwelling uses both heating and cooling.		

At-A-Glance Measure List

								1st Baseline								2nd Baseline													
Measure Code	Version Source	Measure Description	Measure Application Type	Building Type	Building Vintage	Climate Zone	Unit Definition	KW Peak Electric Demand Reduction	KWh Electric Savings	THM Gas Savings	(EUL) LIFE CYCLE	Base Case Cost ($/unit)	Measure Cost ($/unit)	Labor Cost ($/unit)	IMC Incremental Measure Cost ($/unit)	KW Peak Electric Demand Reduction	KWh Electric Savings	THM Gas Savings	LIFE CYCLE	Base Case Cost ($/unit)	Measure Cost ($/unit)	Labor Cost ($/unit)	Incremental Measure	GRR_ kW	GRR_ kWh	GRR_ therm	NTG	Implementation Method [DI, DD, I]	ISR
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z01	Household	0.00	0.00	48.68	20	$373.07	$687.48	$0.00	$314.41	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z02	Household	0.00	0.00	50.93	20	$587.18	$1,082.04	$0.00	$494.86	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z03	Household	0.00	0.00	45.75	20	$510.51	$940.76	$0.00	$430.25	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z04	Household	0.00	0.00	36.36	20	$492.75	$908.02	$0.00	$415.28	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z05	Household	0.00	0.00	50.92	20	$558.20	$1,028.63	$0.00	$470.44	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z11	Household	0.00	0.00	43.23	20	$614.30	$1,132.01	$0.00	$517.72	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1
H##1		95% AFUE FURNACE (WITHOUT BUILT-IN VSM)	ROB, NC	SFM	AV	Z12	Household	0.00	0.00	41.92	20	$581.57	$1,071.71	$0.00	$490.14	0	0	0	0	0	0	0	0	1	1	1	0.55	I	1

Note: For the complete list of Measures, refer to Appendix A for the accompanying calculation spreadsheet

Work Paper Approvals

Grant Brohard Manager, Technical Product Support	Date
Paola Benassi Manager, HVAC and Motors Product	Date

Document Revision History

Revision #	Revision Date	Section-by-Section Description of Revisions	Author (Company)
Revision 0	06/19/2012	PGECOHVC145-R0_Res 95_furnace	Christopher Li (PG&E)

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Section 1. General Measure & Baseline Data

1.1 Product Measure Description & Background

Catalog Description – The 95% AFUE central gas furnace for residential single family, multifamily and mobile homes is part of PG&E's deemed rebate program delivered under the downstream catalog rebate program.

Program Restrictions and Guidelines
This measure is applied to a residential single family, multifamily and mobile homes located in PG&E's service territory. To qualify the applicant must have natural gas distributed to the installation address for the gas furnace only rebate and have both natural gas and electricity for the natural gas furnace with variable speed motor (VSM) rebate. The central natural gas furnace must have an Annual Fuel Utilization Efficiency (AFUE) rating of ≥ 95% and < 97%.

Terms and Conditions:
Furnace Only:

- Customer must have natural gas distributed by PG&E to the installation address.
- All installations must replace the previously installed product.
- The central natural gas forced air furnace must have an Annual Fuel Utilization Efficiency (AFUE) rating of 95 percent to 96.9 percent.
- Go to www.ahridirectory.org to search for qualifying products that meet or exceed the requirements in the Furnace Rebate Table.

Furnace with built-in Variable Speed Motor (VSM):

- Customer must have both natural gas and electricity distributed by PG&E to the installation address.
- Only available to homes located in climate zones (CZ) 11, 12, or 13. To find your climate zone go to www.energy.ca.gov/maps/Climate_Zones_by_City.pdf.
- All installations must replace the previously installed product.
- The central natural gas forced air furnace with Built-In Variable Speed Motor must have an AFUE rating of 95 percent to 96.9 percent.
- Go to www.ahridirectory.org to search for qualifying products that meet or exceed the requirements in the Furnace with VSM Rebate Table.
- A brushless DC motor, also known as an electronically commutated motor (ECM) may qualify for this rebate.
- Note: Consult with your licensed contractor to verify your furnace has a built-in VSM.

Market Applicability:
This measure applies to all types of residential buildings, including mobile homes, single family, and multi-family buildings.

1.2 Product Technical Description

1.2.1 Furnace only:

Natural gas burning furnaces provides heat to the conditioned space by passing combustion products past a heat exchanger. The forced air heating system uses natural gas, mixing it with air inside a burner where it ignites inside the combustion chamber. A blower fan pulls cool air in and from the rooms through the return air ducts into the furnace heat exchanger. The cool air is then heated by passing over the heat exchanger connected to the combustion chamber. Warm air then flows back into the rooms through the ductwork. The exhaust gases from the burner are vented outside through the flue passage connected to the heat exchanger. Furnaces usually have high utilization hours through the year. A gain in efficiency can therefore result in significant energy savings.

1.2.2 Furnace with Variable Speed Motor:

Most existing small-scale residential furnace blowers come with low cost, low efficiency, single speed PSC motors. These motors usually range in power between 1/3 to 2 hp. They turn on and off as required by thermostat control. This results in temperature variations, and high energy consumption of the furnace air handler blower motor.

Most major furnace manufacturers are now offering optional variable-speed motor on their air handlers, and some comes built into the unit. These motors have integrated electronic controls that modulate the motor and fan speed based on the cooling or heating load of the system; most variable speed motors are programmed to run at lower speed majority of the time. These motors provide much more efficient operation, and improve the quality of the air distribution; however, they come at a premium price.

This measure is designed to encourage the installation of such variable-speed motor air handlers in residential buildings. Because of the (ideally) cubic relationship between fan power and fan speed, a small reduction in fan speed can result in large energy savings.

1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on www.deeresources.com under *DEER2011for 13-14 Database Format* hyperlink, DEER2011 Database format, spreadsheet "*SPTdata_format-V0.97.xls*"[1], defines the terms as follows:

Table 1: Measure Application Type

Code	Description	Comment
ROB	Replace on Burnout	*measure applied when existing equipment fails or maintenance requires replacement*
NC	New Construction	*measure applied during construction design phase as an alternative to a code-compliant standard design*

The application type for this measure is replaced on burnout (ROB) and new construction (NC). Both ROB and NC use the effective useful life (EUL) as the basis for measure life.

The base case for both ROB and NC is a central natural gas furnace meeting minimum federal standards of 80% Annual Fuel Utilization Efficiency (AFUE).

1.4 Product Base Case and Measure Case Data

1.4.1 DEER Base Case and Measure Case Information

The 2011 Database for Energy Efficient Resources (DEER2011)[2] v4.01 data include: gas energy savings, equipment useful life, and net-to-gross of this measure (Res-GasFurnace-AFUE95). However, it does not contain information on equipment unit costs, equipment and incremental costs, therefore the data from DEER2008 v2.05 was used to estimate the equipment costs and incremental costs. For units with built-in variable speed motor, eQUEST[3] simulation tool was used to estimate the energy and peak demand savings. These differences are explained with each data variable table in this section. See the calculation section (2) for this conversion

Table 2: DEER Use and Technology Table

DEER USE and TECHNOLOGY TABLE			
Use Category Description	Use Category	Use Sub Category Description	Use Sub Category
HVAC	HVAC	Space Heating	HVAC-SpHt
Technology Groups Description	Technology Groups	Technology Types Descriptions	Technology Types
Space Heating Equipment	SpaceHtg_eq	Gas Furnace	GasFurnace

Delta Wattage Assumption (ΔW): The wattage for the base case furnace with PSC motor is assumed to be 0.650 Watts/CFM and measure case furnace with variable speed motor assumed a wattage of 0.365 Watts/CFM. The wattage assumption was based on recent studies.

EUL Electric Savings (ΔW): DEER does not have furnace with variable speed motor measure. However, within their eQUEST modeling, DEER assumes all furnace measures would have a low blower motor baseline power usage of 0.365 Watts/CFM. But based on three recent studies by Scott Pigg at Wisconsin Energy Center and a CEC PIER report, majority of existing furnaces would have older PSC (Permanent Split Capacitor) blower motors, which uses on average 0.650 Watts/CFM. The savings methodology is reflected on Section 2 below for furnace with variable speed motor.

Building type	Bldg Vintage	Climate Zone	Savings kW/unit	Deer units	DEER Version	Impact IDs
SFM	AV	Z11	0.27	Household	DEER2008	N/A
SFM	AV	Z12	0.21	Household	DEER2008	N/A
SFM	AV	Z13	0.21	Household	DEER2008	N/A

RUL Electric Savings (ΔW): RUL Electric Savings does not apply to this measure as the application type is ROB and NC, no early retirement.

Therms Savings Assumption (ΔTh): This measure is listed in the DEER2011 READI v0.99.7 and the Impact savings is extracted from this database under measure ID, Res-GasFurnace-AFUE95.

EUL Gas Savings (ΔTh): EUL Gas Savings for this measure was downloaded from the DEER2011 READI tool with impact ID, Res-Furnace-dHIR.

Building type	Bldg Vintage	Climate Zone	Interactive Only? Yes / No	Gas Savings Therms	Deer units	DEER Version	Impact IDs
SFM	AV	Z11	Yes	43.23	Household	DEER2011	Res-Furnace-dHIR
SFM	AV	Z12	Yes	41.92	Household	DEER2011	Res-Furnace-dHIR
SFM	AV	Z13	Yes	41.02	Household	DEER2011	Res-Furnace-dHIR

RUL Gas Savings (ΔTh): RUL Electric Savings does not apply to this measure as the application type is ROB and NC, no early retirement.

Hours of Operation: Residential furnaces have a wide range of equivalent full load hours (EFLH) where it varies depending on PG&E's climate zones. Since DEER data was used for the calculation of energy impacts, the hours of operation are assumed to been embedded in those values.

Building type	Bldg Vintage	Climate Zone	Hours of Operation hrs/yr	DEER Version	Measure IDs
SFM	AV	Z11	DEER hours	DEER2011	Res-GasFurnace-AFUE95
SFM	AV	Z12	DEER hours	DEER2011	Res-GasFurnace-AFUE95
SFM	AV	Z13	DEER hours	DEER2011	Res-GasFurnace-AFUE95

Base Case Costs and Measure Case Costs: DEER does not contain any costs data for base case furnace of 80% AFUE and measure case 95% AFUE furnace, however it does contain costs data for 94% and 96% AFUE furnace. To determine the costs, an interpolation method was used. The DEER unit is "cost ($) per mBtuh".

			Costs ($)			
Building type	Bldg Vintage	Climate Zone	Base Case	Measure Case	IMC	DEER Version
SFM	AV	Z11	$663.93	$1,223.92	$559.99	DEER2008
SFM	AV	Z12	$621.76	$1,146.17	$524.41	DEER2008
SFM	AV	Z13	$628.66	$1,158.89	$530.24	DEER2008

Net-to-Gross Assumption: The NTG ratio was based on the DEER 2011, the value was obtained from the "DEER2011_NTGR_2012-05-16.xls"[4] spreadsheet under the "DEER2011 NTGr Values tab.

Table 3 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

Table 3: DEER Net-to-Gross Ratios

		DEER Spreadsheet	
Program Approach	NTG	File name	Cell Number
All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years	0.55	DEER2011_NTGR_2012-05-16.xls	U54

The NTG Ratios in Table 3 are appropriate for the measure because:

- The current DEER 2011 spreadsheet does not contain a NTG value for this measure.
- This measure is replacing a non-operable existing unit with a high efficiency unit.

Effective Useful Life / Remaining Useful Life: The Effective Useful Life (EUL) estimates were downloaded directly from DEER2011; an EUL value of 20 years was obtained from the "EUL_Summary_10-1-08.xls"[5] spreadsheet, under the "DEER EUL Summary" tab and located on cell number D118.

Remaining Useful Life does not apply to this measure as the measure application type is ROB and NC, no early retirement in our program.

Building type	Bldg Vintage	Climate Zone	EUL (yrs)	RUL (yrs)	DEER Version
ALL	AV	ALL	20	0	DEER2008

In-service rate/first year installation rate: DEER does not have an in-service rate (ISR) for this measure. An assumption has been taken to assume the ISR will be 1 since majority of the customers will replace their furnace after the existing furnace burns out.

Building type	Bldg Vintage	Climate Zone	In-service rate	DEER Version
ALL	AV	ALL	1	DEER2011

1.4.2 Codes & Standards Requirements Base Case and Measure Information

Title 20: This measure does not fall under Title 20 of the California Energy Regulations.

Title 24: This measure does not fall under Title 24 of the California Energy Regulations.

Federal Standards: This measure do fall under Federal DOE (10 CFR Part 430)[6] Energy Regulations. Under this regulation, compliance with the standards in the direct final rule will be required on May 1, 2013 for non-weatherized furnaces and on January 1, 2015 for weatherized furnaces and central air conditioners and heat pumps. Because most residential type furnaces are installed inside the house, it's considered as non-weatherized for which the minimum AFUE is 80% for units less than 225,000 Btu/h in input capacity.

Federal Std. Description	Base or Measure Case	Value	Units	Code Source or Reference
76 FR 37408	Non-Weatherized gas	80% AFUE	Per System	CFR Part 430

1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

There are no EM&V study identified that address residential furnaces, however there is a report, "California Residential Efficiency Market Share Tracking, HVAC 2005", prepared by Itron and completed on December 2005, that address the average annual AFUE ratings of central gas furnaces, which ranges from 81.0 to 82.6, during the study period. This study also tracks the market share of Energy Star qualified units sold in California.

For furnaces with variable speed motor, there are two Energy Center of Wisconsin studies and one PIER report that address the blower motor baseline usage, which was used in the eQUEST modeling.

Scott Pigg- Energy Center of Wisconsin Study[7]

"Central Air Conditioning in Wisconsin: A compilation of recent field research", Scott Pigg, Energy Center of Wisconsin, May 2008 emended December 15, 2010.

The report summarizes the field measurements of 61 (37 PSC and 24 ECM) furnace air hander units involving residential homes in Wisconsin. Based on the results, the study found that furnaces with electronically commutated motor (ECM) uses on average 190 watts of less power per 1000 CFM of airflow than conventional furnaces with standard PSC motor. Table 3 shows that older PSC (Permanent Split Capacitor) motors used 517±33 watts to 528±35 watts and ECM air handler ranged from 320±40 watts to 341±43 watts per 1000 cfm of airflow. A 2007 focus field study confirmed this finding, with ECM air handlers averaging about 35 percent lower power consumption than standard PSC air handlers.

Table 4: Wisconsin Energy Center Field Study

	Mean air handler power (Watts per 1000 cfm)		
	PSC (n=37)	ECM (n=24)	Difference
As-found	528 ± 35	341 ± 43	187 ± 60
Post-adjustment	517 ± 33	320 ± 40	197 ± 51

CEC Public Interest Energy Research (PIER) Study[8]

"Efficiency Characteristics and Opportunities for New California Homes (ECO)", John Proctor, Proctor Engineering Group, Ltd, March 2011.

In this study, the New California Homes (ECO) project surveyed selected energy efficiency measures in 80 single family and multifamily homes built under the 2005 Building Energy Efficiency Standards for residential buildings. The goal is to reduce end use energy consumption and peak electrical demand in California by improving the standards. During the HVAC Phase one research, the split system air conditioner evaporator blowers with PSC motor drew an average of 650 watts per 1000 CFM of airflow for 45 HVAC systems. And in one test, one unit had the PSC fan motor replaced by a BPM fan motor adjusted to the same supply airflow, the fan watt draw dropped by 102 watts and the efficiency increased by more than 4 percent.

1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

Gas Savings Assumption (ΔTherms): This measure is located in the DEER 2011; gas impact savings were extracted from the READI tool and are use for this measure.

Energy Savings Assumption (ΔW): The DEER 2011 v4.1 does not have this measure with variable speed motor (VSM). To determine the energy savings coming from the high efficiency blower motor, the DOE2 eQUEST[3] simulation tool was used. The following are steps taken to derive the impact savings for furnace with variable speed motor.

- DEER eQUEST input (.inp)[9] files was extracted from the DEER MASControl[10] v1.02.71 of both base case and measure case furnaces for units located in CZ11, 12, and 13.
- Replace blower motor baseline power (SUPPLY-KW/FLOW) with 0.650 watts/CFM based on three studies, two by Pigg at the Wisconsin Energy Center and one from a PIER report.
- It's found that DEER assumes a high efficiency blower motor at 0.365 watts/CFM; therefore no modifications are needed for measure case blower motor power.
- eQUEST single family prototype consists of two (2) one-story homes and two (2) two-story homes. One house in each pair is rotated 90 degrees to capture the effect of orientation. To weight the usage, the number of stories (provided by DEER) is used to determine the multiplier for the one- and two- story homes to come up with a single weighted value. See Appendix C for more details on DEER residential prototypes.
- DEER has separate prototypes for each of 6 vintages in each of the sixteen California climate zones. For this effort, only the first 5 vintages in CZ11, 12, and 13 is analyzed, due to unavailable weighting percentage for the last vintage from DEER.
- Typical Meteorological Year 3 (TMY3)[11] weather data was downloaded from the National Solar Radiation Data Base, which is used in the eQUEST runs.
- Run eQUEST with updated input (.inp) files to generate the simulation (.SIM) results file.
- Record the ventilation fans ("VENT FANS") usage in kWh/yr from the BEPU (Building Utility Performance) report. (Note: For Single family, there are two electric meters, multifamily has 24 electric meters, and mobile homes have two electric meters, therefore the results need to be divided by the numbers of meters for that building type.)
- To determine the demand kW, the "hourly results" in .csv file was downloaded from the simulation results (.SIM) file.
- The demand values were then converted to "peak kW" which represents the three consecutive hottest days from 2pm to 5pm.
- The energy and peak kW usage is then weighted using DEER weighting ratios from DEER weighting spreadsheet, "DEER2008 Database Definition – v3.xls"[12], and thermostat settings weighting from using the DEER residential thermostat weighting spreadsheet, "DEER2008 Residential Calibration Tables 01Jun08-format2.xls."[13]
- The savings will be the difference between the weighted base case usage and the weighted measure case usage.

Building type	Bldg Vintage	Climate Zone	Electric Savings Watts (kW)	Savings units	Reference
SFM	AV	Z11	0.27	Household	eQUEST
SFM	AV	Z12	0.21	Household	eQUEST
SFM	AV	Z13	0.21	Household	eQUEST

Building type	Bldg Vintage	Climate Zone	Interactive Only? Yes / No	Gas Savings Therms	Savings units	Reference
SFM	AV	Z11	Yes	43.23	Household	DEER2011
SFM	AV	Z12	Yes	41.92	Household	DEER2011
SFM	AV	Z13	Yes	41.02	Household	DEER2011

Base Case Costs and Measure Case Costs: DEER does not contain any costs data for base case furnace of 80% AFUE and measure case 95% AFUE furnace, however it does contain costs data for 78%, 81%, 94% and 96% AFUE furnace. To determine the costs, an interpolation method was used. The unit from DEER is "cost per mBtuh".

Refer to section 4 for more costs calculation details.

			Costs ($)			
Building type	Bldg Vintage	Climate Zone	Base Case	Measure Case	IMC	Reference
SFM	AV	Z11	$663.93	$1,223.92	$559.99	DEER Interpolation
SFM	AV	Z12	$621.76	$1,146.17	$524.41	DEER Interpolation
SFM	AV	Z13	$628.66	$1,158.89	$530.24	DEER Interpolation

1.4.5 Time-of-Use Adjustment Factor

We are required by CPUC decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0.

1.5 Summary of Inputs for Savings Calculations

The following table provides references to sections that document the inputs for calculation for "Single family" home:

Input Variable	Variations	Base Case 1 Average Value	Base Case 2 Average Value	Measure Case Average Value	Reference Section
Electric Savings	CZ, BT, BV	677.01	NA	258.78	Section 2
Gas Savings	CZ, BT, BV, IE	NA	NA	37.36	Section 2
Hours of operation	CZ, BT, BV	NA	NA	NA	Section 1.4.1
Full Cost	ROB, NC	$452.83	NA	$956.73	Section 4
Incremental Cost	ROB, NC	NA	NA	$511.77	Section 4
EUL /RUL	ROB, NC	20 yrs	NA	20 yrs	Section 1.4.1
NTG	One	NA	NA	0.55	Section 1.4.1
ISR	No	NA	NA	1	Section 1.4.1
TOU Factor	NA	NA	NA	0	Section 1.4.5

Section 2. Calculation Methods

Measure Application Type	*Measure Life Basis*	*First Baseline Period: Energy Savings Baseline*	*Second Baseline Period: Energy Savings Baseline*
ROB (replace-on-burnout)	EUL	Code Baseline	N/A
NC (new construction)	RUL/EUL-RUL	Code Baseline	N/A

Note: For ROB and NC measures, First Baseline is the baseline for the full EUL. There is no second baseline.

2.1 Electric Energy Savings Estimation Methodologies

Electric energy savings are only applied to furnace with variable speed motor (VSM). DEER2011[2] does not have this measure with variable speed motor, therefore the energy savings calculations were based on running the eQUEST simulation model. For the full list of energy savings for this measure, refer to the "DEER_furnaces_060112.xlsx"[14] spreadsheet.

eQUEST (v 3.64)[3] is a DOE2 based simulation software package used for estimating of energy use of prototype residential and commercial building models. For this effort, DEER single family, multi-family, and mobile home prototypes were used as the basis for all eQUEST runs. The single family prototype consists of four homes, two (2) one-story and two (2) two-story, one house in each pair is rotated 90 degrees to capture the effect of orientation. To capture the solar effects, the DEER single family prototypes include a fence like surface exterior, which has a schedule for solar transmittance to simulate the variation in shading over the seasons around the parameters of the house. The multi-family prototype consists of two apartment buildings, each contains twelve apartments and one building is rotated 90 degrees to capture the effect of orientation. The mobile homes prototype consists of two houses with one rotated 90 degrees to capture the effect of orientation. Additionally, the mobile home prototype has two walls on each side of the house, similar to the single family for solar effects. See Appendix C for more details on the DEER prototypes and house orientations.

The residential DEER prototype models were downloaded by running the DEER MASControl database (v1.02.71) for measures that relates the closes to this measure. To correspond to the Energy Divisions recommendation of using eQUEST, no modifications will be made to the DEER prototypes or DEER input files, except one adjustment, which is the baseline blower motor power (SUPPLY-KW/FLOW). Several studies have indicated a much higher blower motor power use in the field than what is used in the DEER prototypes. Based on those studies, for this analysis we chose 0.650 watts/CFM to represent the base case with a PSC motor and 0.365 Watts/CFM (the DEER default assumption) to represent the measure case with a BPM motor.

The eQUEST model was used along with the TMY3 weather data to derive the energy use for each building type, building vintage, and thermostat settings from obtaining the energy use from the BEPU (Building Utility Performance) Report in the simulation (.SIM) file. The final value savings was calculated using numerous DEER weightings spreadsheet.

∆kWh/unit: The energy difference (kilowatts per unit) is simply the difference between the electric energy use of the base case unit and the electric energy use of the energy efficient unit. It is used in the calculations for energy savings.

EUL ∆kWh/unit = (Weighted EUL Base Case kWh/unit) – (Weighted Measure Case Unit kWh/unit)

Where,

Weighted EUL Base Case = code/industry standard weighted with DEER ratios
Weighted EUL Measure Case = measure case weighted with DEER ratios

ROB and NC measures will have no annual RUL electric savings.

Example Calculation: Single family building type with building vintage built before 1978 in climate zone 11. The DEER heating and cooling thermostat settings is assumed to be T1 (Heating setpoint at 55 degrees and Cooling setpoint at 74 degrees).

1. Energy use from eQUEST run for 80% AFUE with PSC motor is found to be 1106 kWh/yr for one-story home and 2217 kWh/yr for two-story home, because there are two electric meters (EM1 and EM2) in each result (representing four homes), each result is divided by 2, resulting in 553 kWh/yr and 1108.5 kWh/yr.

2. DEER provides ratios on the number of stories in homes located in climate zone 11 and buildings built before 1978, the ratio is then separated into two multipliers for one- and two-story homes. The multipliers are then used to weight the energy use.

To determine the multipliers, it's found the number of stories for this example is 1.26.

One-story multiplier = 2 – 1.26
= 0.74

Two-story multiplier = 1.26 – 1
= 0.26

3. The result is then multiple by the thermostat weight (T1), which is found to be 20%.

Weighted energy use for 80% AFUE (T1) = ([(553 kWh/yr * 0.74) + (1108.5 kWh/yr * 0.26)]*20%)
= 139.486 kWh/yr

4. Similar steps for the measure case 95% AFUE furnace. The energy use results are 310.5 kWh/yr for one-story and 622.5 kWh/yr for two-story.

5. The energy use for 95% AFUE furnace with variable speed motor.

Weighted energy use for 80% AFUE (T1) = ([(310.5 kWh/yr * 0.74) + (622.5 kWh/yr * 0.26)]*20%)
= 78.324 kWh/yr

6. With the weighted energy use, the savings is the delta difference between the 80% furnace with PSC motor and 95% furnace with variable speed motor.

Energy Savings (T1) = 139.486 kWh – 78.324 kWh/yr
= 61.162 kWh/yr

7. DEER has five (5) thermostat settings for each building vintage, and in each thermostat setting, there is a thermostat weight ratio, all five weighted ratio adds up to 100%.

8. Using the energy use from eQUEST for all five thermostat runs and following the steps and using the equations above, yields a weighted savings of 274.75 kWh/yr for 95% AFUE furnace with variable speed motor for building vintage built before 1978. See "DEER_furnaces_060112.xlsx"[14] file for energy savings of this measure with variable speed motor.

2.2. Demand Reduction Estimation Methodologies

The peak demand reduction for gas furnace with variable speed motor was determined from using eQUEST modeling. The peak kW usage is the "hourly results" from the simulation (.SIM) files. To define the peak kW use, the "Vent fan end-use energy" from the hourly results file was used. The file was filtered to show the run hours from 2-5pm for the three consecutive hottest weekdays, the final result is the average of the 9 peak hours. See "DEER_furnaces_060112.xlsx" file for peak kW savings for this measure with variable speed motor.

The weight savings will follow the same procedures as the Electric Energy Savings Calculations above.

2.3. Gas Energy Savings Estimation Methodologies

The 2011 Database for Energy Efficient Resources (DEER2011)[15] v4.01 data include: gas energy savings for this measure (Res-GasFurnace-AFUE95). Gas impact savings for this measure was pulled directly from the DEER READI tool; see "DEER_furnaces_060112.xlsx"[15] spreadsheet for range of savings.

Section 3. Load Shapes

3.1 Base Case Load Shapes

The closes load shape chosen for this measure is the "DEER: Res.Elc.&Ht.Pump Heating" load shape. See Table 5 for a list of all Building Types and Load Shapes. See the KEMA[16] report for a more thorough discussion regarding the load shapes for this measure.

Table 5: Base Case Building Types and Load Shapes

Building Type	E3 Alt. Building Type	Load Shape
Single Family	RES	DEER: Res.Elc.&Ht.Pump Heating
Multifamily	RES	DEER: Res.Elc.&Ht.Pump Heating
Mobile Homes	RES	DEER: Res.Elc.&Ht.Pump Heating

3.2 Measure Load Shapes

The measure load shape is the same as the base case load shape, DEER: Res.Elc.&Ht.Pump Heating.

Section 4. Base Case & Measure Costs

Measure Application Type	Measure Life Basis	First Baseline Period Gross Measure Cost (RUL)	Second Baseline Period Gross Measure Cost (EUL – RUL)
ROB(replace on burnout)	*EUL*	*Calculated as Incremental Measure Cost*	*N/A*
NC (new construction)	*EUL*	*Calculated as Full Gross Measure Cost*	*N/A*

Note: For ROB and NC measures, First Baseline is the baseline for the full EUL. There is no second baseline.

4.1 Base Case(s) Costs

DEER2011 does not show any base case cost for 80% AFUE furnace. However, DEER2008 does contain base case costs for 78% and 81% AFUE furnaces. To estimate the base case cost, an excel "FORECAST" function was used to interpolate the cost for 80% AFUE furnace, as shown on equation 1 below. Using the excel FORECAST function, the base case cost of an 80% AFUE furnace is estimated at $9.35 per mBtuh, as shown on Table 6 below, the material cost is then converted to a "per furnace" basis by using the number energy of common units in mBtuh furnace size from DEER.

Equation 1: 80% AFUE Base case cost (therms/household) = FORECAST(x, known_y's, known_x's)

Where, FORECAST = MS Excel function
x = 80% AFUE
Known_y's = DEER Gas Impacts for 78% and 81% AFUE furnaces
Known_x's = 78% and 81% AFUE

Table 6: Base case and Measure case cost analysis, per mBtuh

80% Base case cost ($/mBtuh)	
78%	$8.66
80%	$9.35
81%	$9.69
90%	$12.79
92%	$14.46
94%	$16.26
96%	$18.20
95%	$17.23
97%	$19.03
Labor Cost ($/mBtuh)	
	$5.84
With VSM motor based on HVAC distributor, EFI	
Material Cost:	$198.85

The following Measure Application Types are appropriate to these measures. The Base Case Costs are:

Table 7: Base Case Costs (per mBtuh)

Measure Code	Building Type	Measure Application Type	Baseline	Equipment Cost	Labor / Installation Cost	Maintenance / Other Cost	Total Base Case Cost
	SFM	ROB, NC	Code	$373.07	$233.02	$0	$606.08
	SFM	ROB, NC	Code	$587.18	$366.75	$0	$953.93
	SFM	ROB, NC	Code	$510.51	$318.86	$0	$829.37
	SFM	ROB, NC	Code	$492.75	$307.77	$0	$800.51
	SFM	ROB, NC	Code	$558.20	$348.65	$0	$906.84
	SFM	ROB, NC	Code	$614.30	$383.69	$0	$997.98
	SFM	ROB, NC	Code	$581.57	$363.25	$0	$944.82
	SFM	ROB, NC	Code	$590.92	$369.09	$0	$960.01
	SFM	ROB, NC	Code	$556.33	$347.48	$0	$903.81
	MFM	ROB, NC	Code	$162.69	$101.62	$0	$264.31
	MFM	ROB, NC	Code	$244.97	$153.01	$0	$397.98
	MFM	ROB, NC	Code	$240.30	$150.09	$0	$390.38
	MFM	ROB, NC	Code	$231.88	$144.83	$0	$376.71
	MFM	ROB, NC	Code	$242.17	$151.26	$0	$393.42
	MFM	ROB, NC	Code	$319.77	$199.73	$0	$519.50
	MFM	ROB, NC	Code	$287.05	$179.29	$0	$466.33
	MFM	ROB, NC	Code	$299.20	$186.88	$0	$486.08
	MFM	ROB, NC	Code	$264.61	$165.27	$0	$429.88
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$514.25	$321.20	$0	$835.45
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$515.19	$321.78	$0	$836.97
	DMO	ROB, NC	Code	$514.25	$321.20	$0	$835.45

All costs are noted as $ per measure unit

4.2 Measure Case Costs

Similarly to base case costs, DEER2011 does not have cost data for this measure case. The measure case costs is estimated by using the excel “FORECAST” function and using DEER2008 cost data for 94% and 96% AFUE furnaces in equation 1 above. Table 8 shows the estimated measure cost per mBtuh for this measure. The estimated cost is then converted to a “per furnace” basis using the DEER number energy common units in mBtuh furnace heating capacity.

The Measure Application Types of ROB and NC are appropriate to these measures. The Measure Case Costs are:

Table 8: Measure Case Costs (per mBtuh)

Measure Code	Building Type	Measure Application Type	Baseline	Equipment Cost	Labor / Installation Cost	Maintenance / Other Cost	Total Base Case Cost
	SFM	ROB, NC	Code	$687.48	$233.02	$0	$920.49
	SFM	ROB, NC	Code	$1,082.04	$366.75	$0	$1,448.80
	SFM	ROB, NC	Code	$940.76	$318.86	$0	$1,259.62
	SFM	ROB, NC	Code	$908.02	$307.77	$0	$1,215.79
	SFM	ROB, NC	Code	$1,028.63	$348.65	$0	$1,377.28
	SFM	ROB, NC	Code	$1,132.01	$383.69	$0	$1,515.70
	SFM	ROB, NC	Code	$1,071.71	$363.25	$0	$1,434.95
	SFM	ROB, NC	Code	$1,088.94	$369.09	$0	$1,458.02
	SFM	ROB, NC	Code	$1,025.19	$347.48	$0	$1,372.67
	MFM	ROB, NC	Code	$299.80	$101.62	$0	$401.42
	MFM	ROB, NC	Code	$451.43	$153.01	$0	$604.43
	MFM	ROB, NC	Code	$442.81	$150.09	$0	$592.90
	MFM	ROB, NC	Code	$427.30	$144.83	$0	$572.14
	MFM	ROB, NC	Code	$446.26	$151.26	$0	$597.51
	MFM	ROB, NC	Code	$589.27	$199.73	$0	$788.99
	MFM	ROB, NC	Code	$528.96	$179.29	$0	$708.25
	MFM	ROB, NC	Code	$551.36	$186.88	$0	$738.24
	MFM	ROB, NC	Code	$487.61	$165.27	$0	$652.88
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$947.65	$321.20	$0	$1,268.85
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$949.37	$321.78	$0	$1,271.16
	DMO	ROB, NC	Code	$947.65	$321.20	$0	$1,268.85

All costs are noted as $ per measure unit

There are no DEER data available for furnace with VSM measure. The costs estimates were based on a data sheet from an HVAC distributor, Energy Federation Incorporated (EFI) distributor[17]. The estimated charge for a brushless permanent magnet (BPM) blower motor is $198.85 per motor. Table 9 below shows the estimated cost for Measure case furnace with variable speed motor.

Table 9: Measure case cost for units with variable speed motor

Measure Code	Building Type	Measure Application Type	Climate Zone	Equipment Cost	Labor / Installation Cost	Maintenance / Other Cost	Total Base Case Cost
	SFM	ROB, NC	Z11	$1,330.86	$383.69	$0	$1,714.55
	SFM	ROB, NC	Z12	$1,270.56	$363.25	$0	$1,633.80
	SFM	ROB, NC	Z13	$1,287.79	$369.09	$0	$1,656.87
	MFM	ROB, NC	Z11	$788.12	$199.73	$0	$987.84
	MFM	ROB, NC	Z12	$727.81	$179.29	$0	$907.10
	MFM	ROB, NC	Z13	$750.21	$186.88	$0	$937.09
	DMO	ROB, NC	Z11	$1,146.50	$321.20	$0	$1,467.70
	DMO	ROB, NC	Z12	$1,148.22	$321.78	$0	$1,470.01
	DMO	ROB, NC	Z13	$1,148.22	$321.78	$0	$1,470.01

4.3 Incremental & Full Measure Costs

Measure Application Type	Gross Measure Cost (RUL Period/First Baseline)	Gross Measure Cost (EUL-RUL Period/ Second Baseline)	Incremental Measure Cost
ROB	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost
NC	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost

4.3.1 Gross Measure Cost

Gross Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application type.

This Measure Application Types are: NC or ROB, so the Gross Measure Cost (GMC) is represented by the equation below (choose):

GMC = Measure Equipment Cost – Base Case Equipment *Cost*

*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time. We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value.

4.3.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. While IMC has a straightforward definition depending on the Measure Application type, the equation does vary.

This Measure Application Types are: NC or ROB so the Gross Measure Cost (GMC) is represented by the appropriate equation below:

IMC = Measure Equipment Cost – Base Case Equipment Cost

*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time. We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value.

Table 10: Summary of Costs for Furnace without Variable Speed Motor

Measure Code	Building Type	Measure Application Type	Base Case Total Cost	Measure Case Total Cost	Gross Measure Case Cost	Incremental Measure Cost
	SFM	ROB, NC	$373.07	$687.48	$311.89	$314.41
	SFM	ROB, NC	$587.18	$1,082.04	$505.20	$494.86
	SFM	ROB, NC	$510.51	$940.76	$430.52	$430.25
	SFM	ROB, NC	$492.75	$908.02	$413.17	$415.28
	SFM	ROB, NC	$558.20	$1,028.63	$474.22	$470.44
	SFM	ROB, NC	$614.30	$1,132.01	$559.99	$517.72
	SFM	ROB, NC	$581.57	$1,071.71	$524.41	$490.14
	SFM	ROB, NC	$590.92	$1,088.94	$530.24	$498.02
	SFM	ROB, NC	$556.33	$1,025.19	$469.38	$468.86
	MFM	ROB, NC	$162.69	$299.80	$175.36	$137.11
	MFM	ROB, NC	$244.97	$451.43	$214.65	$206.46
	MFM	ROB, NC	$240.30	$442.81	$202.80	$202.52
	MFM	ROB, NC	$231.88	$427.30	$190.85	$195.42
	MFM	ROB, NC	$242.17	$446.26	$161.29	$204.09
	MFM	ROB, NC	$319.77	$589.27	$270.54	$269.50
	MFM	ROB, NC	$287.05	$528.96	$242.57	$241.92
	MFM	ROB, NC	$299.20	$551.36	$252.56	$252.16
	MFM	ROB, NC	$264.61	$487.61	$231.30	$223.00
	DMO	ROB, NC	$515.19	$949.37	$434.18	$434.19
	DMO	ROB, NC	$515.19	$949.37	$434.29	$434.19
	DMO	ROB, NC	$515.19	$949.37	$433.92	$434.19
	DMO	ROB, NC	$515.19	$949.37	$433.98	$434.19
	DMO	ROB, NC	$515.19	$949.37	$434.08	$434.19
	DMO	ROB, NC	$514.25	$947.65	$434.16	$433.40
	DMO	ROB, NC	$515.19	$949.37	$434.49	$434.19
	DMO	ROB, NC	$515.19	$949.37	$433.53	$434.19
	DMO	ROB, NC	$514.25	$947.65	$433.56	$433.40

All costs are noted as $ per measure unit

Table 11: Summary of Costs for Furnace with Variable Speed Motor, CZ11, 12, and 13

Measure Code	Building Type	Measure Application Type	Base Case Total Cost	Measure Case Total Cost	Gross Measure Case Cost	Incremental Measure Cost
	SFM	ROB, NC	$614.30	$1,330.86	$716.57	$716.57
	SFM	ROB, NC	$581.57	$1,270.56	$688.99	$688.99
	SFM	ROB, NC	$590.92	$1,287.79	$696.87	$696.87
	MFM	ROB, NC	$319.77	$788.12	$468.35	$468.35
	MFM	ROB, NC	$287.05	$727.81	$440.77	$440.77
	MFM	ROB, NC	$299.20	$750.21	$451.01	$451.01
	DMO	ROB, NC	$514.25	$1,146.50	$632.25	$632.25
	DMO	ROB, NC	$515.19	$1,148.22	$633.04	$633.04
	DMO	ROB, NC	$515.19	$1,148.22	$633.04	$633.04

All costs are noted as $ per measure unit

Input Appendices

A. (1.4.1) DEER Base Case and Measure Case Information

This appendix contains the savings calculations and complete tables for DEER Base case and Measure case inputs.

95_DEER_furnaces_
061512.xlsx

B (1.4.2) Codes & Standards Requirements Base Case and Measure Information

Title 20:

Title 20 Std. Description	Base or Measure Case	Value	Units	Code Source or Reference
CEC-140-2008-001-REV1	Standards for Gas- and Oil-Fired Central Furnaces	78% AFUE	Per System	Table E-4

Title 24:

Title 24 Std. Description	Base or Measure Case	Value	Units	Code Source or Reference
CEC-400-2008-016-CMF-Rev1	Gas and Oil Space Heaters	78% AFUE (less than 225,000 Btu/h)	Per System	Section 4.2.1

Federal Standards: This measure do fall under Federal DOE (10 CFR Part 430) Energy Regulations. Under this regulation, compliance with the standards in the direct final rule will be required on May 1, 2013 for non-weatherized furnaces and on January 1, 2015 for weatherized furnaces and central air conditioners and heat pumps. Because most residential type furnaces are installed inside the house, it's considered as non-weatherized, for which the minimum AFUE is 80%.

Federal Standards:

Federal Std. Description	Base or Measure Case	Value	Units	Code Source or Reference
76 FR 37408	Non-Weatherized gas	80% AFUE	Per System	CFR Part 430

Because the California Title 20 and 24 will adopt the Federal Standards, baseline of 80% AFUE was used in all savings calculation.

C. eQUEST Simulation Model for Furnace with Variable Speed Motor

DOE2 eQUEST Energy Simulation Process

eQUEST[9] is a DOE2 based simulation software package used to produce estimates of energy use of prototype residential building models. DEER single family, multifamily and mobile homes prototypes were used as the basis for all eQUEST simulations. The single family prototype consists of four homes, two (2) one-story and two (2) two-story, one house in each pair is rotated 90 degrees to capture the effect of orientation as shown in Figure 1. To capture the solar effects, the DEER single family prototypes include a fence like surface exterior, which has a schedule for solar transmittance to simulate the variation in shading over the seasons around the parameters of the house. The multi-family prototype consists of two apartment buildings, each contains twelve apartments and one building is rotated 90 degrees to capture the effect of orientation as shown in Figure 2. The mobile homes prototype consists of two houses with one rotated 90 degrees to capture the effect of orientation as shown in Figure 3. Additionally, the mobile home prototype has two walls on each side of the house, similar to the single family for solar effects. The DEER database has separate prototypes for each of 6 vintages in each of the sixteen California climate zones. Each vintage has different values for building and system component properties based either on the current code. Prototypes were developed for representative vintages to approximate the range of housing stock in PG&E climate zones 11, 12, and 13. Prototypes were pulled from the MASControl v1.02.71 database and then run through eQUEST with TMY3 weather files and the five different DEER thermostat schedules. As described on section 2.1 above, modifications were made to the eQUEST input files to mimic a base case furnace with a PSC motor, no changes were made for measure case as it already assumes a high efficiency motor. See Table 12 below for details on the TMY weather city.

Table 12: TMY Weather City by PG&E Climate Zone and HDD

California Climate Zone Number	TMY2 Weather City Name	TMY3 Weather City Name	TMY3 Heating Degree Days (HDD)
Z11	Red Bluff	Red Bluff Municipal Airport	2,824
Z12	Sacramento	Sacramento Metropolitan	2,647
Z13	Fresno	Fresno Yosemite Intl Airport	2,325

Figure 1: eQUEST Single Family Home Prototype

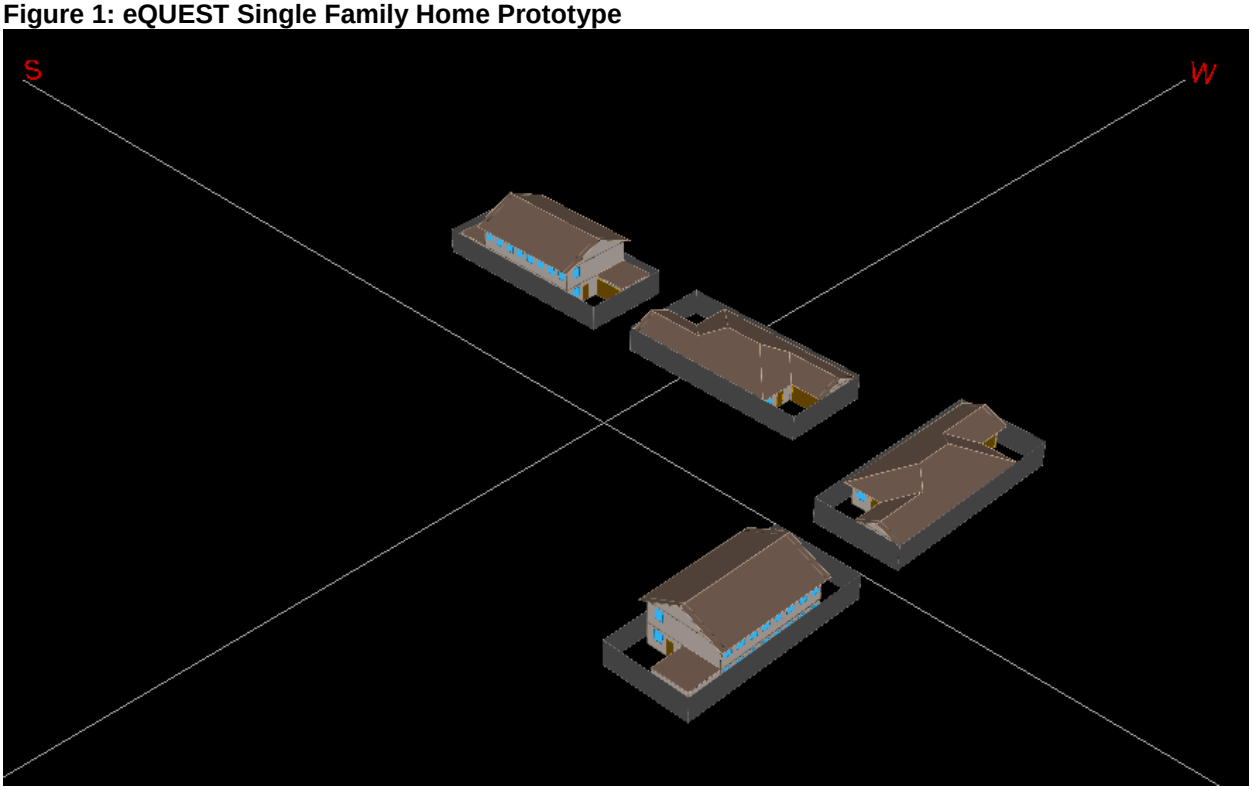


Figure 2: eQUEST Multifamily Building Prototype

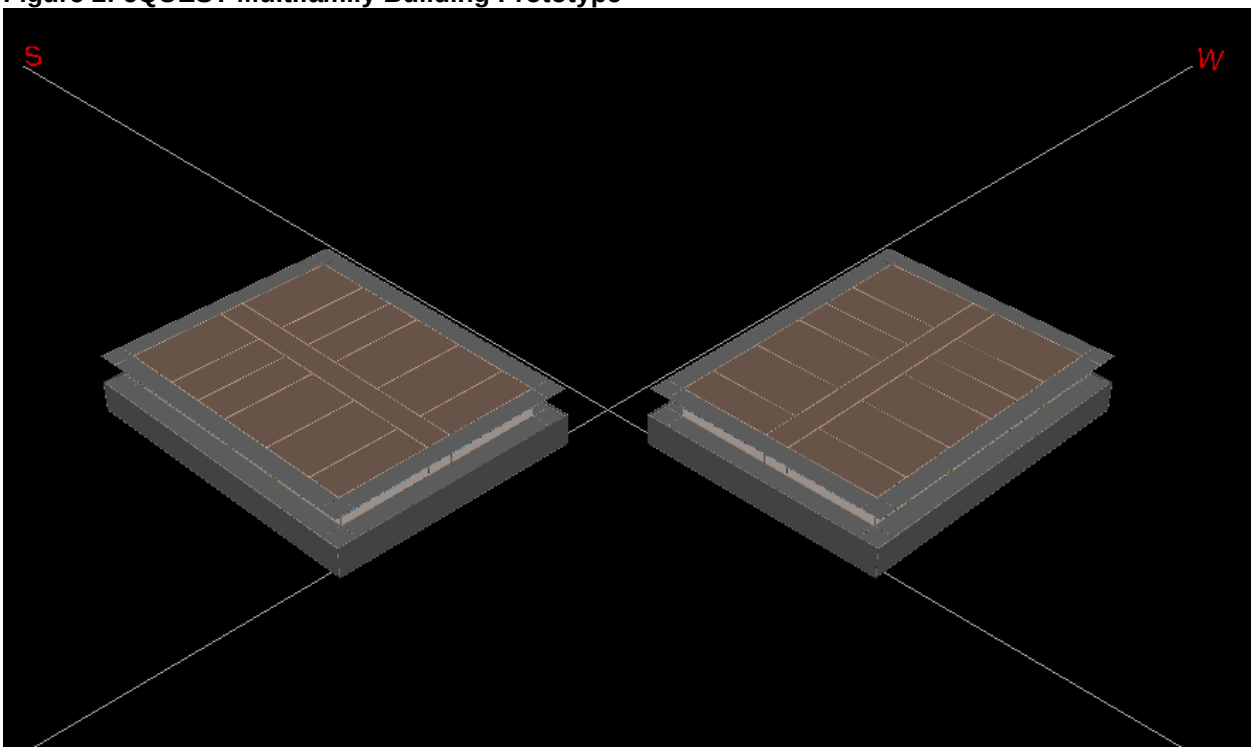
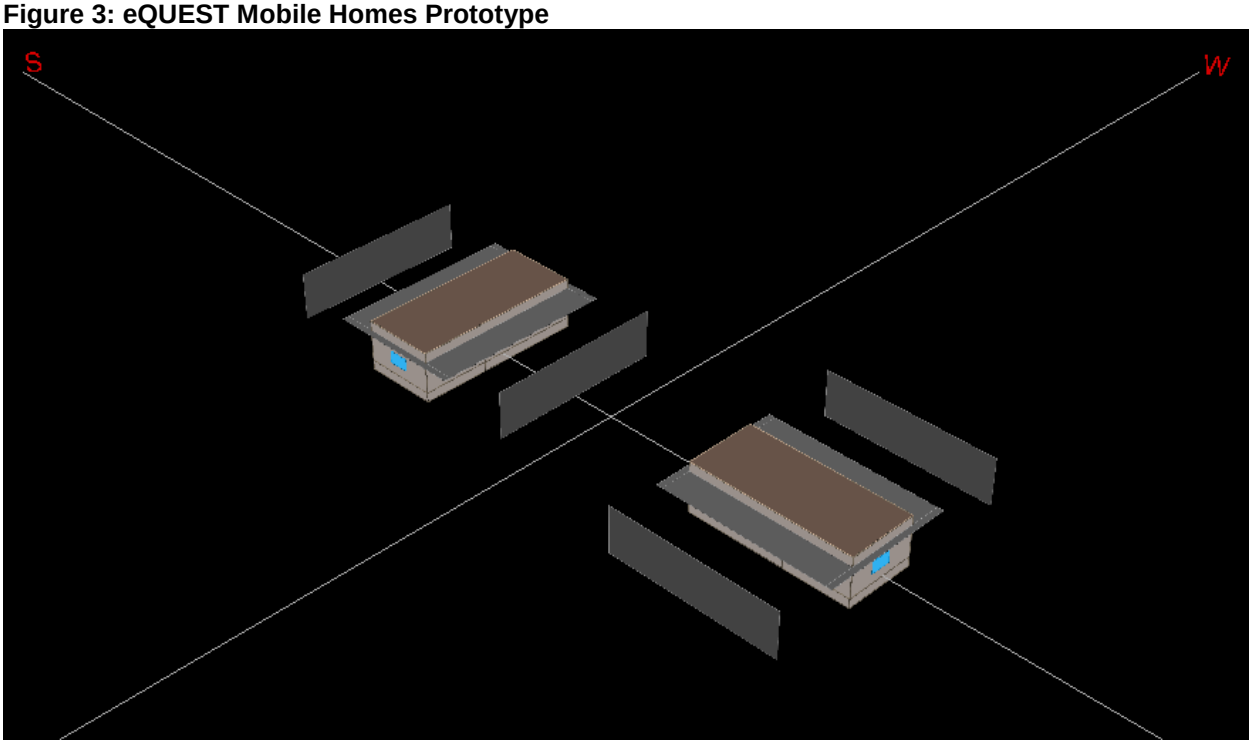


Figure 3: eQUEST Mobile Homes Prototype



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[2] Database for Energy Efficiency Resources (DEER) 2011 version 2011 4.01, "READI (version 0.99.7), November 2011. http://www.deeresources.com

[3] eQUEST – Building Energy Use and Cost Analysis Software, developed by James J. Hirsch & Associates (JJH), version 3.64 was the latest release. http://www.doe2.com/

[4] DEER 2011 Update Net-To-Gross Table, "DEER2011_NTGR_2012-05-16.xls", May 23, 2012. http://www.deeresources.com

[5] Itron, Inc. "DEER EUL/RUL (Effective/Remaining Useful Life) Values, Updated 10 October 2008. http://www.deeresources.com/

[6] Department of Energy, "Energy Conservation Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps", 10 CFR Part 430, Docket Number EERE-2011-BT-STD-0011, June 27, 2011. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf

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[8] Results are summarized in "Table 14 – Mean System Airflow…" of the PIER report Efficiency Characteristics and Opportunities for New California Homes by Proctor, Chitwood and Wilcox for the CEC. http://www.energy.ca.gov/2012publications/CEC-500-2012-062/CEC-500-2012-062.pdf

[9] (example) DOE2 eQUEST input file for baseline 80% AFUE furnace with PSC motor for single family home in CZ11 with building vintage built before 1978.

SFM-w11-v75-t1-cC Av-mRG-80PSC.inp

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[12] DEER 2008 building weighting, "DEER2008 Database Definition – v3.xls.", 2008.

DEER2008 Database Definition - v3.xlsx

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http://www.efi.org/wholesale/pdfs/concept_3.pdf

concept_3.pdf

PG&E - Residential 97% AFUE Fur Using equations from ACM Manual, Section 2.5. HIR (95%) = **1.04**

24.00

Climate Zone	Vintage	Building Vintage	Tstat Run	Thermostat Weight	Floor/Roof Area	80% AFUE w/PSC (usage from DMO Electric
11	1	MH Before 1976	T1	0.20	1196	852.50
			T2	0.20		956.50
			T3	0.20		949.50
			T4	0.30		562.50
			T5	0.10		709.50
11	2	MH 1976-1994	T1	0.20	1242	1048.50
			T2	0.25		1038.50
			T3	0.25		1162.50
			T4	0.10		1070.00
			T5	0.20		921.00
11	3	MH 1995 - 2005	T1	0.20	1242	1168.50
			T2	0.35		1118.50
			T3	0.25		975.00
			T4	0.15		1048.50
			T5	0.05		743.00
11	4	MH After 2005	T1	0.15	1242	1340.00
			T2	0.35		896.00
			T3	0.25		987.00
			T4	0.15		916.00
			T5	0.10		985.00
12	1	MH Before 1976	T1	0.10		1003.00
			T2	0.15		845.00
			T3	0.20		520.50
			T4	0.25		588.50
			T5	0.30		653.00
12	2	MH 1976-1994	T1	0.10		1009.50
			T2	0.15		719.00
			T3	0.30		911.00
			T4	0.25		851.50
			T5	0.20		775.50
12	3	MH 1995	T1	0.20		1019.50
			T2	0.35		966.50

		MH 1995 - 2005	T3	0.25		816.00
			T4	0.10		622.00
			T5	0.10		673.50
12	4	MH After 2005	T1	0.10		1113.50
			T2	0.15		989.50
			T3	0.35		679.00
			T4	0.25		764.50
			T5	0.15		843.50
13	1	MH Before 1976	T1	0.10		1108.00
			T2	0.20		929.50
			T3	0.10		1030.50
			T4	0.30		676.50
			T5	0.30		638.50
13	2	MH 1976-1994	T1	0.20		1127.00
			T2	0.10		1199.00
			T3	0.20		975.50
			T4	0.30		892.00
			T5	0.20		731.50
13	3	MH 1995 - 2005	T1	0.10		1198.50
			T2	0.15		1146.00
			T3	0.25		1026.00
			T4	0.25		1083.00
			T5	0.25		1116.00
13	4	MH After 2005	T1	0.10		1389.50
			T2	0.20		1140.00
			T3	0.30		1118.00
			T4	0.25		879.00
			T5	0.15		888.50

RASS data weighting.

T24 CZ	Vintage	SF - H/C	SF Weights	MF - H/C	MF Weights	MH - H/C	MH Weights
1	Before 1978	397	100%	119	37%	0	0%

1	Before 1978	397	100%	113	37%	0	0%
1	1978 - 1992	0	0%	206	63%	165	100%
1	1993 - 2001	0	0%	0	0%	0	0%
1	2002 - 2005	0	0%	0	0%	0	0%
1	2005-2007	0	0%	0	0%	0	
1	Total	397		325		165	
2	Before 1978	32,828	48%	3,913	19%	9,718	65%
2	1978 - 1992	20,589	30%	10,490	51%	3,704	25%
2	1993 - 2001	8,267	12%	4,764	23%	1,146	8%
2	2002 - 2005	4,037	6%	951	5%	373	2%
2	2005-2007	2,019	3%	475	2%	187	
2	Total	67,740		20,593		14,941	
3	Before 1978	40,018	54%	16,756	44%	5,815	75%
3	1978 - 1992	14,456	19%	14,292	37%	1,776	23%
3	1993 - 2001	15,608	21%	3,588	9%	163	2%
3	2002 - 2005	3,096	4%	2,448	6%	0	0%
3	2005-2007	1,548	2%	1,224	3%	0	
3	Total	74,726		38,307		7,754	
4	Before 1978	103,414	62%	26,782	33%	4,705	58%
4	1978 - 1992	27,167	16%	30,658	38%	1,699	21%
4	1993 - 2001	18,590	11%	13,782	17%	934	12%
4	2002 - 2005	11,824	7%	5,974	7%	747	9%
4	2005-2007	5,912	4%	2,987	4%	373	
4	Total	166,907		80,183		8,084	
5	Before 1978	8,622	61%	166	3%	467	32%
5	1978 - 1992	4,413	31%	412	7%	970	68%
5	1993 - 2001	689	5%	5,141	90%	0	0%
5	2002 - 2005	291	2%	0	0%	0	0%
5	2005-2007	145	1%	0	0%	0	
5	Total	14,160		5,719		1,437	
11	Before 1978	82,175	43%	17,869	45%	20,733	46%
11	1978 - 1992	51,811	27%	20,892	52%	21,614	48%
11	1993 - 2001	30,803	16%	713	2%	2,176	5%
11	2002 - 2005	17,728	9%	347	1%	659	1%
11	2005-2007	8,864	5%	174	0%	329	
11	Total	191,380		39,994		45,181	
12	Before 1978	248,162	45%	68,782	37%	17,996	63%
12	1978 - 1992	160,129	29%	88,913	48%	8,660	30%
12	1993 - 2001	83,534	15%	15,965	9%	1,446	5%
12	2002 - 2005	39,813	7%	7,777	4%	653	2%
12	2005-2007	19,907	4%	3,889	2%	327	
12	Total	551,545		185,326		28,756	
13	Before 1978	126,201	47%	50,381	58%	20,400	77%
13	1978 - 1992	74,142	27%	30,124	34%	5,924	22%
13	1993 - 2001	44,780	17%	5,404	6%	237	1%
13	2002 - 2005	16,912	6%	1,022	1%	0	0%
13	2005-2007	8,456	3%	511	1%	0	
13	Total	270,491		87,442		26,561	
16	Before 1978	14,476	50%	0	0%	2,219	34%
16	1978 - 1992	10,914	37%	292	100%	3,755	58%
16	1993 - 2001	3,479	12%	0	0%	467	7%
16	2002 - 2005	249	1%	0	0%	0	0%
16	2005-2007	125	0%	0	0%	0	
16	Total	29,243		292		6,441	

HIR (97%)= **1.02** HIR (80%)= **1.23** *Note: ECM/VSM savings is for CZ11, 12, and 13 only.

Blower Savings (kWh)				**Blower Savings (kW)**				
		95% & 97% AFUE w/ECM (usage	eQUEST savings (therms)*	80% AFUE w/PSC (usage from		95% & 97% AFUE w/ECM (usage		eQUEST savings (therms)*
Weighted	DMO Electric	Weighted		DMO Electric	Weighted	DMO Electric	Weighted	
170.50	478.50	95.70	74.80	0.771	0.154	0.433	0.087	0.068
191.30	537.00	107.40	83.90	0.774	0.155	0.435	0.087	0.068
189.90	533.50	106.70	83.20	0.776	0.155	0.436	0.087	0.068
168.75	316.00	94.80	73.95	0.732	0.220	0.411	0.123	0.096
70.95	398.50	39.85	31.10	0.614	0.061	0.345	0.034	0.027
791.40		444.45	346.95		0.745		0.419	0.327
209.70	589.00	117.80	91.90	0.881	0.176	0.495	0.099	0.077
259.63	583.00	145.75	113.88	0.847	0.212	0.476	0.119	0.093
290.63	652.50	163.13	127.50	0.846	0.211	0.475	0.119	0.093
107.00	601.00	60.10	46.90	0.780	0.078	0.438	0.044	0.034
184.20	517.00	103.40	80.80	0.740	0.148	0.416	0.083	0.065
1051.15		590.18	460.98		0.825		0.463	0.362
233.70	641.00	128.20	105.50	0.814	0.163	0.487	0.097	0.065
391.48	628.00	219.80	171.68	0.823	0.288	0.462	0.162	0.126
243.75	547.50	136.88	106.88	0.783	0.196	0.439	0.110	0.086
157.28	588.50	88.28	69.00	0.780	0.117	0.438	0.066	0.051
37.15	417.50	20.88	16.28	0.706	0.035	0.396	0.020	0.015
1063.35		594.03	469.33		0.799		0.455	0.344
201.00	750.50	112.58	88.43	0.223	0.033	0.125	0.019	0.015
313.60	501.50	175.53	138.08	0.189	0.066	0.106	0.037	0.029
246.75	553.00	138.25	108.50	0.199	0.050	0.112	0.028	0.022
137.40	513.00	76.95	60.45	0.204	0.031	0.115	0.017	0.013
98.50	551.50	55.15	43.35	0.189	0.019	0.106	0.011	0.008
997.25		558.45	438.80		0.199		0.112	0.087
			408.72					**0.341**
100.30	563.50	56.35	43.95	0.695	0.070	0.390	0.039	0.030
126.75	474.50	71.18	55.58	0.614	0.092	0.345	0.052	0.040
104.10	292.50	58.50	45.60	0.617	0.123	0.347	0.069	0.054
147.13	330.50	82.63	64.50	0.618	0.155	0.347	0.087	0.068
195.90	366.50	109.95	85.95	0.568	0.170	0.319	0.096	0.075
674.18		378.60	295.58		0.610		0.343	0.267
100.95	567.00	56.70	44.25	0.754	0.075	0.423	0.042	0.033
107.85	403.50	60.53	47.33	0.706	0.106	0.396	0.059	0.046
273.30	511.50	153.45	119.85	0.704	0.211	0.396	0.119	0.093
212.88	478.00	119.50	93.38	0.623	0.156	0.350	0.087	0.068
155.10	435.50	87.10	68.00	0.575	0.115	0.323	0.065	0.050
850.08		477.28	372.80		0.663		0.372	0.291
203.90	572.50	114.50	89.40	0.754	0.151	0.423	0.085	0.066
338.28	542.50	189.88	148.40	0.706	0.247	0.396	0.139	0.108

204.00	458.00	114.50	89.50	0.704	0.176	0.396	0.099	0.077
62.20	349.00	34.90	27.30	0.623	0.062	0.350	0.035	0.027
67.35	378.50	37.85	29.50	0.575	0.058	0.323	0.032	0.025
875.73		491.63	384.10		0.694		0.389	0.304
111.35	623.50	62.35	49.00	0.754	0.075	0.423	0.042	0.033
148.43	554.00	83.10	65.33	0.706	0.106	0.396	0.059	0.046
237.65	380.50	133.18	104.48	0.704	0.247	0.396	0.138	0.108
191.13	428.00	107.00	84.13	0.623	0.156	0.350	0.087	0.068
126.53	472.50	70.88	55.65	0.575	0.086	0.323	0.048	0.038
815.08		456.50	358.58		0.670		0.376	0.294
			324.43					**0.256**
110.80	622.00	62.20	48.60	0.689	0.069	0.387	0.039	0.030
185.90	522.00	104.40	81.50	0.693	0.139	0.389	0.078	0.061
103.05	578.50	57.85	45.20	0.695	0.070	0.390	0.039	0.030
202.95	380.00	114.00	88.95	0.644	0.193	0.362	0.108	0.085
191.55	358.50	107.55	84.00	0.526	0.158	0.296	0.089	0.069
794.25		446.00	348.25		0.628		0.353	0.275
225.40	633.00	126.60	98.80	0.790	0.158	0.444	0.089	0.069
119.90	673.50	67.35	52.55	0.700	0.070	0.393	0.039	0.031
195.10	548.00	109.60	85.50	0.706	0.141	0.396	0.079	0.062
267.60	501.00	150.30	117.30	0.653	0.196	0.367	0.110	0.086
146.30	411.00	82.20	64.10	0.531	0.106	0.298	0.060	0.047
954.30		536.05	418.25		0.671		0.377	0.294
119.85	673.00	67.30	52.55	0.790	0.079	0.444	0.044	0.035
171.90	643.50	96.53	75.38	0.700	0.105	0.393	0.059	0.046
256.50	576.00	144.00	112.50	0.706	0.176	0.396	0.099	0.077
270.75	608.00	152.00	118.75	0.653	0.163	0.367	0.092	0.072
279.00	626.50	156.63	122.38	0.531	0.133	0.298	0.075	0.058
1098.00		616.45	481.55		0.656		0.369	0.288
138.95	778.00	77.80	61.15	0.790	0.079	0.444	0.044	0.035
228.00	638.50	127.70	100.30	0.700	0.140	0.393	0.079	0.061
335.40	626.00	187.80	147.60	0.706	0.212	0.396	0.119	0.093
219.75	492.00	123.00	96.75	0.653	0.163	0.367	0.092	0.072
133.28	497.50	74.63	58.65	0.531	0.080	0.298	0.045	0.035
1055.38		590.93	464.45		0.674		0.378	0.295
			364.98					**0.277**

PG&E - Residential 97% AFUE Furnace Calc Using equations from ACM Manua HIR (95%) = **1.04**

24.00

Climate Zone	Vintage	Total Floor Area	Building Vintage	Tstat Run	Thermostat Weight	80% AFUE w/PSC (usage from MFM Electric
11	1	11681.28	Before 1978	T1	0.20	431.88
				T2	0.20	385.67
				T3	0.20	365.63
				T4	0.30	278.21
				T5	0.10	184.79
11	2	12288.00	1978-1992	T1	0.20	438.71
				T2	0.25	372.46
				T3	0.25	364.08
				T4	0.10	318.79
				T5	0.20	182.17
11	3	10944.48	1993 - 2001	T1	0.20	288.04
				T2	0.35	275.25
				T3	0.25	225.92
				T4	0.15	207.75
				T5	0.05	171.17
11	4	11383.68	2002 - 2005	T1	0.15	516.58
				T2	0.35	407.42
				T3	0.25	366.25
				T4	0.15	260.75
				T5	0.10	330.63
11	5	11383.68	After 2005	T1	0.45	472.50
				T2	0.35	359.96
				T3	0.10	315.33
				T4	0.05	227.25
				T5	0.05	244.04
12	1	11681.28	Before 1978	T1	0.10	319.79
				T2	0.15	300.88
				T3	0.20	252.75
				T4	0.25	245.25
				T5	0.30	211.96
12	2	12288.00		T1	0.10	435.79
				T2	0.15	271.88

			1978-1992	T3	0.30	255.25
				T4	0.25	237.17
				T5	0.20	170.79
12	3	10944.48	1993 - 2001	T1	0.20	215.42
				T2	0.35	188.50
				T3	0.25	165.00
				T4	0.10	162.04
				T5	0.10	68.63
12	4	11383.68	2002 - 2005	T1	0.10	257.79
				T2	0.15	219.88
				T3	0.35	231.33
				T4	0.25	207.42
				T5	0.15	156.54
12	5	11383.68	After 2005	T1	0.35	305.71
				T2	0.20	227.75
				T3	0.25	196.42
				T4	0.10	176.96
				T5	0.10	252.50
13	1	11681.28	Before 1978	T1	0.10	447.42
				T2	0.20	392.54
				T3	0.10	398.21
				T4	0.30	308.08
				T5	0.30	179.88
13	2	12288.00	1978-1992	T1	0.20	458.79
				T2	0.10	383.04
				T3	0.20	368.58
				T4	0.30	343.50
				T5	0.20	205.29
13	3	10944.48	1993 - 2001	T1	0.10	321.08
				T2	0.15	268.17
				T3	0.25	260.54
				T4	0.25	195.75
				T5	0.25	101.29
13	4	11383.68	2002 - 2005	T1	0.10	275.58
				T2	0.20	296.00
				T3	0.30	366.71
				T4	0.25	259.50
				T5	0.15	232.92

13	5	11383.68	After 2005	T1	0.20	353.25
				T2	0.25	375.46
				T3	0.30	262.63
				T4	0.15	276.04
				T5	0.10	277.33

HIR (97%)= **1.02** HIR (80%)= **1.23** *Note: ECM/VSM savings is for CZ11, 12, and 13 only.

Blower Savings (kWh)				**Blower Savings (kW)**				
	95% & 97% AFUE w/ECM (usage		eQUEST savings (therms)*	80% AFUE w/PSC (usage from		95% & 97% AFUE w/ECM (usage		eQUEST savings (therms)*
Weighted	MFM Electric	Weighted		MFM Electric	Weighted	MFM Electric	Weighted	
86.38	242.50	48.50	37.88	0.275	0.055	0.155	0.031	0.024
77.13	216.58	43.32	33.82	0.287	0.057	0.161	0.032	0.025
73.13	205.33	41.07	32.06	0.292	0.058	0.164	0.033	0.026
83.46	156.21	46.86	36.60	0.269	0.081	0.151	0.045	0.035
18.48	103.75	10.38	8.10	0.210	0.021	0.118	0.012	0.009
338.58		190.12	148.45		0.273		0.153	0.120
87.74	246.38	49.28	38.47	0.283	0.057	0.159	0.032	0.025
93.11	209.17	52.29	40.82	0.295	0.074	0.166	0.041	0.032
91.02	204.46	51.11	39.91	0.300	0.075	0.169	0.042	0.033
31.88	179.04	17.90	13.98	0.156	0.016	0.156	0.016	0.000
36.43	102.29	20.46	15.98	0.219	0.044	0.123	0.025	0.019
340.19		191.04	149.15		0.265		0.156	0.109
57.61	161.75	32.35	25.26	0.223	0.045	0.125	0.025	0.020
96.34	154.58	54.10	42.23	0.189	0.066	0.106	0.037	0.029
56.48	126.88	31.72	24.76	0.199	0.050	0.112	0.028	0.022
31.16	116.67	17.50	13.66	0.204	0.031	0.115	0.017	0.013
8.56	96.13	4.81	3.75	0.189	0.009	0.106	0.005	0.004
250.15		140.48	109.67		0.201		0.113	0.088
77.49	290.08	43.51	33.98	0.223	0.033	0.125	0.019	0.015
142.60	228.79	80.08	62.52	0.189	0.066	0.106	0.037	0.029
91.56	205.67	51.42	40.15	0.199	0.050	0.112	0.028	0.022
39.11	146.42	21.96	17.15	0.204	0.031	0.115	0.017	0.013
33.06	185.67	18.57	14.50	0.189	0.019	0.106	0.011	0.008
383.82		215.54	168.29		0.199		0.112	0.087
212.63	264.58	119.06	93.56	0.223	0.100	0.125	0.056	0.044
125.99	201.58	70.55	55.43	0.189	0.066	0.106	0.037	0.029
31.53	176.58	17.66	13.88	0.199	0.020	0.112	0.011	0.009
11.36	127.25	6.36	5.00	0.204	0.010	0.115	0.006	0.004
12.20	136.67	6.83	5.37	0.189	0.009	0.106	0.005	0.004
393.71		220.47	173.24		0.206		0.116	0.090
			148.40					**0.112**
31.98	179.58	17.96	14.02	0.195	0.020	0.126	0.013	0.007
45.13	168.96	25.34	19.79	0.207	0.031	0.130	0.019	0.012
50.55	141.92	28.38	22.17	0.235	0.047	0.132	0.026	0.021
61.31	137.71	34.43	26.89	0.210	0.053	0.118	0.029	0.023
63.59	119.00	35.70	27.89	0.142	0.043	0.080	0.024	0.019
252.56		141.81	110.75		0.193		0.112	0.081
43.58	244.71	24.47	19.11	0.229	0.023	0.129	0.013	0.010
40.78	152.67	22.90	17.88	0.240	0.036	0.135	0.020	0.016

76.58	143.33	43.00	33.58	0.244	0.073	0.137	0.041	0.032
59.29	133.17	33.29	26.00	0.219	0.055	0.123	0.031	0.024
34.16	95.92	19.18	14.98	0.149	0.030	0.084	0.017	0.013
254.39		142.85	111.54		0.217		0.122	0.095
43.08	120.96	24.19	18.89	0.150	0.030	0.084	0.017	0.013
65.98	105.83	37.04	28.93	0.161	0.056	0.091	0.032	0.025
41.25	92.67	23.17	18.08	0.165	0.041	0.093	0.023	0.018
16.20	91.00	9.10	7.10	0.147	0.015	0.082	0.008	0.006
6.86	38.54	3.85	3.01	0.091	0.009	0.051	0.005	0.004
173.38		97.35	76.02		0.151		0.085	0.066
25.78	144.75	14.48	11.30	0.223	0.022	0.125	0.013	0.010
32.98	123.46	18.52	14.46	0.189	0.028	0.106	0.016	0.012
80.97	129.92	45.47	35.50	0.199	0.070	0.112	0.039	0.031
51.85	116.46	29.11	22.74	0.204	0.051	0.115	0.029	0.022
23.48	87.92	13.19	10.29	0.189	0.028	0.106	0.016	0.012
215.06		120.77	94.30		0.200		0.112	0.088
107.00	171.21	59.92	47.08	0.223	0.078	0.125	0.044	0.034
45.55	127.54	25.51	20.04	0.189	0.038	0.106	0.021	0.017
49.10	110.00	27.50	21.60	0.199	0.050	0.112	0.028	0.022
17.70	99.08	9.91	7.79	0.204	0.020	0.115	0.011	0.009
25.25	141.38	14.14	11.11	0.189	0.019	0.106	0.011	0.008
244.60		136.98	107.62		0.205		0.115	0.090
			107.38					**0.081**
44.74	251.25	25.13	19.62	0.250	0.025	0.140	0.014	0.011
78.51	220.42	44.08	34.43	0.261	0.052	0.146	0.029	0.023
39.82	223.63	22.36	17.46	0.265	0.027	0.149	0.015	0.012
92.43	173.00	51.90	40.53	0.243	0.073	0.136	0.041	0.032
53.96	101.00	30.30	23.66	0.185	0.055	0.104	0.031	0.024
309.46		173.77	135.69		0.232		0.130	0.102
91.76	257.63	51.53	40.23	0.258	0.052	0.145	0.029	0.023
38.30	215.08	21.51	16.80	0.270	0.027	0.151	0.015	0.012
73.72	206.96	41.39	32.33	0.275	0.055	0.154	0.031	0.024
103.05	192.92	57.88	45.18	0.251	0.075	0.141	0.042	0.033
41.06	115.29	23.06	18.00	0.193	0.039	0.108	0.022	0.017
347.89		195.36	152.53		0.248		0.139	0.109
32.11	180.29	18.03	14.08	0.173	0.017	0.097	0.010	0.008
40.23	150.58	22.59	17.64	0.183	0.027	0.103	0.015	0.012
65.14	146.29	36.57	28.56	0.188	0.047	0.105	0.026	0.021
48.94	109.92	27.48	21.46	0.172	0.043	0.097	0.024	0.019
25.32	56.88	14.22	11.10	0.127	0.032	0.071	0.018	0.014
211.73		118.89	92.84		0.166		0.093	0.073
27.56	154.75	15.48	12.08	0.223	0.022	0.125	0.013	0.010
59.20	166.21	33.24	25.96	0.189	0.038	0.106	0.021	0.017
110.01	205.92	61.78	48.24	0.199	0.060	0.112	0.034	0.026
64.88	145.71	36.43	28.45	0.204	0.051	0.115	0.029	0.022
34.94	130.79	19.62	15.32	0.189	0.028	0.106	0.016	0.012

296.58		166.54	130.05		0.199		0.112	0.087
70.65	197.83	39.57	31.08	0.223	0.045	0.125	0.025	0.020
93.86	210.25	52.56	41.30	0.189	0.047	0.106	0.026	0.021
78.79	147.08	44.13	34.66	0.199	0.060	0.112	0.034	0.026
41.41	154.58	23.19	18.22	0.204	0.031	0.115	0.017	0.013
27.73	155.29	15.53	12.20	0.189	0.019	0.106	0.011	0.008
312.44		174.97	137.47		0.201		0.113	0.088
			138.79					**0.100**

PG&E - Residential 97% AFUE Furnace Calc

Using equations from A

Climate Zone	Vintage	Total Floor Area	Number of Stories	1-Story (multiplier)	2-Story (multiplier)	Building Vintage	Tstat Run	Thermostat Weight
11	1	1528	1.26	0.74	0.26	Before 1978	T1	0.20
							T2	0.20
							T3	0.20
							T4	0.30
							T5	0.10
11	2	1704	1.23	0.77	0.23	1978-1992	T1	0.20
							T2	0.25
							T3	0.25
							T4	0.10
							T5	0.20
11	3	2032	1.40	0.60	0.40	1993 - 2001	T1	0.20
							T2	0.35
							T3	0.25
							T4	0.15
							T5	0.05
11	4	1949	1.40	0.60	0.40	2002 - 2005	T1	0.15
							T2	0.35
							T3	0.25
							T4	0.15
							T5	0.10
11	5	1949	1.40	0.60	0.40	After 2005	T1	0.45
							T2	0.35
							T3	0.10
							T4	0.05
							T5	0.05
12	1	1528	1.26	0.74	0.26	Before 1978	T1	0.10
							T2	0.15
							T3	0.20
							T4	0.25
							T5	0.30

12	2	1704	1.23	0.77	0.23	1978-1992	T1	0.10
							T2	0.15
							T3	0.30
							T4	0.25
							T5	0.20
12	3	2032	1.40	0.60	0.40	1993 - 2001	T1	0.20
							T2	0.35
							T3	0.25
							T4	0.10
							T5	0.10
12	4	1949	1.40	0.60	0.40	2002 - 2005	T1	0.10
							T2	0.15
							T3	0.35
							T4	0.25
							T5	0.15
12	5	1949	1.40	0.60	0.40	After 2005	T1	0.35
							T2	0.20
							T3	0.25
							T4	0.10
							T5	0.10
13	1	1528	1.26	0.74	0.26	Before 1978	T1	0.10
							T2	0.20
							T3	0.10
							T4	0.30
							T5	0.30
13	2	1704	1.23	0.77	0.23	1978-1992	T1	0.20
							T2	0.10
							T3	0.20
							T4	0.30
							T5	0.20
13	3	2032	1.40	0.60	0.40	1993 - 2001	T1	0.10
							T2	0.15
							T3	0.25
							T4	0.25
							T5	0.25
13	4	1949	1.40	0.60	0.40	2002 - 2005	T1	0.10
							T2	0.20
							T3	0.30

							T4	0.25
							T5	0.15
13	5	1949	1.40	0.60	0.40	After 2005	T1	0.20
							T2	0.25
							T3	0.30
							T4	0.15
							T5	0.10

ACM Manual, Section 2.5.2.10, 2-64 for AFUE > 83.5 HIR (95%) = **1.0440212** HIR (94%)=

Blower Savings (kWh)

80% AFUE w/PSC (usage from BEPU)*			95% & 97% AFUE w/ECM (usage from BEPU)*			eQUEST savings (therms)*
1-Story Electric	2-Story Electric	Weighted by Stories	1-Story Electric	2-Story Electric	Weighted by Stories	
553	1108.5	139.486	310.5	622.5	78.324	61.162
643	1230	159.124	361	690.5	89.334	69.79
638	1215.5	157.63	358	682.5	88.474	69.156
298.5	635.5	115.836	167.5	356.5	64.992	50.844
441.5	831	54.277	248	466.5	30.481	23.796
	Weighted (Stry/Tstat)	626.353			351.605	274.748
617	1362	157.67	346.5	765	88.551	69.119
597	1307.5	190.1038	335	734	106.6925	83.41125
687	1480.5	217.3763	385.5	831.5	122.02	95.35625
642	1399.5	81.6225	360.5	786	45.8365	35.786
491.5	1074.5	125.118	276	603.5	70.265	54.853
	Weighted (Stry/Tstat)	771.8905			433.365	338.5255
664	1418.5	193.16	373	796.5	108.48	84.68
626.5	1339.5	319.095	352	752	179.2	139.895
528.5	1137	192.975	297	638.5	108.4	84.575
573.5	1233.5	125.625	322	692.5	70.53	55.095
349	825.5	26.98	196	463.5	15.15	11.83
	Weighted (Stry/Tstat)	857.835			481.76	376.075
842.5	1607	172.245	473	902.5	96.72	75.525
518.5	1008.5	250.075	291	566.5	140.42	109.655
555	1076.5	190.9	312	604.5	107.25	83.65
502	983.5	104.19	282	552.5	58.53	45.66
520	1015.5	71.82	292	570.5	40.34	31.48
	Weighted (Stry/Tstat)	789.23			443.26	345.97
741	1436.5	458.64	416	807	257.58	201.06
440.5	877.5	215.355	247.5	493	120.995	94.36
500	989	69.56	280.5	555.5	39.05	30.51
909	894.5	45.16	253	502.5	17.64	27.52
488.5	968	34.015	274.5	543.5	19.105	14.91
	Weighted (Stry/Tstat)	822.73			454.37	368.36
				Weighted savings Vin(		**315.48984**
626	1198.5	77.485	351.5	673	43.509	33.976
538.5	1027.5	99.846	302.5	577	56.0805	43.7655
239.5	519	62.434	134.5	291.5	35.064	27.37
297.5	614	94.9475	167	344.5	53.2875	41.66
368	707.5	136.881	206.5	397.5	76.848	60.033
	Weighted (Stry/Tstat)	471.5935			264.789	206.8045

508.5	1155	65.7195	285.5	648.5	36.899	28.8205
302	756.5	60.98025	169.5	425	34.23975	26.7405
441.5	1009	171.6075	248	566.5	96.3765	75.231
412.5	932	132.9963	231.5	523.5	74.665	58.33125
349.5	764	88.967	196.5	429	49.995	38.972
	Weighted (Stry/Tstat)	520.2705			292.1753	228.09525
513	1135	152.36	288	637.5	85.56	66.8
454	1009.5	236.67	255	567	132.93	103.74
356.5	807.5	134.225	200	453.5	75.35	58.875
211	538	34.18	118.5	302	19.19	14.99
259	616.5	40.2	145.5	346.5	22.59	17.61
	Weighted (Stry/Tstat)	597.635			335.62	262.015
626.5	1248	87.51	351.5	701	49.13	38.38
503.5	1013	106.095	282.5	568.5	59.535	46.56
357	733	177.59	200.5	411.5	99.715	77.875
194	421.5	71.25	109	237	40.05	31.2
331	684	70.83	186	384	39.78	31.05
	Weighted (Stry/Tstat)	513.275			288.21	225.065
524	1067.5	259.49	294	599.5	145.67	113.82
440	905.5	125.24	247	508.5	70.32	54.92
224.5	489.5	82.625	126	275	46.4	36.225
292	613.5	42.06	164	344.5	23.62	18.44
342	709.5	48.9	192	398.5	27.46	21.44
	Weighted (Stry/Tstat)	558.315			313.47	244.845
				Weighted savings Vin(		**224.03877**
759.5	1437	93.565	426.5	807	52.543	41.022
599.5	1148	148.422	336.5	644.5	83.316	65.106
670	1264	82.444	376.5	710	46.321	36.123
382.5	760	144.195	215	427	81.036	63.159
388.5	719.5	142.368	218	404	79.908	62.46
	Weighted (Stry/Tstat)	610.994			343.124	267.87
666	1424.5	168.091	374	800	94.396	73.695
719.5	1538	90.7755	404	863.5	50.9685	39.807
523.5	1146	133.335	294	643.5	74.877	58.458
455	995	173.76	255.5	559	97.5915	76.1685
340.5	733	86.155	191.5	411.5	48.42	37.735
	Weighted (Stry/Tstat)	652.1165			366.253	285.8635
694.5	1469	100.43	390	825	56.4	44.03
631	1340	137.19	354	752.5	77.01	60.18
542.5	1158	197.175	304.5	650.5	110.725	86.45
584.5	1233.5	211.025	328	692.5	118.45	92.575
624	1317.5	225.35	350.5	739.5	126.525	98.825
	Weighted (Stry/Tstat)	871.17			489.11	382.06
743	1424	101.54	417	799.5	57	44.54
594	1146.5	163	333.5	644	91.54	71.46
492.5	958	203.61	276.5	538	114.33	89.28

498	969.5	171.65	280	544.5	96.45	75.2
350	709.5	74.07	196.5	398.5	41.595	32.475
	Weighted (Stry/Tstat)	713.87			400.915	312.955
746	1452.5	205.72	419	815.5	115.52	90.2
581	1141.5	201.3	326	641	113	88.3
551.5	1089.5	230.01	309.5	611.5	129.09	100.92
401.5	807	84.555	225.5	453	47.475	37.08
400	806	56.24	224.5	452.5	31.57	24.67
	Weighted (Stry/Tstat)	777.825			436.655	341.17
				Weighted savings Vin(		**296.81658**

1.0562796 HIR (80%)= **1.232529** *Note: ECM/VSM savings is for CZ11

Blower Savings (kW)

80% AFUE w/PSC (usage from BEPU)*			95% & 97% AFUE w/ECM (usage from BEPU)*			eQUEST savings (therms)*
1-Story Electric	2-Story Electric	Weighted by Stories	1-Story Electric	2-Story Electric	Weighted by Stories	
0.5846332	1.053154167	0.14129	0.328294	0.591385	0.07934	0.06195
0.5910606	1.064014167	0.142806	0.331903	0.597485	0.080191	0.062615
0.5938499	1.06892375	0.143474	0.33347	0.600242	0.080566	0.062908
0.5425963	0.9859375	0.19736	0.304689	0.553642	0.110825	0.086535
0.4012435	0.780261667	0.049979	0.225314	0.438147	0.028065	0.021914
	Weighted (Stry/Tstat)	0.674908			0.378986	0.295921
0.7128192	1.367135833	0.172662	0.400275	0.767699	0.096957	0.075706
0.666465	1.289258333	0.202427	0.374246	0.723968	0.11367	0.088756
0.6582071	1.275582917	0.200051	0.369609	0.716288	0.112336	0.087715
0.537111	1.083984583	0.066289	0.301608	0.6087	0.037224	0.029065
0.5056417	1.034383333	0.12545	0.283937	0.580846	0.070445	0.055005
	Weighted (Stry/Tstat)	0.76688			0.430632	0.336247
0.5744263	1.136509167	0.159852	0.322562	0.638193	0.089763	0.070089
0.5341966	1.061784167	0.260831	0.299972	0.596232	0.146467	0.114364
0.4970093	1.00227625	0.174779	0.27909	0.562816	0.098145	0.076634
0.4887215	0.9909375	0.103441	0.274436	0.556449	0.058086	0.045355
0.3815655	0.8173275	0.027794	0.214264	0.458961	0.015607	0.012186
	Weighted (Stry/Tstat)	0.726697			0.408068	0.318629
0.488939	0.977622083	0.102662	0.274558	0.54897	0.057648	0.045013
0.488939	0.974758333	0.239143	0.274558	0.547363	0.134288	0.104855
0.4827338	0.92605	0.165015	0.271074	0.520012	0.092662	0.072353
0.4636594	0.87805625	0.094413	0.260363	0.493062	0.053016	0.041396
0.4585413	0.866190417	0.06216	0.246735	0.463995	0.033364	0.028796
	Weighted (Stry/Tstat)	0.663393			0.370979	0.292414
0.488939	0.977622083	0.307986	0.274558	0.54897	0.172945	0.13504
0.488939	0.974758333	0.239143	0.274558	0.547363	0.134288	0.104855
0.4827338	0.92605	0.066006	0.271074	0.520012	0.037065	0.028941
0.4636594	0.87805625	0.031471	0.260363	0.493062	0.017672	0.013799
0.4585413	0.866190417	0.03108	0.246735	0.463995	0.016682	0.014398
	Weighted (Stry/Tstat)	0.675686			0.378652	0.297034
				Weighted savings Vin(		**0.269376**
0.5124825	0.92349	0.061934	0.287778	0.518575	0.034779	0.027156
0.4196972	0.786995	0.077279	0.235676	0.441928	0.043395	0.033884
0.4248268	0.795073	0.104218	0.233396	0.437621	0.057299	0.046919
0.4263183	0.7996165	0.130844	0.239394	0.449016	0.073474	0.05737
0.3716595	0.71504885	0.138282	0.208701	0.401528	0.077651	0.060631
	Weighted (Stry/Tstat)	0.512558			0.286597	0.225961

0.5540819	1.088415	0.067698	0.311138	0.611187	0.038015	0.029683
0.4920982	0.9932325	0.091104	0.276332	0.557739	0.051158	0.039946
0.4875005	0.985595	0.180619	0.27375	0.553449	0.101424	0.079194
0.364526	0.798849	0.116105	0.204695	0.448585	0.065197	0.050908
0.3211809	0.728039	0.082952	0.180355	0.408822	0.046581	0.036371
	Weighted (Stry/Tstat)	0.538477			0.302376	0.236101
0.4690983	0.9442825	0.131834	0.263417	0.530251	0.07403	0.057804
0.4109285	0.842223	0.204206	0.230752	0.472941	0.11467	0.089537
0.3604408	0.759546	0.130021	0.209951	0.437515	0.075244	0.054777
0.348485	0.741003636	0.050549	0.199103	0.423057	0.028868	0.021681
0.2522397	0.5851144	0.038539	0.141642	0.328564	0.021641	0.016898
	Weighted (Stry/Tstat)	0.55515			0.314453	0.240696
0.488939	0.977622083	0.068441	0.274558	0.54897	0.038432	0.030009
0.488939	0.974758333	0.10249	0.274558	0.547363	0.057552	0.044938
0.4827338	0.92605	0.231021	0.271074	0.520012	0.129727	0.101294
0.4636594	0.87805625	0.157355	0.260363	0.493062	0.088361	0.068994
0.4585413	0.866190417	0.09324	0.246735	0.463995	0.050046	0.043194
	Weighted (Stry/Tstat)	0.652547			0.364118	0.288429
0.488939	0.977622083	0.239544	0.274558	0.54897	0.134513	0.105031
0.488939	0.974758333	0.136653	0.274558	0.547363	0.076736	0.059917
0.4827338	0.92605	0.165015	0.271074	0.520012	0.092662	0.072353
0.4636594	0.87805625	0.062942	0.260363	0.493062	0.035344	0.027598
0.4585413	0.866190417	0.06216	0.246735	0.463995	0.033364	0.028796
	Weighted (Stry/Tstat)	0.666315			0.372619	0.293695
				Weighted savings Vin(		**0.20667**
0.4978423	0.892284167	0.06004	0.279557	0.501053	0.033715	0.026325
0.5046763	0.902492917	0.121622	0.283395	0.506785	0.068295	0.053326
0.5071345	0.907233333	0.061116	0.284775	0.509446	0.034319	0.026797
0.4522604	0.82734375	0.164935	0.253962	0.464585	0.092617	0.072318
0.322482	0.629608833	0.1207	0.181086	0.35355	0.067778	0.052923
	Weighted (Stry/Tstat)	0.528413			0.296724	0.231689
0.5748269	1.099480833	0.139099	0.317065	0.610563	0.076914	0.062185
0.4412405	0.903620833	0.054759	0.247773	0.507418	0.030749	0.02401
0.4738985	0.95052375	0.116704	0.266112	0.533756	0.065534	0.05117
0.4104635	0.854377917	0.153769	0.230491	0.479766	0.086347	0.067422
0.2552921	0.604267042	0.067111	0.143356	0.339319	0.037686	0.029426
	Weighted (Stry/Tstat)	0.531443			0.29723	0.234213
0.5369718	1.04428375	0.07399	0.301531	0.586405	0.041548	0.032442
0.4779635	0.936354167	0.099198	0.268395	0.525799	0.055703	0.043494
0.4297266	0.86105625	0.150565	0.241308	0.483517	0.084548	0.066017
0.4225776	0.847559167	0.148143	0.237294	0.475937	0.083188	0.064955
0.3093476	0.672240417	0.113626	0.173711	0.377489	0.063805	0.049821
	Weighted (Stry/Tstat)	0.585521			0.328793	0.256728
0.488939	0.977622083	0.068441	0.274558	0.54897	0.038432	0.030009
0.488939	0.974758333	0.136653	0.274558	0.547363	0.076736	0.059917
0.4827338	0.92605	0.198018	0.271074	0.520012	0.111195	0.086823

0.4636594	0.87805625	0.157355	0.260363	0.493062	0.088361	0.068994
0.4585413	0.866190417	0.09324	0.246735	0.463995	0.050046	0.043194
	Weighted (Stry/Tstat)	0.653707			0.364769	0.288938
0.488939	0.977622083	0.136882	0.274558	0.54897	0.076865	0.060018
0.488939	0.974758333	0.170817	0.274558	0.547363	0.09592	0.074897
0.4827338	0.92605	0.198018	0.271074	0.520012	0.111195	0.086823
0.4636594	0.87805625	0.094413	0.260363	0.493062	0.053016	0.041396
0.4585413	0.866190417	0.06216	0.246735	0.463995	0.033364	0.028796
	Weighted (Stry/Tstat)	0.66229			0.37036	0.291931
				Weighted savings Vin(		**0.214797**

, 12, and 13 only.

Guidance Initiatives	Sum of Cost	Sum of 2016 Cost		
			possibly eliminated	
General Administration				
Workforce Education & Training	**$54,000**	**$18,424**		
Workforce Monitoring Software Licensing	$54,000	$18,424		
Inspections				
Reduce the Number of Visits to a Home	**$126,842**	**$43,373**		
3rd Party Inspections	$126,842	$43,373	5735	high usage verification associated - see variance detail
Marketing and Outreach				
Improve In Home Energy Education	**$1,268,000**	**$391,000**		
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$797,000	$210,000		
English and Spanish Energy Education Booklets	$90,000	$30,000		
Post ESA Treatment Follow Up - Ringorang	$381,000	$151,000		
Improve Multifamily Sector Participation	**$321,223**	**$104,810**		
1 FTE Multifamily Single Point of Contact	$321,223	$104,810		
New Strategies for Increasing Enrollment	**$1,279,708**	**$760,425**		
Customer Research Analyst	$79,178	$25,875		
High Poverty Outreach	$35,000	$10,000		
Lifeline/Cover CA Leveraging	$46,364	$15,450		
Mass Media Placement	$759,930	$555,235	555235	
Outreach Contractor Administration	$188,236	$62,334		
Outsourced Marketing Support (Agency)	$96,000	$66,531		
Rural Outreach	$30,000	$10,000		
Special Needs Outreach	$45,000	$15,000		
Training Center				
Standardize Contractor Training and Materials Across Service Territories	**$1,028,568**	**$465,978**		
2 FTE Trainers	$541,905	$176,815		
ESA Contractor Training Materials Development	$347,500	$180,000		
Online Contractor Training Development	$139,163	$109,163		
Grand Total	**$4,078,341**	**$1,784,010**		

Upward Pressure	2016 ESA Labor	2016 ESA Non-Labor	2016 ESA Total	Training Center Cost	Inspections Cost	Marketing and Outreach Cost	Statewide Marketing Education and Outreach	Measurement and Evaluation Studies	Regulatory Compliance	General Administration Cost	CPUC Energy Division	Total	
Internal													
Employee Expenses Variance from 2013/2014 Average and 2016 Estimates Variance	$ -	$ 4,144	$ 4,144		$ 4,144							$ 4,144	$ -
Salary Variance from 2013/2014 Average and Actual Existing FTE Salary projections	$ 185,465	$ -	$ 185,465		$ 4,527	$ (1,021)			$ 46,252	$ 135,707		$ 185,465	$ -
Variance caused by Actual projected cost being unrelated to 2013/2014 actual cost.	$ -	$ 35,759	$ 35,759				$ 57,726	$ (59,894)			$ 37,927	$ 35,759	$ -
Estimated Variance caused by approximately 3.4 FTE labor vacancies in 2013/2014	$ 280,000	$ -	$ 280,000							$ 280,000		$ 280,000	$ -
Internal Subtotal:	$ 465,465	$ 39,903	$ 505,368	$ -	$ 8,671	$ (1,021)	$ 57,726	$ (59,894)	$ 46,252	$ 415,707	$ 37,927	$ 505,368	$ -
Commission Directives													$ -
New Strategies for Increasing Enrollment - Address High Poverty, Rural, Lifeline Leveraging and General Enrollment. (ESA ME&O, CARE Program Delivery)													$ -
High Poverty Outreach	$ -	$ 10,000	$ 10,000	$ -	$ -	$ 10,000						$ 10,000	$ -
Lifeline/Cover CA Leveraging	$ -	$ 15,450	$ 15,450			$ 15,450						$ 15,450	$ -
Rural Outreach	$ -	$ 10,000	$ 10,000			$ 10,000						$ 10,000	$ -
Special Needs Outreach	$ -	$ 15,000	$ 15,000			$ 15,000						$ 15,000	$ -
Analytics & Research	$ -	$ 25,875	$ 25,875			$ 25,875						$ 25,875	$ -
Outreach Contractor Administration	$ -	$ 62,334	$ 62,334			$ 62,334						$ 62,334	$ -
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$ -	$ 210,000	$ 210,000			$ 210,000						$ 210,000	$ -
Customer Research Analyst	$ 25,875	$ -	$ 25,875			$ -				$ 25,875		$ 25,875	$ -
Outsourced Marketing Support (Agency)	$ -	$ 66,531	$ 66,531			$ 66,531						$ 66,531	$ -
Mass Media Placement	$ -	$ 555,235	$ 555,235			$ 555,235						$ 555,235	$ -
New Strategies for Increasing Enrollment Subtotal:	$ 25,875	$ 970,425	$ 996,300	$ -	$ -	$ 970,425				$ 25,875		$ 996,300	$ -
ESA Program Implementation Strategies													$ -
Reduce the Number of Visits to a Home													$ -
3rd Party Inspections	$ -	$ 43,373	$ 43,373	$ -	$ 43,373	$ -				$ -		$ 43,373	$ -
Improve In Home Energy Education													$ -
Post ESA Treatment Follow Up - Ringorang	$ -	$ 151,000	$ 151,000			$ 151,000						$ 151,000	$ -
English and Spanish Energy Education Booklets	$ -	$ 30,000	$ 30,000			$ 30,000						$ 30,000	$ -
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$ -	$ 210,000	$ 210,000			$ 210,000						$ 210,000	$ -
Standardize Contractor Training and Materials Across Service Territories													$ -
2 FTE Trainers	$ 176,815	$ 3,467	$ 180,282	$ 180,282								$ 180,282	$ -
ESA Contractor Training Materials Development	$ -	$ 180,000	$ 180,000	$ 180,000								$ 180,000	$ -
Online Contractor Training Development	$ -	$ 109,163	$ 109,163	$ 109,163								$ 109,163	$ -
Improve Multifamily Sector Participation			$ -										$ -
1 FTE Multifamily Single Point of Contact	$ 104,810		$ 104,810	$ -	$ -	$ -	$ -	$ -	$ -	$ 104,810		$ 104,810	$ -
Workforce Education & Training													$ -
Workforce Monitoring Software Licensing	$ -	$ 43,373	$ 43,373							$ 43,373		$ 43,373	$ -
Infrastructure Required to Support Commission Directives													$ -
Increased inspections for High Usage Verification process	$ 5,736	$ -	$ 5,736		$ 5,736					$ -		$ 5,736	$ -
System Enhancements	$ -	$ 236,715	$ 236,715							$ 236,715		$ 236,715	$ -
Increase in IT Support	$ -	$ 98,678	$ 98,678							$ 98,678		$ 98,678	$ -
RHA Call Center Support Cost increase	$ -	$ 286,185	$ 286,185			$ 286,185						$ 286,185	$ -
Project Specialist	$ 26,203	$ -	$ 26,203							$ 26,203		$ 26,203	$ -
Commission Directives Subtotal:	$ 339,439	$ 2,362,379	$ 2,701,818	$ 469,445	$ 49,109	$ 1,647,610	$ -	$ -	$ -	$ 535,654	$ -	$ 2,701,818	$ -
Total Upward Pressures:	**$ 804,904**	**$ 2,402,282**	**$ 3,207,186**	**$ 469,445**	**$ 57,780**	**$ 1,646,589**	**$ 57,726**	**$ (59,894)**	**$ 46,252**	**$ 951,361**	**$ 37,927**	**$ 3,207,186**	$ -
Savings													$ -
LAB Reductions													$ -
- 1 ESA FTE Beginning in April 2015	$ (40,000)		$ (40,000)							$ (40,000)		$ (40,000)	$ -
- 1 ESA FTE Beginning in July 2015	$ (40,000)		$ (40,000)							$ (40,000)		$ (40,000)	$ -
LAB Savings Subtotal:	$ (80,000)	$ -	$ (80,000)							$ (80,000)		$ (80,000)	$ -
Non-labor Savings[1]													$ -
Reduction in Direct Marketing and Contact Costs	$ -	$ (557,312)	$ (557,312)			$ (557,312)						$ (557,312)	$ -
Employee Expenses Reduction	$ -	$ (12,211)	$ (12,211)						$ (5,160)	$ (7,051)		$ (12,211)	$ -
Non-Labor Savings Subtotal:	$ -	$ (569,523)	$ (569,523)	$ -	$ -	$ (557,312)	$ -	$ -	$ (5,160)	$ (7,051)	$ -	$ (569,523)	$ -
Total Savings:	**$ (80,000)**	**$ (569,523)**	**$ (649,523)**	**$ -**	**$ -**	**$ (557,312)**	**$ -**	**$ -**	**$ (5,160)**	**$ (87,051)**	**$ -**	**$ (649,523)**	$ -
Net Administrative Cost Increase/(Decrease)	**$ 724,904**	**$ 1,832,759**	**$ 2,557,663**	**$ 469,445**	**$ 57,780**	**$ 1,089,277**	**$ 57,726**	**$ (59,894)**	**$ 41,092**	**$ 864,310**	**$ 37,927**	**$ 2,557,663**	$ -
2013-2014 Average	1,460,238	1,458,125	2,918,363	-	90,058	738,418	2,274	137,394	227,500	1,715,645	7,073	2,918,362	$ (1)
2016 Proposed Budget	2,185,142	3,290,884	5,476,026	469,445	147,838	1,827,695	60,000	77,500	268,592	2,579,956	45,000	5,476,026	$ -
Difference	724,904	1,832,759	2,557,663	469,445	57,780	1,089,277	57,726	(59,894)	41,092	864,311	37,927	2,557,664	$ 1
													$ -

1. Negative dollars indicate SDG&E's change in strategy to address specific sectors in outreach and marketing as reflected in rows 9 through 19 above.

subtract 10%	5737	555,735	257,995.60
	142,101	1,271,960	2,321,960.40
subtract 10%		127,196.0	
		1,144,764	

Guidance Initiatives	Sum of Cost	Sum of 2016 Cost
General Administration		
Workforce Education & Training	**$54,000**	**$18,424**
Workforce Monitoring Software Licensing	$54,000	$18,424
Inspections		
Reduce the Number of Visits to a Home	**$126,842**	**$43,373**
3rd Party Inspections	$126,842	$43,373
Marketing and Outreach		
Improve In Home Energy Education	**$1,268,000**	**$391,000**
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$797,000	$210,000
English and Spanish Energy Education Booklets	$90,000	$30,000
Post ESA Treatment Follow Up - Ringorang	$381,000	$151,000
Improve Multifamily Sector Participation	**$321,223**	**$104,810**
1 FTE Multifamily Single Point of Contact	$321,223	$104,810
New Strategies for Increasing Enrollment	**$1,279,708**	**$760,425**
Customer Research Analyst	$79,178	$25,875
High Poverty Outreach	$35,000	$10,000
Lifeline/Cover CA Leveraging	$46,364	$15,450
Mass Media Placement	$759,930	$555,235
Outreach Contractor Administration	$188,236	$62,334
Outsourced Marketing Support (Agency)	$96,000	$66,531
Rural Outreach	$30,000	$10,000
Special Needs Outreach	$45,000	$15,000
Training Center		
Standardize Contractor Training and Materials Across Service Territories	**$1,028,568**	**$465,978**
2 FTE Trainers	$541,905	$176,815
ESA Contractor Training Materials Development	$347,500	$180,000
Online Contractor Training Development	$139,163	$109,163
Grand Total	**$4,078,341**	**$1,784,010**

Category	2013	2014 [1]	Average Cost	2016 Proposed	Difference	% Increase/-Decrease
Training Center	**-**	**-**	**-**	**469,445**	**469,445**	**N/A**
Labor	-	-	-	176,815	176,815	N/A
Non-Labor	-	-	-	292,630	292,630	N/A
Inspections	**97,563**	**82,553**	**90,058**	**147,838**	**57,780**	**64%**
Labor	96,939	82,464	89,702	99,965	10,264	11%
Non-Labor	624	89	356	47,873	47,517	13331%
Marketing and Outreach	**739,804**	**737,032**	**738,418**	**1,827,695**	**1,089,277**	**148%**
Labor	2,043	-	1,021	-	(1,021)	-100%
Non-Labor	737,761	737,032	737,397	1,827,695	1,090,298	148%
Statewide Marketing Education and Outreach	**4,548**	**-**	**2,274**	**60,000**	**57,726**	**2539%**
Labor	-	-	-	-	-	N/A
Non-Labor	4,548	-	2,274	60,000	57,726	2539%
Measurement and Evaluation Studies	**73,405**	**201,384**	**137,394**	**77,500**	**(59,894)**	**-44%**
Labor	-	-	-	-	-	N/A
Non-Labor	73,405	201,384	137,394	77,500	(59,894)	-44%
Regulatory Compliance	**212,403**	**242,598**	**227,500**	**268,592**	**41,092**	**18%**
Labor	166,954	217,414	192,184	238,436	46,252	24%
Non-Labor	45,449	25,184	35,317	30,156	(5,161)	-15%
General Administration	**1,579,573**	**1,851,716**	**1,715,645**	**2,579,956**	**864,311**	**50%**
Labor	1,141,198	1,213,464	1,177,331	1,669,926	492,595	42%
Non-Labor	438,375	638,252	538,314	910,030	371,717	69%
CPUC Energy Division	**7,119**	**7,027**	**7,073**	**45,000**	**37,927**	**536%**
Labor	-	-	-	-	-	N/A
Non-Labor	7,119	7,027	7,073	45,000	37,927	536%
Total	**2,714,415**	**3,122,310**	**2,918,363**	**5,476,026**	**2,557,663**	**88%**
Labor	1,407,134	1,513,341	1,460,238	2,185,142	724,904	50%
Non-Labor	1,307,281	1,608,969	1,458,125	3,290,884	1,832,759	126%

1. 2014 Costs are preliminary. Final costs will be available when the Low Income Annual Report for 2014 is filed in May, 2015.

Upward Pressure	2016 ESA Labor	2016 ESA Non-Labor	2016 ESA Total	Training Center Cost	Inspections Cost	Marketing and Outreach Cost	Statewide Marketing Education and Outreach	Measurement and Evaluation Studies	Regulatory Compliance	General Administration Cost	CPUC Energy Division	Total	
Internal													
Employee Expenses Variance from 2013/2014 Average and 2016 Estimates Variance	$ -	$ 4,144	$ 4,144		$ 4,144							$ 4,144	$ -
Salary Variance from 2013/2014 Average and Actual Existing FTE Salary projections	$ 185,465	$ -	$ 185,465		$ 4,527	$ (1,021)			$ 46,252	$ 135,707		$ 185,465	$ -
Variance caused by Actual projected cost being unrelated to 2013/2014 actual cost.	$ -	$ 35,759	$ 35,759				$ 57,726	$ (59,894)			$ 37,927	$ 35,759	$ -
Estimated Variance caused by approximately 3.4 FTE labor vacancies in 2013/2014	$ 280,000	$ -	$ 280,000							$ 280,000		$ 280,000	$ -
Internal Subtotal:	$ 465,465	$ 39,903	$ 505,368	$ -	$ 8,671	$ (1,021)	$ 57,726	$ (59,894)	$ 46,252	$ 415,707	$ 37,927	$ 505,368	$ -
Commission Directives													$ -
New Strategies for Increasing Enrollment - Address High Poverty, Rural, Lifeline Leveraging and General Enrollment. (ESA ME&O, CARE Program Delivery)													$ -
High Poverty Outreach	$ -	$ 10,000	$ 10,000	$ -	$ -	$ 10,000						$ 10,000	$ -
Lifeline/Cover CA Leveraging	$ -	$ 15,450	$ 15,450			$ 15,450						$ 15,450	$ -
Rural Outreach	$ -	$ 10,000	$ 10,000			$ 10,000						$ 10,000	$ -
Special Needs Outreach	$ -	$ 15,000	$ 15,000			$ 15,000						$ 15,000	$ -
Analytics & Research	$ -	$ 25,875	$ 25,875			$ 25,875						$ 25,875	$ -
Outreach Contractor Administration	$ -	$ 62,334	$ 62,334			$ 62,334						$ 62,334	$ -
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$ -	$ 210,000	$ 210,000			$ 210,000						$ 210,000	$ -
Customer Research Analyst	$ 25,875	$ -	$ 25,875			$ -				$ 25,875		$ 25,875	$ -
Outsourced Marketing Support (Agency)	$ -	$ 66,531	$ 66,531			$ 66,531						$ 66,531	$ -
Mass Media Placement	$ -	$ 555,235	$ 555,235			$ 555,235						$ 555,235	$ -
New Strategies for Increasing Enrollment Subtotal:	$ 25,875	$ 970,425	$ 996,300	$ -	$ -	$ 970,425				$ 25,875		$ 996,300	$ -
ESA Program Implementation Strategies													$ -
Reduce the Number of Visits to a Home													$ -
3rd Party Inspections	$ -	$ 43,373	$ 43,373	$ -	$ 43,373	$ -				$ -		$ 43,373	$ -
Improve In Home Energy Education													$ -
Post ESA Treatment Follow Up - Ringorang	$ -	$ 151,000	$ 151,000			$ 151,000						$ 151,000	$ -
English and Spanish Energy Education Booklets	$ -	$ 30,000	$ 30,000			$ 30,000						$ 30,000	$ -
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$ -	$ 210,000	$ 210,000			$ 210,000						$ 210,000	$ -
Standardize Contractor Training and Materials Across Service Territories													$ -
2 FTE Trainers	$ 176,815	$ 3,467	$ 180,282	$ 180,282								$ 180,282	$ -
ESA Contractor Training Materials Development	$ -	$ 180,000	$ 180,000	$ 180,000								$ 180,000	$ -
Online Contractor Training Development	$ -	$ 109,163	$ 109,163	$ 109,163								$ 109,163	$ -
Improve Multifamily Sector Participation			$ -										$ -
1 FTE Multifamily Single Point of Contact	$ 104,810		$ 104,810	$ -	$ -	$ -	$ -	$ -	$ -	$ 104,810		$ 104,810	$ -
Workforce Education & Training													$ -
Workforce Monitoring Software Licensing	$ -	$ 43,373	$ 43,373							$ 43,373		$ 43,373	$ -
Infrastructure Required to Support Commission Directives													$ -
Increased inspections for High Usage Verification process	$ 5,736	$ -	$ 5,736		$ 5,736					$ -		$ 5,736	$ -
System Enhancements	$ -	$ 236,715	$ 236,715							$ 236,715		$ 236,715	$ -
Increase in IT Support	$ -	$ 98,678	$ 98,678							$ 98,678		$ 98,678	$ -
RHA Call Center Support Cost increase	$ -	$ 286,185	$ 286,185			$ 286,185						$ 286,185	$ -
Project Specialist	$ 26,203	$ -	$ 26,203							$ 26,203		$ 26,203	$ -
Commission Directives Subtotal:	$ 339,439	$ 2,362,379	$ 2,701,818	$ 469,445	$ 49,109	$ 1,647,610	$ -	$ -	$ -	$ 535,654	$ -	$ 2,701,818	$ -
Total Upward Pressures:	**$ 804,904**	**$ 2,402,282**	**$ 3,207,186**	**$ 469,445**	**$ 57,780**	**$ 1,646,589**	**$ 57,726**	**$ (59,894)**	**$ 46,252**	**$ 951,361**	**$ 37,927**	**$ 3,207,186**	$ -
Savings													$ -
LAB Reductions													$ -
- 1 ESA FTE Beginning in April 2015	$ (40,000)		$ (40,000)							$ (40,000)		$ (40,000)	$ -
- 1 ESA FTE Beginning in July 2015	$ (40,000)		$ (40,000)							$ (40,000)		$ (40,000)	$ -
LAB Savings Subtotal:	$ (80,000)	$ -	$ (80,000)							$ (80,000)		$ (80,000)	$ -
Non-labor Savings[1]													$ -
Reduction in Direct Marketing and Contact Costs	$ -	$ (557,312)	$ (557,312)			$ (557,312)						$ (557,312)	$ -
Employee Expenses Reduction	$ -	$ (12,211)	$ (12,211)						$ (5,160)	$ (7,051)		$ (12,211)	$ -
Non-Labor Savings Subtotal:	$ -	$ (569,523)	$ (569,523)	$ -	$ -	$ (557,312)	$ -	$ -	$ (5,160)	$ (7,051)	$ -	$ (569,523)	$ -
Total Savings:	**$ (80,000)**	**$ (569,523)**	**$ (649,523)**	**$ -**	**$ -**	**$ (557,312)**	**$ -**	**$ -**	**$ (5,160)**	**$ (87,051)**	**$ -**	**$ (649,523)**	$ -
Net Administrative Cost Increase/(Decrease)	**$ 724,904**	**$ 1,832,759**	**$ 2,557,663**	**$ 469,445**	**$ 57,780**	**$ 1,089,277**	**$ 57,726**	**$ (59,894)**	**$ 41,092**	**$ 864,310**	**$ 37,927**	**$ 2,557,663**	$ -
2013-2014 Average	1,460,238	1,458,125	2,918,363	-	90,058	738,418	2,274	137,394	227,500	1,715,645	7,073	2,918,362	$ (1)
2016 Proposed Budget	2,185,142	3,290,884	5,476,026	469,445	147,838	1,827,695	60,000	77,500	268,592	2,579,956	45,000	5,476,026	$ -
Difference	724,904	1,832,759	2,557,663	469,445	57,780	1,089,277	57,726	(59,894)	41,092	864,311	37,927	2,557,664	$ 1
													$ -

1. Negative dollars indicate SDG&E's change in strategy to address specific sectors in outreach and marketing as reflected in rows 9 through 19 above.

A.14-11-009 SDGE Response
Data Request No: ORA_SDG&E_008 (2015)
Energy Savings Assistance Program
Dated March 5, 2015
Question 1
Submitted: March 19, 2015

1. Regarding the ESA administrative budget proposed for 2016, please provide all workpapers supporting Table A-1 "ESA Budget," for the following line items:
    a. For each

Training Center
Inspections
Marketing and Outreach
Statewide Marketing Education and Outreach [2]
Measurement and Evaluation Studies
Regulatory Compliance
General Administration
CPUC Energy Division

Workpapers should include quantitative support for the final amount requested, and may include cost of employee, by employee title, cost of activity, by specific activity, assumptions

a. For each line item, explain the difference in cost between 2016, and the annual average of costs in 2013 & 2014. Specifically identify the drivers of the cost increase or decrease, including but not limited to
    a. Greater or fewer number of the same activities performed in previous years,
    b. The addition or subtraction of an activity in the program,
    c. staff additions or subtractions,
    d. cost increases or decreases in materials,
    e. efficiencies gained or lost.

SDG&E Response 1:

1.a. SDG&E's assumptions for 2015-2016, specific to 2016 are as follows:

- Program Budgets methodology
    - Zero based
        - Labor
            - Existing staffing salaries used
            - New position salaries estimated using similar existing positions
        - Non-labor
            - Estimated costs for goal attainment and new initiatives
            - Expenses based on anticipated cost
            - Historical cost used where appropriate

SDG&E Response 1 Continued:

- ESA Goals for homes treated set at 20,316 per year
- New enrollments will be more difficult as the percent of unable or unwilling goes up over time.
- ESA Program will budget for the following initiatives as set forth in the guidance document:
    - Workforce Education & Training
    - Reduce the Number of Visits to a Home
    - Improve In Home Energy Education
    - Improve Multifamily Sector Participation
    - Standardize Contractor Training and Materials Across Service Territories
- Escalation (inflation) rates per year:

Cost Type	2015	2016	2017
Labor	**2.35%**	**2.65%**	**2.71%**
Non-Labor Electric	2.17%	2.45%	2.39%
Non-Labor Gas	2.15%	2.26%	2.27%
ESA Program Admin Non-labor (Blended Rate: 50%/50% Gas/Elec)	**2.16%**	**2.36%**	**2.33%**

The attached spreadsheet provides the 2016 budget detail for the labor and non-labor budgets.

Budget Detail - 2016.xlsx

1.a.a. SDG&E used a modified zero based budgeting method for administrative costs, estimating cost for goal attainment and new initiatives, using historical cost only when appropriate. SDG&E did not use an average historical cost basis incremental budget method as factors such as unusually low activity in 2013 and the growing increase in unwillingness factors necessitate change in outreach and marketing to enroll the remaining eligible population.

The attached variance analysis between 2013 and 2014 average cost attempts to identify major differences between these costs and the 2016 budget, but it was not the basis for budget formation.

2013-2014 Avg vs 2016.xlsx

Person Responsible for the Response: Sandra Williams and Berkeley Loveless

A 14-11-009 SDGE Response
Data Request No: DRA_SDG&E-003 (2014)
Energy Savings Assistance Program
Dated December 26, 2014
Question 4
Submitted: January 9, 2015

Question 4:

Regarding ESA Table A-2 filed in A.14-11-009, please provide the source(s) of the energy savings estimate utilized for each measure in column A (Measures). Source(s) may include 2011 Impact Evaluation Report (released Aug 2013), DEER database (specify date of update to DEER), workpapers, other. If source of energy savings estimate is workpapers or other, provide a copy of the workpapers or other source.

SDG&E Response:
Table 1 below lists the sources of the energy savings shown in Table A-2. The workpapers listed can be found on the CPUC's work paper archive website; directions for accessing the workpapers are provided below.

Table 1: Source of Energy Savings for Measures Listed in Table A-2

Measure	Source of kWh Savings Estimates	Source of therm Savings Estimates
High Efficiency Clothes Washer	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
Refrigerators	PY2011 ESA Impact Evaluation	n/a
Microwaves	PY2011 ESA Impact Evaluation	PG&E
Water Heater Blanket	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
Low Flow ShowerHead	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
Water Heater Pipe Insulation	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
Faucet Aerator	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
Water Heater Repair/Replacement	n/a	PY2011 ESA Impact Evaluation
Thermostatic Shower Valve	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
New - Combined Showerhead/TSV	Used estimate for thermostatic shower valve	SDG&E workpaper
New - Heat Pump Water Heater	SDG&E workpaper WPSDGEREWH0022	n/a
New - Tub Diverter	Used estimate for thermostatic shower valve	SDG&E workpaper
Air Sealing	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
Attic Insulation	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
FAU Standing Pilot Light Conversion	n/a	PY2011 ESA Impact Evaluation
Furnace Repair/Replacement	n/a	PY2011 ESA Impact Evaluation
Room A/C Replacement	PY2011 ESA Impact Evaluation	n/a
Duct Testing and Sealing	PY2011 ESA Impact Evaluation	PY2011 ESA Impact Evaluation
New - Energy Efficient Fan Control	SDG&E workpaper WPSDGEREHC0024	n/a
New - Prescriptive Duct Sealing	SDG&E workpaper WPSDGEREHC1065	n/a
Furnace Clean and Tune	n/a	PY2011 ESA Impact Evaluation
Central A/C Tune-up	PY2011 ESA Impact Evaluation	n/a
Compact Fluorescent Lights (CFLs)	PY2011 ESA Impact Evaluation	n/a
Interior Hard wired CFL fixtures	PY2011 ESA Impact Evaluation	n/a
Exterior Hard wired CFL fixtures	PY2011 ESA Impact Evaluation	n/a
Torchiere	PY2011 ESA Impact Evaluation	n/a
LED Night Lights	PY2011 ESA Impact Evaluation	n/a
New - LED Diffuse Bulb (60W Replace)	SDG&E workpaper WPSDGENRLG0106	n/a
New - LED Reflector Bulb (BR30 Recessed Can)	SDG&E workpaper WPSDGENRLG0106	n/a
Smart Strip	PY2011 ESA Impact Evaluation	n/a
New - Smart Strip Tier II	Used estimate for smart strip	n/a

To obtain the workpapers listed above:

a. Logon to the website www.deeresources.info (a username and password is required).
b. After logging in, you will be on the Platform Home webpage. Click on the link for Workpaper Project Archive (WPA).
c. On the WPA webpage, search for projects where project name contains WPSDGE.
d. The search will result in a list of SDG&E workpapers. The four workpapers listed in Table 1 above are included in the list.

Person Responsible for the Response: Brenda Gettig

Guidance Initiatives	Sum of Cost	Sum of 2016 Cost	
General Administration			
Workforce Education & Training	**$54,000**	**$18,424**	
Workforce Monitoring Software Licensing	$54,000	$18,424	
Inspections			
Reduce the Number of Visits to a Home	**$126,842**	**$43,373**	
3rd Party Inspections	$126,842	$43,373	
Marketing and Outreach			
Improve In Home Energy Education	**$1,268,000**	**$391,000**	
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$797,000	$210,000	
English and Spanish Energy Education Booklets	$90,000	$30,000	
Post ESA Treatment Follow Up - Ringorang	$381,000	$151,000	
Improve Multifamily Sector Participation	**$321,223**	**$104,810**	
1 FTE Multifamily Single Point of Contact	$321,223	$104,810	
New Strategies for Increasing Enrollment	**$1,279,708**	**$760,425**	
Customer Research Analyst	$79,178	$25,875	
High Poverty Outreach	$35,000	$10,000	
Lifeline/Cover CA Leveraging	$46,364	$15,450	
Mass Media Placement	$759,930	$555,235	can be eliminated
Outreach Contractor Administration	$188,236	$62,334	
Outsourced Marketing Support (Agency)	$96,000	$66,531	
Rural Outreach	$30,000	$10,000	
Special Needs Outreach	$45,000	$15,000	
Training Center			
Standardize Contractor Training and Materials Across Service Territories	**$1,028,568**	**$465,978**	
2 FTE Trainers	$541,905	$176,815	
ESA Contractor Training Materials Development	$347,500	$180,000	
Online Contractor Training Development	$139,163	$109,163	
Grand Total	**$4,078,341**	**$1,784,010**	

Upward Pressure	2016 ESA Labor	2016 ESA Non-Labor	2016 ESA Total	Training Center Cost	Inspections Cost	Marketing and Outreach Cost	Statewide Marketing Education and Outreach	Measurement and Evaluation Studies	Regulatory Compliance	General Administration Cost	CPUC Energy Division	Total	
Internal													
Employee Expenses Variance from 2013/2014 Average and 2016 Estimates Variance	$ -	$ 4,144	$ 4,144		$ 4,144							$ 4,144	$ -
Salary Variance from 2013/2014 Average and Actual Existing FTE Salary projections	$ 185,465	$ -	$ 185,465		$ 4,527	$ (1,021)			$ 46,252	$ 135,707		$ 185,465	$ -
Variance caused by Actual projected cost being unrelated to 2013/2014 actual cost.	$ -	$ 35,759	$ 35,759				$ 57,726	$ (59,894)			$ 37,927	$ 35,759	$ -
Estimated Variance caused by approximately 3.4 FTE labor vacancies in 2013/2014	$ 280,000	$ -	$ 280,000							$ 280,000		$ 280,000	$ -
Internal Subtotal:	$ 465,465	$ 39,903	$ 505,368	$ -	$ 8,671	$ (1,021)	$ 57,726	$ (59,894)	$ 46,252	$ 415,707	$ 37,927	$ 505,368	$ -
Commission Directives													$ -
New Strategies for Increasing Enrollment - Address High Poverty, Rural, Lifeline Leveraging and General Enrollment. (ESA ME&O, CARE Program Delivery)													$ -
High Poverty Outreach	$ -	$ 10,000	$ 10,000	$ -	$ -	$ 10,000						$ 10,000	$ -
Lifeline/Cover CA Leveraging	$ -	$ 15,450	$ 15,450			$ 15,450						$ 15,450	$ -
Rural Outreach	$ -	$ 10,000	$ 10,000			$ 10,000						$ 10,000	$ -
Special Needs Outreach	$ -	$ 15,000	$ 15,000			$ 15,000						$ 15,000	$ -
Analytics & Research	$ -	$ 25,875	$ 25,875			$ 25,875						$ 25,875	$ -
Outreach Contractor Administration	$ -	$ 62,334	$ 62,334			$ 62,334						$ 62,334	$ -
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$ -	$ 210,000	$ 210,000			$ 210,000						$ 210,000	$ -
Customer Research Analyst	$ 25,875	$ -	$ 25,875			$ -				$ 25,875		$ 25,875	$ -
Outsourced Marketing Support (Agency)	$ -	$ 66,531	$ 66,531			$ 66,531						$ 66,531	$ -
Mass Media Placement	$ -	$ 555,235	$ 555,235			$ 555,235						$ 555,235	$ -
New Strategies for Increasing Enrollment Subtotal:	$ 25,875	$ 970,425	$ 996,300	$ -	$ -	$ 970,425				$ 25,875		$ 996,300	$ -
ESA Program Implementation Strategies													$ -
Reduce the Number of Visits to a Home													$ -
3rd Party Inspections	$ -	$ 43,373	$ 43,373	$ -	$ 43,373	$ -				$ -		$ 43,373	$ -
Improve In Home Energy Education													$ -
Post ESA Treatment Follow Up - Ringorang	$ -	$ 151,000	$ 151,000			$ 151,000						$ 151,000	$ -
English and Spanish Energy Education Booklets	$ -	$ 30,000	$ 30,000			$ 30,000						$ 30,000	$ -
Comparative Home Energy Usage Reports/Residential Behavior-Based Energy Efficiency (Opower)	$ -	$ 210,000	$ 210,000			$ 210,000						$ 210,000	$ -
Standardize Contractor Training and Materials Across Service Territories													$ -
2 FTE Trainers	$ 176,815	$ 3,467	$ 180,282	$ 180,282								$ 180,282	$ -
ESA Contractor Training Materials Development	$ -	$ 180,000	$ 180,000	$ 180,000								$ 180,000	$ -
Online Contractor Training Development	$ -	$ 109,163	$ 109,163	$ 109,163								$ 109,163	$ -
Improve Multifamily Sector Participation			$ -										$ -
1 FTE Multifamily Single Point of Contact	$ 104,810		$ 104,810	$ -	$ -	$ -	$ -	$ -	$ -	$ 104,810		$ 104,810	$ -
Workforce Education & Training													$ -
Workforce Monitoring Software Licensing	$ -	$ 43,373	$ 43,373							$ 43,373		$ 43,373	$ -
Infrastructure Required to Support Commission Directives													$ -
Increased inspections for High Usage Verification process	$ 5,736	$ -	$ 5,736		$ 5,736					$ -		$ 5,736	$ -
System Enhancements	$ -	$ 236,715	$ 236,715							$ 236,715		$ 236,715	$ -
Increase in IT Support	$ -	$ 98,678	$ 98,678							$ 98,678		$ 98,678	$ -
RHA Call Center Support Cost increase	$ -	$ 286,185	$ 286,185			$ 286,185						$ 286,185	$ -
Project Specialist	$ 26,203	$ -	$ 26,203							$ 26,203		$ 26,203	$ -
Commission Directives Subtotal:	$ 339,439	$ 2,362,379	$ 2,701,818	$ 469,445	$ 49,109	$ 1,647,610	$ -	$ -	$ -	$ 535,654	$ -	$ 2,701,818	$ -
Total Upward Pressures:	**$ 804,904**	**$ 2,402,282**	**$ 3,207,186**	**$ 469,445**	**$ 57,780**	**$ 1,646,589**	**$ 57,726**	**$ (59,894)**	**$ 46,252**	**$ 951,361**	**$ 37,927**	**$ 3,207,186**	$ -
Savings													$ -
LAB Reductions													$ -
- 1 ESA FTE Beginning in April 2015	$ (40,000)		$ (40,000)							$ (40,000)		$ (40,000)	$ -
- 1 ESA FTE Beginning in July 2015	$ (40,000)		$ (40,000)							$ (40,000)		$ (40,000)	$ -
LAB Savings Subtotal:	$ (80,000)	$ -	$ (80,000)							$ (80,000)		$ (80,000)	$ -
Non-labor Savings[1]													$ -
Reduction in Direct Marketing and Contact Costs	$ -	$ (557,312)	$ (557,312)			$ (557,312)						$ (557,312)	$ -
Employee Expenses Reduction	$ -	$ (12,211)	$ (12,211)						$ (5,160)	$ (7,051)		$ (12,211)	$ -
Non-Labor Savings Subtotal:	$ -	$ (569,523)	$ (569,523)	$ -	$ -	$ (557,312)	$ -	$ -	$ (5,160)	$ (7,051)	$ -	$ (569,523)	$ -
Total Savings:	**$ (80,000)**	**$ (569,523)**	**$ (649,523)**	**$ -**	**$ -**	**$ (557,312)**	**$ -**	**$ -**	**$ (5,160)**	**$ (87,051)**	**$ -**	**$ (649,523)**	$ -
Net Administrative Cost Increase/(Decrease)	**$ 724,904**	**$ 1,832,759**	**$ 2,557,663**	**$ 469,445**	**$ 57,780**	**$ 1,089,277**	**$ 57,726**	**$ (59,894)**	**$ 41,092**	**$ 864,310**	**$ 37,927**	**$ 2,557,663**	$ -
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Difference	724,904	1,832,759	2,557,663	469,445	57,780	1,089,277	57,726	(59,894)	41,092	864,311	37,927	2,557,664	$ 1
													$ -

1. Negative dollars indicate SDG&E's change in strategy to address specific sectors in outreach and marketing as reflected in rows 9 through 19 above.

A.14-11-009 SDGE Response
Data Request No: ORA_SDG&E_008 (2015)
Energy Savings Assistance Program
Dated March 5, 2015
Question 1
Submitted: March 19, 2015

1. Regarding the ESA administrative budget proposed for 2016, please provide all workpapers supporting Table A-1 "ESA Budget," for the following line items:
    a. For each

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Statewide Marketing Education and Outreach [2]
Measurement and Evaluation Studies
Regulatory Compliance
General Administration
CPUC Energy Division

Workpapers should include quantitative support for the final amount requested, and may include cost of employee, by employee title, cost of activity, by specific activity, assumptions

a. For each line item, explain the difference in cost between 2016, and the annual average of costs in 2013 & 2014. Specifically identify the drivers of the cost increase or decrease, including but not limited to
    a. Greater or fewer number of the same activities performed in previous years,
    b. The addition or subtraction of an activity in the program,
    c. staff additions or subtractions,
    d. cost increases or decreases in materials,
    e. efficiencies gained or lost.

SDG&E Response 1:

1.a. SDG&E's assumptions for 2015-2016, specific to 2016 are as follows:

- Program Budgets methodology
    - Zero based
        - Labor
            - Existing staffing salaries used
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            - Estimated costs for goal attainment and new initiatives
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            - Historical cost used where appropriate

SDG&E Response 1 Continued:

- ESA Goals for homes treated set at 20,316 per year
- New enrollments will be more difficult as the percent of unable or unwilling goes up over time.
- ESA Program will budget for the following initiatives as set forth in the guidance document:
    - Workforce Education & Training
    - Reduce the Number of Visits to a Home
    - Improve In Home Energy Education
    - Improve Multifamily Sector Participation
    - Standardize Contractor Training and Materials Across Service Territories
- Escalation (inflation) rates per year:

Cost Type	2015	2016	2017
Labor	**2.35%**	**2.65%**	**2.71%**
Non-Labor Electric	2.17%	2.45%	2.39%
Non-Labor Gas	2.15%	2.26%	2.27%
ESA Program Admin Non-labor (Blended Rate: 50%/50% Gas/Elec)	**2.16%**	**2.36%**	**2.33%**

The attached spreadsheet provides the 2016 budget detail for the labor and non-labor budgets.

Budget Detail - 2016.xlsx

1.a.a. SDG&E used a modified zero based budgeting method for administrative costs, estimating cost for goal attainment and new initiatives, using historical cost only when appropriate. SDG&E did not use an average historical cost basis incremental budget method as factors such as unusually low activity in 2013 and the growing increase in unwillingness factors necessitate change in outreach and marketing to enroll the remaining eligible population.

The attached variance analysis between 2013 and 2014 average cost attempts to identify major differences between these costs and the 2016 budget, but it was not the basis for budget formation.

2013-2014 Avg vs 2016.xlsx

Person Responsible for the Response: Sandra Williams and Berkeley Loveless

A.11-05-018 SCG Response
Data Request No: DRA_SoCalGas-3 (2012)
Dated November 15, 2012
Question 2
Submitted: November 30, 2012

Question 2:

Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

Response to Q2:
SoCalGas is currently working with Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company to update, simplify and make uniform a property owner waiver form and co-pay form that the utilities can utilize statewide to comply with Ordering Paragraphs 27 and 70 of D.12-08-044.

PACIFIC GAS AND ELECTRIC COMPANY
Low Income Program – Project Year 2012-2014
Application 11-05-019
Data Response

PG&E Data Request No.:	DRA_012-01-04		
PG&E File Name:	LowIncomeProgramPY12-14_DR_DRA_012-Q01-04		
Request Date:	November 15, 2012	Requester DR No.:	012
Date Sent:	December 3, 2012	Requesting Party:	Division of Ratepayer Advocates
PG&E Witness:	Mary O'Drain	Requester:	Camille Watts-Zagha

QUESTION 1

Please explain how PG&E has complied with Ordering Paragraph 29 of D.12-08-044 which requires PG&E to integrate the Home Energy Efficiency Surveys (HEES) and California Integrated Customers Energy Audit tool (Audit Tool) into ESAP. Please provide a copy of the reports/forms/or printout of the software by which ESAP contractors use the HEES and Audit Tool for customer enrollment and assessments.

ANSWER 1

PG&E's Progressive Energy Audit Tool Suite (PG&E's PEAT – Equivalent to SCE's California Integrated Customer Energy Audit Tool software) replaced the Home Energy Efficiency Surveys (HEES) in March 2012. The Progressive Energy Audit Suite of tools (and HEES surveys before that) are available to complement the specific services and assessments provided through the Energy Savings Assistance (ESA) program. They are not designed to augment or replace the current ESA measure feasibility and eligibility criteria and assessment processes. Rather, the PEAT suite of tools are intended to be utilized to enable customers to explore services that may be available to address increased energy efficiency, demand response, and solar options beyond available measures that are provided at no or minimal cost through the ESA program. As a means of promoting IDSM, PG&E intends to inform ESA customers through their in-home energy education about the availability of PG&E's tool suite. PG&E customers can access the tool suite by logging into My Energy and clicking on the "My Usage" and "Ways to Save" tabs. See also: http://www.pge.com/myhome/saveenergymoney/analyzer/ and http://www.pge.com/myhome/myaccount/using/

QUESTION 2

Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

ANSWER 2

PG&E is currently working with San Diego Gas and Electric Company, Southern California Edison Company, and Southern California Gas Company to update, simplify and make uniform a property owner waiver form and co-pay form that the utilities can utilize statewide to comply with Ordering Paragraphs 27 and 70 of D.12-08-044.

QUESTION 3

Please provide documentation of ESAP program and process changes to Multi-family buildings in compliance with Ordering Paragraph 70 of D.12-08-044, for Strategies 4 (EUC/MIDI/MFEER), 5 (Single Point of Contact, and 6 (Same Day Enrollment, Assessment and Installation).

ANSWER 3

Strategy 4 – EUC/MIDI/MFEER Coordination

PG&E EUC/MIDI/MFEER and ESA staff meet regularly to discuss coordination that will occur under the Joint Advice Letter (SCE 2681-E-B, PG&E 3268-G-B/3972-E-B, SoCalGas 4312·G-B, and SDG&E 2320-E-B/2081-G-B), which was approved, effective September 23, 2012. PG&E is currently developing its integrated MF program as specified in the Advice Letter.

Strategy 5 – Single Point of Contact

See Response to Strategy 4. PG&E is currently working to develop a single point of contact as part of its integrated MF program.

Strategy 6 – Same Day Enrollment, Assessment, and Installation

PG&E coordinates enrollment, assessment, and installation activities to the degree practical, feasible and convenient to the customer. In most cases these activities are not possible on the same day. Energy specialists performing initial outreach, enrollment and assessment activities, are not installers. The marketing and people skills required to perform outreach and enrolment activities are not the same technical skills required to install energy efficiency measures, so it is rarely a case of simply cross-training personnel to perform both functions. In addition, appliances need to be ordered to

fit. For example, installers and appliance contractors cannot carry each of the different sizes of refrigerators or types of air conditioner on their trucks. PG&E endeavors to coordinate activities as closely as possible in all housing types.

QUESTION 4

Please identify any evaluation projects that PG&E has submitted to Energy Division in compliance with Ordering Paragraph 131 of D.12-08-044.

Answer 4

PG&E has not submitted any low income program related evaluation projects to the Energy Division since the date D. 12-08-044 was issued.

Southern California Edison
ESAP-CARE 2012-2014 A.11-05-017

DATA REQUEST SET A.11-05-017 DRA-SCE-002 (2012)

To: DRA
Prepared by: John Fasana
Title: Project Manager
Dated: 11/28/2012

Question 01:

1. Please explain how SCE has complied with Ordering Paragraph 29 of D.12-08-044 which requires SCE to integrate the Home Energy Efficiency Surveys (HEES) and California Integrated Customers Energy Audit tool (Audit Tool) into ESAP. Please provide a copy of the reports/forms/or printout of the software by which ESAP contractors use the HEES and Audit Tool for customer enrollment and assessments.

Response to Question 01:

SCE's Home Energy Advisor (SCE's California Integrated Customer Energy Audit Tool software) ultimately will replace the Home Energy Efficiency Surveys (HEES). HEES and the California Integrated Customer Energy Audit tool are available to complement the specific services and assessments provided through the Energy Savings Assistance (ESA) program. They are not designed to augment or replace the current ESA measure feasibility and eligibility criteria and assessment processes. As a means of promoting IDSM, SCE intends to inform ESA customers through In-Home Energy Education about the availability of SCE's Home Energy Advisor. The Home Energy Advisor will enable customers to explore services that may be available to address increased energy efficiency, solar, and demand response options beyond available measures that are provided at no or minimal cost through the ESA program.

Home Energy Advisor is available to SCE customers at: https://www.scehomeenergyadvisor.com/

Southern California Edison
ESAP-CARE 2012-2014 A.11-05-017

DATA REQUEST SET A.11-05-017 DRA-SCE-002 (2012)

To: DRA
Prepared by: John Fasana
Title: Project Manager
Dated: 11/28/2012

Question 02:

2. Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

Response to Question 02:

SCE is currently working with Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Gas Company to update, simplify, and make uniform a property owner waiver form and co-pay form that the utilities can use statewide to comply with Ordering Paragraphs 27 and 70 of D.12-08-044.

Southern California Edison
ESAP-CARE 2012-2014 A.11-05-017

DATA REQUEST SET A.11-05-017 DRA-SCE-002 (2012)

To: DRA
Prepared by: John Fasana
Title: Project Manager
Dated: 11/28/2012

Question 03:

3. Please provide documentation of ESAP program and process changes to Multi-family buildings in compliance with Ordering Paragraph 70 of D.12-08-044, for Strategies 4 (EUC/MIDI/MFEER), 5 (Single Point of Contact, and 6 (Same Day Enrollment, Assessment and Installation).

Response to Question 03:

Strategy 4 – EUC/MIDI/MFEER Coordination

SCE EUC/MIDI/MFEER and ESA staff meet regularly to discuss coordination that will occur under the Joint Advice Letter, SCE 2681-E-B, PG&E 3268-G-B/3972-E-B, SoCalGas 4312·G-B, and SDG&E 2320-E-B/2081-G-B, which was approved, effective September 23, 2012. SCE is currently working with SoCalGas in developing an integrated multi-family program as specified in the Advice Letter.

Strategy 5 – Single Point of Contact

See Response to Strategy 4. SCE, in coordination with SoCalGas, implemented the Integrated Multi-family Demonstration Project with LINC Housing in the latter part of 2012 to test the Single Point of Contact strategy. Information from this Demonstration Project will assist in developing the Single Point of Contact strategy as part of an integrated multi-family program.

Strategy 6 – Same Day Enrollment, Assessment, and Installation

SCE coordinates enrollment, assessment, and installation activities whenever practical, feasible and convenient to the customer throughout SCE's service territory. In most cases, it is not possible to engage in all three activities on the same day.

Energy Specialists who perform the initial outreach, enrollment and assessment activities are not installers of complex measures such as HVAC systems. The Energy Specialists possess the marketing and people skills necessary to be effective in outreach and enrollment efforts but generally do not possess the technical skills required to install energy efficiency measures other than simple measures such as CFLs or smart powerstrips. Therefore, it's not a case of simply

cross-training personnel to perform both functions.

Southern California Edison
ESAP-CARE 2012-2014 A.11-05-017

DATA REQUEST SET A.11-05-017 DRA-SCE-002 (2012)

To: DRA
Prepared by: John Fasana
Title: Project Manager
Dated: 11/28/2012

Question 04:

4. Please identify any evaluation projects that SCE has submitted to Energy Division in compliance with Ordering Paragraph 131 of D.12-08-044.

Response to Question 04:

SCE has not submitted any low income program related evaluation projects to the Energy Division since the date D. 12-08-044 was issued.

DRA

Division of Ratepayer Advocates
California Public Utilities Commission

Joseph P. Como, Acting Director

505 Van Ness Avenue
San Francisco, CA 94102
Phone: (415) 703-2544
Fax: (415) 703-2057

http://dra.ca.gov

DRA DATA REQUEST

Date:		**May 3, 2013**
Responses Due:		**May 17, 2013**
To:	Mary O'Drain PG&E	Email: mjob@pge.com
	Patti Landry	Email: pxls@pge.com
Cc:	Ann Kim Staff Counsel PG&E	Email: ahk4@pge.com Phone: (415) 973-6646
From:	Camille Watts-Zagha Project Coordinator Division of Ratepayer Advocates 505 Van Ness Avenue San Francisco, CA 94102	Phone: (415) 703-2881 Email: kwz@cpuc.ca.gov Fax: (415) 703-1673
	Attorney for DRA Mitchell Shapson	Email: sha@cpuc.ca.gov Phone: (415) 703-2727

Data Request No: DRA_PG&E-7 (2013)

INSTRUCTIONS

You are instructed to answer the following Data Requests, with written, verified responses per Public Utilities Code §§ 309.5 and 314, and Rules 1.1 and 10.1 of the California Public Utilities Commission's Rules of Practice and Procedure. Restate the text of each request prior to providing the response. For any questions, email the DRA contact(s) above with a copy to the DRA attorney.

Each Data Request is continuing in nature. Provide your response as it becomes available, but no later than the due date noted above. If you are unable to provide a response by this date, notify DRA as soon as possible, with a written explanation as to why the response date cannot be met and a best estimate of when the information can be provided. If you acquire additional information after providing an answer to any request, you must supplement your response following the receipt of such additional information.

Identify the person providing the answer to each data request and his/her contact information. Responses should be provided both in the original electronic format. (If available in Word format, send the Word document and do not send the information as a PDF file.) All electronic documents submitted in response to this data request should be in readable, downloadable, printable, and searchable formats, unless use of such formats is infeasible. Each page should be numbered. If any of your answers refer to or reflect calculations, provide a copy of

the supporting electronic files that were used to derive such calculations, such as Excel-compatible spreadsheets or computer programs, with data and formulas intact and functioning.

If a request, definition, or an instruction, is unclear, notify DRA as soon as possible via email. In any event, answer the request to the fullest extent possible, specifying the reason for your inability to answer the remaining portion of the Data Request.

Request:

1. Please provide copies of materials used by PG&E's ESA Energy Specialists regarding PG&E's Progressive Energy Audit Tool Suite. Please provide tracking data and any other evidence of ESA participants' utilization of the PG&E's Progressive Energy Audit Tool Suite.

2. Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

3. Please provide documentation of PG&E's development of its integrated Multifamily Program that it described in its response of December 3, 2012 to DRA's Data Request 3 sent November 15, 2012, question 3.

4. Please describe in detail how the Single Point of Contact has been further implemented in 2013. Identify the number of ESA building owners in 2013 that have interacted with a "Single Point of Contact" during their ESA service.

5. Please identify the number of ESA participants in 2012 who were enrolled into the ESA program via "self-certification," and the various authorities under which these customers were self-certified.

6. Regarding PG&E's Monthly CARE report as of March 2013, table 3B, please describe the status of PG&E's CARE high use verification process.

    a. Why haven't any high use customers been requested to verify income?
    b. Please provide copies of the income verification request that is sent to CARE customers using 400-600% of baseline.
    c. Please provide a copy of the notice regarding their eligibility for CARE sent to CARE customers using 600% or more of baseline.
    d. Please provide a timeline for full implementation of PG&E's CARE high use verification process.

Questions regarding this data request should be directed to Camille Watts-Zagha at (415) 703-2881 or kwz@cpuc.ca.gov.

END OF REQUEST

DRA

Division of Ratepayer Advocates
California Public Utilities Commission

Joseph P. Como, Acting Director

505 Van Ness Avenue
San Francisco, CA 94102
Phone: (415) 703-2544
Fax: (415) 703-2057

http://dra.ca.gov

DRA DATA REQUEST

Date: **May 3, 2013**
Responses Due: **May 17, 2013**

To: John Fasana, SCE — Email: john.fasana@sce.com

Andrea Tozer, Attorney for SCE — Email: andrea.tozer@sce.com

From: Camille Watts-Zagha, Project Coordinator, Division of Ratepayer Advocates, 505 Van Ness Avenue, San Francisco, CA 94102 — Phone: (415) 703-2881, Email: kwz@cpuc.ca.gov, Fax: (415) 703-1673

Attorney for DRA, Mitchell Shapson — Email: sha@cpuc.ca.gov, Phone: (415) 703-2727

Data Request No: DRA_SCE-8 (2013)

INSTRUCTIONS

You are instructed to answer the following Data Requests, with written, verified responses per Public Utilities Code §§ 309.5 and 314, and Rules 1.1 and 10.1 of the California Public Utilities Commission's Rules of Practice and Procedure. Restate the text of each request prior to providing the response. For any questions, email the DRA contact(s) above with a copy to the DRA attorney.

Each Data Request is continuing in nature. Provide your response as it becomes available, but no later than the due date noted above. If you are unable to provide a response by this date, notify DRA as soon as possible, with a written explanation as to why the response date cannot be met and a best estimate of when the information can be provided. If you acquire additional information after providing an answer to any request, you must supplement your response following the receipt of such additional information.

Identify the person providing the answer to each data request and his/her contact information. Responses should be provided both in the original electronic format. (If available in Word format, send the Word document and do not send the information as a PDF file.) All electronic documents submitted in response to this data request should be in readable, downloadable, printable, and searchable formats, unless use of such formats is infeasible. Each page should be numbered. If any of your answers refer to or reflect calculations, provide a copy of the supporting electronic files that were used to derive such calculations, such as Excel-compatible spreadsheets or computer programs, with data and formulas intact and functioning.

If a request, definition, or an instruction, is unclear, notify DRA as soon as possible via email. In any event, answer the request to the fullest extent possible, specifying the reason for your inability to answer the remaining portion of the Data Request.

Request:

1. Please provide copies of materials used by SCE ESA Energy Specialists regarding SCE's Home Energy Advisor audit tool. Please provide tracking data and any other evidence of ESA participants' utilization of the SCE Home Energy Advisor audit tool.

2. Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

3. Please provide documentation of SCE's integrated Multi-family program that it has developed in conjunction with SoCalGas, as described in SCE's response of November 28, 2012 to DRA Data Request 2 (2012), question 3.

4. Please provide written results of the Integrated Multifamily Demonstration Project with LINC Housing that SCE implemented in 2012. Please describe in detail how the Single Point of Contact has been further implemented in 2013. Identify the number of ESA building owners in 2013 that have interacted with a "Single Point of Contact" during their ESA service.

5. Regarding SCE's Monthly CARE report as of March 2013, table 3B, please describe the status of SCE's CARE high use verification process.

    a. Why haven't any high use customers been requested to verify income?
    b. Please provide copies of the income verification request that is sent to CARE customers using 400-600% of baseline.
    c. Please provide a copy of the notice regarding their eligibility for CARE sent to CARE customers using 600% or more of baseline.

6. As a follow-up to SCE's response of January 14, 2013 to DRA Data Request 3 (2012) of December 21, 2012, Question 3:
    a. The customer totals for winter usage & summer usage data, for the same climate zone/dwelling type/electric heat status/medical baseline status should be the same but in many cases are not. Please explain this discrepancy and correct the data if necessary.

Questions regarding this data request should be directed to Camille Watts-Zagha at (415) 703-2881 or kwz@cpuc.ca.gov.

END OF REQUEST

DRA

Division of Ratepayer Advocates
California Public Utilities Commission

Joseph P. Como, Acting Director

505 Van Ness Avenue
San Francisco, CA 94102
Phone: (415) 703-2544
Fax: (415) 703-2057

http://dra.ca.gov

DRA DATA REQUEST

Date: **May 3, 2013**
Responses Due: **May 17, 2013**

To: Steve Hruby
Regulatory Manager, SoCalGas
Email: shruby@semprautilities.com

Cc: Kim Hassan
Staff Counsel
SoCalGas
Email: khassan@semprautilities.com

From: Camille Watts-Zagha
Project Coordinator
Division of Ratepayer Advocates
505 Van Ness Avenue
San Francisco, CA 94102
Phone: (415) 703-2881
Email: kwz@cpuc.ca.gov
Fax: (415) 703-1673

Attorney for DRA
Mitchell Shapson
Email: sha@cpuc.ca.gov
Phone: (415) 703-2727

Data Request No: DRA_SoCalGas-7 (2013)

INSTRUCTIONS

You are instructed to answer the following Data Requests, with written, verified responses per Public Utilities Code §§ 309.5 and 314, and Rules 1.1 and 10.1 of the California Public Utilities Commission's Rules of Practice and Procedure. Restate the text of each request prior to providing the response. For any questions, email the DRA contact(s) above with a copy to the DRA attorney.

Each Data Request is continuing in nature. Provide your response as it becomes available, but no later than the due date noted above. If you are unable to provide a response by this date, notify DRA as soon as possible, with a written explanation as to why the response date cannot be met and a best estimate of when the information can be provided. If you acquire additional information after providing an answer to any request, you must supplement your response following the receipt of such additional information.

Identify the person providing the answer to each data request and his/her contact information. Responses should be provided both in the original electronic format. (If available in Word format, send the Word document and do not send the information as a PDF file.) All electronic documents submitted in response to this data request should be in readable, downloadable, printable, and searchable formats, unless use of such formats is infeasible. Each page should be numbered. If any of your answers refer to or reflect calculations, provide a copy of

the supporting electronic files that were used to derive such calculations, such as Excel-compatible spreadsheets or computer programs, with data and formulas intact and functioning.

If a request, definition, or an instruction, is unclear, notify DRA as soon as possible via email. In any event, answer the request to the fullest extent possible, specifying the reason for your inability to answer the remaining portion of the Data Request.

Request:

1. Please provide copies of materials used by SoCalGas' ESA outreach specialists regarding SoCalGas' "Ways to Save" audit tool. Please provide evidence of ESA participants utilization of the SoCalGas "Ways to Save" audit tool.

2. Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

3. Please provide documentation of SoCalGas' integrated Multi-family program that it has developed in conjunction with SCE, as described in SoCalGas' response of November 30, 2012 to DRA Data Request 3 (2012), question 3.

4. Please provide written results of the Integrated Multifamily Demonstration Project with LINC Housing that SoCalGas implemented in 2012. Please describe in detail how the Single Point of Contact has been further implemented in 2013. Identify the number of ESA building owners in 2013 that have interacted with a "Single Point of Contact" during their ESA service.

5. Regarding SoCalGas' 2012 Annual ESA report, Table 13, describe the category of ESA enrollment titled "Self-Certification." What authority permits self-certification in ESA? Please identify the number of ESA "self-certification" participants in multifamily (5+units) dwellings and the number of ESA "self-certification" participants in single family (including 2-4 unit) dwellings. Please list the zip codes of the ESA self-certification participants.

Questions regarding this data request should be directed to Camille Watts-Zagha at (415) 703-2881 or kwz@cpuc.ca.gov.

END OF REQUEST

A 11-05-020 SDGE Response
Data Request No: DRA_SDG&E-7 (2013)
Dated May 3, 2013
Question 2
Submitted: May 15, 2013

Question 2:

Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

SDG&E Response:

SDG&E is currently working with Pacific Gas and Electric Company, Southern California Edison Company, and Southern California Gas Company to update, simplify and make uniform a property owner waiver form and co-pay form that the utilities can utilize statewide to comply with Ordering Paragraphs 27 and 70 of D.12-08-044. Work performed to date includes a comparison and evaluation of the current fields and information captured in the utilities' forms and its legal requirements to identify similarities, differences and possible areas of integration. SoCalGas as the lead utility will draft a revised property owner waiver template for review. Subsequent implementation activities include printing of forms and training for contractors.

Please note SDG&E revised its property owner waiver form and co-pay form consistent with the recommendation found in the 2009 Process Evaluation. The revised form is currently being used until such time that the statewide forms are finalized, printed, and available for use.

Person Responsible for the Response: Sandra Williams

A.11-05-020 SDGE Response
Data Request No: DRA_SDG&E-2 (2012)
Dated November 13, 2012
Question 2
Submitted: November 30, 2012

Question 2:

Please provide copies of the updated property owner waiver form and co-pay form as updated in compliance with Ordering Paragraph 27 of D.12-08-044, and in compliance with Ordering Paragraph 70 (Strategy 3) of D.12-08-044.

Response to Q2:

SDG&E is currently working with Pacific Gas and Electric Company, Southern California Edison Company, and Southern California Gas Company to update, simplify and make uniform a property owner waiver form and co-pay form that the utilities can utilize statewide to comply with Ordering Paragraphs 27 and 70 of D.12-08-044.

Response Prepared by: Sandra Williams

HOW MUCH SHOULD WE TRUST DIFFERENCES-IN-DIFFERENCES ESTIMATES? *

Marianne Bertrand
Esther Duflo
Sendhil Mullainathan

This Version: June 2003

Abstract

Most papers that employ Differences-in-Differences estimation (DD) use many years of data and focus on serially correlated outcomes but ignore that the resulting standard errors are inconsistent. To illustrate the severity of this issue, we randomly generate placebo laws in state-level data on female wages from the Current Population Survey. For each law, we use OLS to compute the DD estimate of its "effect" as well as the standard error of this estimate. These conventional DD standard errors severely understate the standard deviation of the estimators: we find an "effect" significant at the 5 percent level for up to 45 percent of the placebo interventions. We use Monte Carlo simulations to investigate how well existing methods help solve this problem. Econometric corrections that place a specific parametric form on the time-series process do not perform well. Bootstrap (taking into account the auto-correlation of the data) works well when the number of states is large enough. Two corrections based on asymptotic approximation of the variance-covariance matrix work well for moderate numbers of states and one correction that collapses the time series information into a "pre" and "post" period and explicitly takes into account the effective sample size works well even for small numbers of states.

*We thank Lawrence Katz (the editor), three anonymous referees, Alberto Abadie, Daron Acemoglu, Joshua Angrist, Abhijit Banerjee, Victor Chernozhukov, Michael Grossman, Jerry Hausman, Kei Hirano, Bo Honore, Guido Imbens, Jeffrey Kling, Kevin Lang, Steven Levitt, Kevin Murphy, Ariel Pakes, Emmanuel Saez, Douglas Staiger, Robert Topel, Whitney Newey and seminar participants at Harvard, Massachusetts Institute of Technology, University of Chicago Graduate School of Business, University of California at Los Angeles, University of California Santa Barbara, Princeton University and University of Texas at Austin for many helpful comments. Tobias Adrian, Shawn Cole, and Francesco Franzoni provided excellent research assistance. We are especially grateful to Khaled for motivating us to write this paper. e-mail: marianne.bertrand@gsb.uchicago.edu; eduflo@mit.edu; mullain@mit.edu.

I. Introduction

Differences-in-Differences (DD) estimation has become an increasingly popular way to estimate causal relationships. DD estimation consists of identifying a specific intervention or *treatment* (often the passage of a law). One then compares the difference in outcomes after and before the intervention for groups affected by the intervention to the same difference for unaffected groups. For example, to identify the incentive effects of social insurance, one might first isolate states that have raised unemployment insurance benefits. One would then compare changes in unemployment duration for residents of states raising benefits to residents of states not raising benefits. The great appeal of DD estimation comes from its simplicity as well as its potential to circumvent many of the endogeneity problems that typically arise when making comparisons between heterogeneous individuals (see Meyer [1995] for an overview).

Obviously, DD estimation also has its limitations. It is appropriate when the interventions are as good as random, conditional on time and group fixed effects. Therefore, much of the debate around the validity of a DD estimate typically revolves around the possible endogeneity of the interventions themselves.[1] In this paper, we address an altogether different problem with DD estimation. We assume away biases in estimating the intervention's effect and instead focus on issues relating to the *standard error* of the estimate.

DD estimates and their standard errors most often derive from using Ordinary Least Squares (OLS) in repeated cross-sections (or a panel) of data on individuals in treatment and control groups for several years before and after a specific intervention. Formally, let Y_{ist} be the outcome of interest for individual i in group s (such as a state) by time t (such as a year) and I_{st} be a dummy for whether the intervention has affected group s at time t.[2] One then typically estimates the following regression using OLS:

$$Y_{ist} = A_s + B_t + c\,X_{ist} + \beta\,I_{st} + \epsilon_{ist}, \tag{1}$$

where A_s and B_t are fixed effects for states and years respectively, X_{ist} are relevant individual

[1] See Besley and Case [2000]. Another prominent concern has been whether DD estimation ever isolates a specific behavioral parameter. See Heckman [2000] and Blundell and MaCurdy [1999]. Abadie [2000] discusses how well the comparison groups used in non-experimental studies approximate appropriate control groups. Athey and Imbens [2002] critique the linearity assumptions used in DD estimation and provide a general estimator that does not require such assumptions.

[2] For simplicity of exposition, we will often refer to interventions as laws, groups as states and time periods as years. This discussion of course generalizes to other types of DD estimates.

controls and ϵ_{ist} is an error term. The estimated impact of the intervention is then the OLS estimate $\hat{\beta}$. Standard errors used to form confidence interval for $\hat{\beta}$ are usually OLS standard errors, sometimes corrected to account for the correlation of shocks within each state-year cell.[3] This specification is a common generalization of the most basic DD set-up (with two periods and two groups), which is valid only under the very restrictive assumption that changes in the outcome variable over time would have been exactly the same in both treatment and control groups in the absence of the intervention.

In this paper, we argue that the estimation of equation (1) is in practice subject to a possibly severe serial correlation problem. While serial correlation is well understood, it has been largely ignored by researchers using DD estimation. Three factors make serial correlation an especially important issue in the DD context. First, DD estimation usually relies on fairly long time series. Our survey of DD papers, which we discuss below, finds an average of 16.5 periods. Second, the most commonly used dependent variables in DD estimation are typically highly positively serially correlated. Third, and an intrinsic aspect of the DD model, the treatment variable I_{st} changes itself very little within a state over time. These three factors reinforce each other so that the standard error for $\hat{\beta}$ could severely understate the standard deviation of $\hat{\beta}$.

To assess the extent of this problem, we examine how DD performs on placebo laws, where treated states and year of passage are chosen at random. Since these laws are fictitious, a significant "effect" at the 5 percent level should be found roughly 5 percent of the time. In fact, we find dramatically higher rejection rates of the null hypothesis of no effect. For example, using female wages (from the Current Population Survey) as a dependent variable and covering 21 years of data, we find a significant effect at the 5 percent level in as much as 45 percent of the simulations. Similar rejection rates arise in two Monte Carlo studies.[4]

[3] This correction accounts for the presence of a common random effect at the state-year level. For example, economic shocks may affect all individuals in a state on an annual basis [Moulton 1990, Donald and Lang 2001]. Ignoring this grouped data problem can lead to inconsistent standard errors. In most of what follows, we will assume that the researchers estimating equation (1) have already accounted for this problem, either by allowing for appropriate random group effects or, as we do, by collapsing the data to a higher level of aggregation (such as state-year cells). For a broader discussion of inference issues in models with grouped errors, see Wooldridge [2002, 2003].

[4] In the first Monte Carlo study, the data generating process is the state-level empirical distribution that puts probability 1/50 on each of the 50 states' observations in the CPS. As the randomization is at the state level, this preserves the within-state autocorrelation structure. In the second Monte Carlo study, the data generating process is an AR(1) with normal disturbances.

We then use Monte Carlo simulations to investigate how several alternative estimation techniques help solve this serial correlation problem. We show that simple parametric corrections which estimate specific data generating processes (such as an AR(1)) fare poorly. A nonparametric technique, block bootstrap, performs well when the number of states is large enough. Two simpler techniques also perform well. First, one can remove the time series dimension by aggregating the data into two periods: pre- and post-intervention. If one adjusts the t-statistics for the small number of observations in the regression, this correction works well even when the number of groups is relatively small (e.g. 10 states). Second, one can allow for an unrestricted covariance structure over time within states, with or without making the assumption that the error terms in all states follow the same process. This technique works well when the number of groups is large (e.g. 50 states) but fare more poorly as the number of groups gets small.

The remainder of this paper proceeds as follows. Section II surveys existing DD papers. Section III examines how DD performs on placebo laws. Section IV describes how alternative estimation techniques help solve the serial correlation problem. We conclude in Section V.

II. A Survey of DD Papers

Whether serial correlation has led to serious over-estimation of t-statistics and significance levels in the DD literature so far depends on: (1) the typical length of the time series used, (2) the serial correlation of the most commonly used dependent variables; and (3) whether any procedures have been used to correct for it [Greene 2002]. Since these factors are inherently empirical, we collected data on all DD papers published in 6 journals between 1990 and 2000.[5] We classified a paper as "DD" if it focuses on specific interventions and uses units unaffected by the law as a control group.[6] We found 92 such papers.

Table I summarizes the number of time periods, the nature of the dependent variable, and the technique(s) used to compute standard errors in these papers. Sixty-nine of the 92 DD papers used more than two periods of data. Four of these papers began with more than two periods but

[5] The journals are the *the American Economic Review*, *the Industrial and Labor Relations Review*, *the Journal of Labor Economics*, *the Journal of Political Economy*, *the Journal of Public Economics*, and *the Quarterly Journal of Economics*.

[6] Hence, for example, we do not classify a paper that regresses wages on unemployment as a DD paper (even though it might suffer from serial correlation issues as well).

collapsed the data into two effective periods: before and after. For the remaining 65 papers, the average number of periods used is 16.5 and the median is 11. More than 75 percent of the papers use more than 5 periods of data.[7]

The most commonly used variables are employment and wages. Other labor market variables, such as retirement and unemployment also receive significant attention, as do health outcomes. Most of these variables are clearly highly auto-correlated. For example, Blanchard and Katz [1992] find strong persistence in shocks to state employment, wages and unemployment. Interestingly, first-differenced variables, which likely exhibit negative auto-correlation, are quite uncommon in DD papers.

A vast majority of the surveyed papers do not address serial correlation at all. Only 5 papers explicitly deal with it. Of these, 4 use a parametric AR(k) correction. As we will see later on, this correction does very little in practice in the way of correcting standard errors. The fifth allows for an arbitrary variance-covariance matrix within each state, one of the solutions we suggest in Section IV.

Two additional points are worth noting. First, 80 of the original 92 DD papers have a potential problem with grouped error terms as the unit of observation is more detailed than the level of variation (a point discussed by Donald and Lang [2001]). Only 36 of these papers address this problem, either by clustering standard errors or by aggregating the data. Second, several techniques are used (more or less informally) for dealing with the possible endogeneity of the intervention variable. For example, 3 papers include a lagged dependent variable in equation (1), 7 include a time trend specific to the treated states, 15 plot some graphs to examine the dynamics of the treatment effect, 3 examine whether there is an "effect" before the law, 2 test whether the effect is persistent, and 11 formally attempt to do triple-differences (DDD) by finding another control group. In Bertrand, Duflo and Mullainathan [2002], we show that most of these techniques do not alleviate the serial correlation issues.

[7] The very long time series reported, such as 51 or 83 at the 95th and 99th percentile respectively, arise because several papers used monthly or quarterly data. When a paper used several data sets with different time spans, we only recorded the shortest span.

III. Over-Rejection in DD Estimation

The survey above suggests that most DD papers may report standard errors that understate the standard deviation of the DD estimator, but it does not help quantify how large the inference problem might be. To illustrate the magnitude of the problem, we turn to a specific data set: a sample of women's wages from the Current Population Survey (CPS).

We extract data on women in their fourth interview month in the Merged Outgoing Rotation Group of the CPS for the years 1979 to 1999. We focus on all women between the ages 25 and 50. We extract information on weekly earnings, employment status, education, age, and state of residence. The sample contains nearly 900,000 observations. We define wage as log(weekly earnings). Of the 900,000 women in the original sample, approximately 540,000 report strictly positive weekly earnings. This generates (50*21=1050) state-year cells, with each cell containing on average a little more than 500 women with strictly positive earnings.

The correlogram of the wage residuals is informative. We estimate first, second and third auto-correlation coefficients for the mean state-year residuals from a regression of wages on state and year dummies (the relevant residuals since DD includes these dummies). The auto-correlation coefficients are obtained by a simple OLS regression of the residuals on the corresponding lagged residuals. We are therefore imposing common auto-correlation parameters for all states. The estimated first order auto-correlation coefficient is 0.51, and is strongly significant. The second and third order auto-correlation coefficients are high (0.44 and 0.33 respectively) and statistically significant as well. They decline much less rapidly than one would expect if the data generating process was a simple AR(1).[8][9]

To quantify the problem induced by serial correlation in the DD context, we randomly generate

[8] Solon [1984] points out that in panel data, when the number of time periods is fixed, the estimates of the auto-correlation coefficients obtained using a simple OLS regression are biased. Using Solon's generalization of Nickell's [1981] formula for the bias, the first order auto-correlation coefficient of 0.51 we estimate with 21 time periods would correspond to a true auto-correlation coefficient of 0.6 if the data generating process were an AR(1). However, Solon's formulas also imply that the second and third order auto-correlation coefficients would be much smaller than the coefficients we observe if the true data generating process were an AR(1) process with an auto-correlation coefficient of 0.6. To match the estimated second and third order auto-correlation parameters, the data would have to follow an AR(1) process with an auto-correlation coefficient of 0.8.

[9] The small sample sizes in each state-year cell can lead to large sampling error and lower serial correlation in the CPS than in other administrative data. See, for example, Blanchard and Katz [1997]. Sampling error may also contribute to complicating the auto-correlation process, making it for example a combination of AR(1) and white noise.

laws that affect some states and not others. We first draw a year at random from a uniform distribution between 1985 and 1995.[10] Second, we select exactly half the states (25) at random and designate them as "affected" by the law. The intervention variable I_{st} is then defined as a dummy variable which equals 1 for all women that live in an affected state after the intervention date, 0 otherwise.[11]

We can then estimate equation (1) using OLS on these placebo laws. The estimation generates an estimate of the law's "effect" and a standard error for this estimate. To understand how well conventional DD performs, we can repeat this exercise a large number of times, each time drawing new laws at random.[12]

For each of these simulations we randomly generate new laws but use the same CPS data. This is analogous to asking "If hundreds of researchers analyzed the effects of various laws in the CPS, what fraction would find a significant effect even when the laws have no effect?" If OLS were to provide consistent standard errors, we would expect to reject the null hypothesis of no effect ($\beta = 0$) roughly 5 percent of the time when we use a threshold of 1.96 for the absolute t-statistic.[13]

The first row of Table II presents the result of this exercise when performed in the CPS micro data, without any correction for grouped error terms. We estimate equation (1) for at least 200 independent draws of placebo laws. The control variables X_{ist} include 4 education dummies (less than high school, high school, some college and college or more) and a quartic in age as controls. We report the fraction of simulations in which the absolute value of the t-statistic was greater than 1.96. We find that the null of no effect is rejected a stunning 67.5 percent of the time.

One important reason for this gross over-rejection is that the estimation fails to account for correlation within state-year cells (Donald and Lang [2001], Moulton [1990]). In other words, OLS assumes that the variance-covariance matrix for the error term is diagonal while in practice it might

[10] We choose to limit the intervention date to the 1985-1995 period to ensure having enough observations prior and post intervention.

[11] We have tried several alternative placebo interventions (such as changing the number of "affected" states or allowing for the laws to be staggered over time) and found similar effects. See Bertrand, Duflo and Mullainathan [2002] for details.

[12] This exercise is similar in spirit to the randomly generated instruments in Bound, Jaeger and Baker [1995]. Also, if true laws were randomly assigned, the distribution of the parameter estimates obtained using these placebo laws could be used to form a randomization inference test of the significance of the DD estimate [Rosenbaum [1996].

[13] Note that we are randomizing the treatment variable while keeping the set of outcomes fixed. In general, the distribution of the test statistic induced by such randomization is not a standard normal distribution and, therefore, the exact rejection rate we should expect is not known. We directly address this issue below by turning to a more formal Monte Carlo study.

be block diagonal, with correlation of the error terms within each state-year cell. As noted earlier, while 80 of the papers we surveyed potentially suffer from this problem, only 36 correct for it. In rows 2 and 3, we account for this issue in two ways. In row 2, we allow for an arbitrary correlation of the error terms at the state-year level. We still find a very high (44 percent) rejection rate.[14] In row 3, we aggregate the data into state-year cells to construct a panel of 50 states over 21 years and then estimate the analogue of equation (1) on this data.[15] Here again, we reject the null of no effect in about 44 percent of the regressions. So correlated shocks within state-year cells explain only part of the over-rejection we observe in row 1.

In the exercise above, we randomly assigned laws over a fixed set of state outcomes. In such a case, the exact rejection rate we should expect is not known, and may be different from 5 percent even for a correctly sized test. To address this issue, we perform a Monte Carlo study where the data generating process is the state-level empirical distribution of the CPS data. Specifically, for each new simulation, we sample states *with replacement* from the CPS, putting probability 1/50 on each of the 50 states. Because we sample entire state vectors, this preserves the within-state autocorrelation of outcomes. In each sample, we then randomly pick half of the states to be "treated" and randomly pick a treatment year (as explained above).

The results of this Monte Carlo study (row 4) are very similar to the results obtained in the first exercise we conducted: OLS standard errors lead to reject the null hypothesis of no effect at the 5 percent significance level in 49 percent of the cases.[16] To facilitate the interpretation of the rejection rates, all the CPS results presented below are based on such Monte Carlo simulations using the state-level empirical distribution of the CPS data.

We have so far focused on Type I error. A small variant of the exercise above allows us to assess

[14] Practically, this is implemented by using the "cluster" command in STATA. We also applied the correction procedure suggested in Moulton [1990]. That procedure forces a constant correlation of the error terms at the state-year level, which puts structure on the intra-cluster correlation matrices and may therefore perform better in finite samples. This is especially true when the number of clusters is small (if in fact the assumption of a constant correlation is a good approximation). The rate of rejection of the null hypothesis of no effect was not statistically different under the Moulton technique.

[15] To aggregate, we first regress individual log weekly earnings on the individual controls (education and age) and form residuals. We then compute means of these residuals by state and year: $\bar{Y}_{st}$. On this aggregated data, we estimate $\bar{Y}_{st} = \alpha_s + \gamma_t + \beta\, I_{st} + \epsilon_{st}$. The results do not change if we also allow for heteroskedasticity when estimating this equation.

[16] We have also run simulations where we fix the treatment year across all simulations (unpublished appendix available from the authors). The rejections rates do not vary much from year to year, and remain above 30 percent in every single year.

Type II error, or power against a specific alternative. After constructing the placebo intervention, I_{st}, we can replace the outcome in the CPS data by the outcome plus I_{st} times whichever effect we wish to simulate. For example, we can replace log(weekly earnings) by log(weekly earnings) plus $I_{st} \times .0x$ to generate a true $.0x$ log point (approximately x percent) effect of the intervention. By repeatedly estimating DD in this altered data (with new laws randomly drawn each time) and counting rejections, we can assess how often DD rejects the null of no effect under a specific alternative.[17] Under the alternative of a 2 percent effect, OLS rejects the null of no effect in 66 percent of the simulations (row 4, last column).

The high rejection rate is due to serial correlation, as we document in the next rows of Table II. As we discussed earlier, an important factor is the serial correlation of the intervention variable I_{st} itself. In fact, if the intervention variable were not serially correlated, OLS standard errors should be consistent. To illustrate this point, we construct a different type of intervention which eliminates the serial correlation problem. As before, we randomly select half of the states to form the treatment group. However, instead of randomly choosing one date after which all the states in the treatment group are affected by the law, we randomly select 10 dates between 1979 and 1999. The law is now defined as 1 if the observation relates to a state that belongs to the treatment group at one of these 10 dates, 0 otherwise. In other words, the intervention variable is now repeatedly turned on and off, with its value in one year telling us nothing about its value the next year. In row 5, we see that the null of no effect is now rejected in only 5 percent of the cases.

Further evidence is provided in rows 6 through 8. Here we repeat the Monte Carlo study (as in row 4) for three different variables in the CPS: employment, hours and change in log wages. We report estimates of the first, second and third order auto-correlation coefficients for each of these variables. As we see, the over-rejection problem diminishes with the serial correlation in the dependent variable. As expected, when the estimate of the first-order auto-correlation is negative (row 8), we find that OLS lead us to reject the null of no effect in *less* than 5 percent of the simulations.

This exercise using the CPS data illustrates the severity of the problem in a commonly used

[17] It is important to note that the "effect" we generate is uniform across states. For some practical applications, one might also be interested in cases where the treatment effect is heterogeneous.

data set. However, one might be concerned that we are by chance detecting actual laws or other relatively discrete changes. Also, there might be other features of the CPS wage data, such as state-specific time trends, that may also give rise to over-rejection. To address this issue, we replicate our analysis in an alternative Monte Carlo study where the data generating process is an AR(1) model with normal disturbances. The data is generated so that its variance structure in terms of relative contribution of state and year fixed effects matches the empirical variance decomposition of female state wages in the CPS.[18] We randomly generate a new data set and placebo laws for each simulation. By construction, we can now be sure that there are no ambient trends and that the laws truly have no effect. In row 9, we assume that the auto-correlation parameter of the AR(1) model (ρ) equals .8. We find a rejection rate of 37 percent. In rows 10 through 14, we show that as ρ goes down, the rejection rates fall. When ρ is negative (row 14), there is under-rejection.

The results in Table II demonstrate that, in the presence of positive serial correlation, conventional DD estimation leads to gross over-estimation of t-statistics and significance levels. In addition, the magnitudes of the estimates obtained in these false rejections do not seem out of line with what is regarded in the literature as "significant" economic impacts. The average absolute value of the estimated "significant effects" in the wage regressions is about .02, which corresponds roughly to a 2 percent effect. Nearly 60 percent of the significant estimates fall in the 1 to 2 percent range. About 30 percent fall in the 2 to 3 percent range, and the remaining 10 percent are larger than 3 percent. These magnitudes are large, considering that DD estimates are often presented as elasticities. Suppose for example that the law under study corresponds to a 5 percent increase in child-care subsidy. An increase in log earnings of .02 would correspond to an elasticity of .4. Moreover, in many DD estimates, the truly affected group is often only a fraction of the treatment group, meaning that a measured 2 percent effect on the full sample would indicate a much larger effect on the truly affected sub-sample.

The stylized exercise above focused on data with 50 states and 21 time periods. Many DD papers use fewer states (or treated and control units), either because of data limitations or because of a desire to focus only on comparable controls. For similar reasons, several DD papers use fewer

[18] We choose an AR(1) process to illustrate the problems caused by auto-correlation in the context of a simple example, not because we think that such a process matches the female wage data the best.

time periods. In Table III, we examine how the rejection rate varies with these two important parameters. We rely on the Monte Carlo studies described above (state-level empirical distribution of the CPS data and AR(1) model with normal disturbances) to analyze these effects. We also report rejection rates when we add a 2 percent treatment effect to the data.

The data sets used by many researchers have fewer than 50 groups. Rows 1-4 and 10-13 show that varying the number of states does not change the extent of the over-rejection. Rows 5-9 and 14-17 vary the number of years. As expected, over-rejection falls as the time span gets shorter, but it does so at a rather slow rate. For example, even with only 7 years of data, the rejection rate is 15 percent in the CPS-based simulations. Conditional on using more than 2 periods, around 60 percent of the DD papers in our survey use at least 7 periods. With 5 years of data, the rejection rate varies between 8 percent (CPS) and 17 percent (AR(1), $\rho = 8$). When T=50, the rejection rate rises to nearly 50 percent in the simulations using an AR(1) model with ρ=.8.

IV. Solutions

In this section, we evaluate the performance of alternative estimators that have been proposed in the literature to deal with serial correlation. To do so, we use placebo interventions in the two Monte Carlo studies described above. We also evaluate the power of each estimator against the specific alternative of a 2 percent effect (we add $I_{st} * 0.02$ to the data). The choice of 2 percent as the alternative is admittedly somewhat arbitrary, but our conclusions on the relative power of each estimator do not dependent on this specific value.[19]

IV.A. Parametric Methods

A first possible solution to the serial correlation problem would be to specify an auto-correlation structure for the error term, estimate its parameters, and use these parameters to compute standard errors. This is the method that was followed in 4 of the 5 surveyed DD papers that attempted

[19] We report the power against the alternative of 2 percent because 2 percent appears as a "reasonable" size effect. Moreover, in simulated data with an AR(1) process with ρ=0.8, the rejection rate when using the *true* variance-covariance matrix is 32.5 percent when there is a 2 percent effect, which is large enough to be very different from the 5 percent rejection rate obtained under the null of no effect.

to deal with serial correlation. We implement several variations of this basic correction method in Table IV.

Row 2 performs the simplest of these parametric corrections, wherein an AR(1) process is estimated in the data, without correction for small sample bias in the estimation of the AR(1) parameter. We first estimate the first order auto-correlation coefficient of the residual by regressing the residual on its lag, and then use this estimated coefficient to form an estimate of the block-diagonal variance-covariance matrix of the residual. This technique does little to solve the serial correlation problem: the rejection rate stays high at 24 percent. The results are the same whether or not we assume that each state has its own auto-correlation parameter. The failure of this correction method is in part due to the downward bias in the estimator of the auto-correlation coefficient. As is already well understood, with short time-series, the OLS estimation of the auto-correlation parameter is biased downwards. In the CPS data, OLS estimates a first-order auto-correlation coefficient of only 0.4. Similarly, in the AR(1) model where we know that the auto-correlation parameter is .8, a $\hat{\rho}$ of .62 is estimated (row 5). However, if we impose a first-order autocorrelation of .8 in the CPS data (row 3), the rejection rate only goes down to 16 percent, a very partial improvement.

Another likely problem with the parametric correction may be that we have not correctly specified the auto-correlation process. As noted earlier, an AR(1) does not fit the correlogram of wages in the CPS. In rows 7 and 8, we use new Monte Carlo simulations to assess the effect of such a mis-specification of the autocorrelation process. In row 7, we generate data according to an AR(2) process with $\rho_1 = .55$ and $\rho_2 = .35$. These parameters were chosen because they match well the estimated first, second and third auto-correlation parameters in the wage data when we apply the formulas to correct for small sample bias given in Solon [1984]. We then correct the standard error assuming that the error term follows an AR(1) process. The rejection rate rises significantly with this mis-specification of the auto-correlation structure (30.5 percent).

In row 8, we use a data generating process that provides an even better match of the time-series properties of the CPS data: the sum of an AR(1) (with auto-correlation parameter 0.95) plus white noise (the variance of the white noise is 13 percent of the total variance of the residual). When trying to correct the auto-correlation in this data by fitting an AR(1), we reject the null of no effect

in about 39 percent of the cases.

The parametric corrections we have explored do not appear to provide an easy solution for the applied researcher.[20] Any mis-specification of the data generating process results in inconsistent standard errors and, at least without much deeper exploration into specification tests, it is difficult to find the true data generating process.[21]

We next investigate alternative techniques that make little or no specific assumption about the structure of the error term. We start by examining a simulation-based technique. We then examine three other techniques that can be more readily implemented using standard statistical packages.

IV.B. Block Bootstrap

Block bootstrap [Efron and Tibshirani, 1994] is a variant of bootstrap which maintains the auto-correlation structure by keeping all the observations that belong to the same group (e.g., state) together. In practice, we bootstrap the t-statistic as follows. For each placebo intervention, we compute the absolute t-statistic $t = abs(\hat{\beta}/SE(\hat{\beta}))$, using the OLS estimate of β and its standard error. We then construct a bootstrap sample by drawing with replacement 50 matrices ($\bar{Y}_s$,V_s), where $\bar{Y}_s$ is the entire time series of observations for state s, and V_s is the matrix of state dummies, time dummies, and treatment dummy for state s. We then run OLS on this sample, obtain an estimate $\hat{\beta}_r$ and construct the absolute t-statistic $t_r = \frac{abs(\hat{\beta}_r - \hat{\beta})}{SE(\hat{\beta}_r)}$. The sampling distribution of t_r is random and changing as N (the number of states) grows. The difference between this distribution and the sampling distribution of t becomes small as N goes to infinity, even in the presence of arbitrary auto-correlation within states and heteroskedasticity. We draw a large number (200) of bootstrap samples, and reject the hypothesis that $\beta = 0$ at a 95 percent confidence level if 95 percent of the t_r are smaller than t. The results of the block bootstrap estimation are reported in Table V.

This correction method presents a major improvement over the parametric techniques discussed

[20] We do not explore in this paper IV/GMM estimation techniques. There is however a large literature on GMM estimation of dynamic panel data models that could potentially be applied here.

[21] For example, when we use the two "reasonable" processes described above in the CPS data or in a Monte Carlo study based on the empirical distribution of the CPS data, the rejection rates remained high.

before. When N equals 50, the rejection rate of the null of no effect is 6.5 percent in data drawn from the CPS and 5 percent in data drawn from an AR(1) model. When there is a 2 percent effect, the null of no effect is rejected in 26 percent of the cases in the CPS data and in 25 percent of the cases in the AR(1) data. However, the method performs less well when the number of states declines. The rejection rate is 13 percent with 20 states and 23 percent with 10 states. The power of this test also declines quite fast. With 20 states, the null of no effect is rejected in only 19 percent of the cases when there is a 2 percent effect.

While block bootstrap provides a reliable solution to the serial correlation problem when the number of groups is large enough, this technique is rarely used in practice by applied researchers, perhaps because it is not immediate to implement.[22] We therefore now turn to three simpler correction methods.

IV.C. Ignoring Time Series Information

The first simpler method we investigate is to ignore the time series information when computing standard errors. To do this, one could simply average the data before and after the law and run equation (1) on this averaged outcome variable in a panel of length 2. The results of this exercise are reported in Table VI. The rejection rate when N equals 50 is now 5.3 percent (row 2).

Taken literally, however, this solution will work only for laws that are passed at the same time for all the treated states. If laws are passed at different times, "before" and "after" are no longer the same for each treated state and not even defined for the control states. One can however slightly modify the technique in the following way. First, one can regress Y_{st} on state fixed effects, year dummies, and any relevant covariates. One can then divide the residuals of the *treatment states only* into two groups: residuals from years before the laws, and residuals from years after the laws. The estimate of the laws' effect and its standard error can then be obtained from an OLS regression in this two-period panel. This procedure does as well as the simple aggregation (row 3 vs. row 2) for laws that are all passed at the same time. It also does well when the laws are staggered over

[22] Implementing block bootstrap does require a limited amount of programming. The codes generated for this study are available upon request.

time (row 4).[23]

When the number of states is small, the t-statistic needs to be adjusted to take into account the smaller number of observations (see Donald and Lang [2001] for a discussion of inference in small-sample aggregated data set). When we do that, simple aggregation continues to perform well, even for quite small numbers of states. Residual aggregation performs a little worst, but the over-rejection remains relatively small. For example, for 10 states, the rejection rate is 5.3 percent under the simple aggregation method (row 10) and about 9 percent under the residual aggregation method (row 11).

The downside of these procedures (both raw and residual aggregation) is that their power is quite low and diminishes fast with sample size. In the CPS simulations with a 2 percent effect, simple aggregation rejects the null only 16 percent of the time with 50 states (row 2), 8.8 percent of time with 20 states (row 6), and 6.5 percent of the time with 10 states (row 10).

IV.D. Empirical Variance-Covariance Matrix

As we have seen in Section IV.A, parametric corrections seem to fail in practice. However, the parametric techniques discussed above did not make use of the fact that we have a large number of states that can be used to estimate the auto-correlation process in a more flexible fashion. Specifically, suppose that the auto-correlation process is the same across all states and that there is no cross-sectional heteroskedasticity. In this case, if the data is sorted by states and (by decreasing order of) years, the variance-covariance matrix of the error term is block diagonal, with 50 identical blocks of size T by T (where T is the number of time periods). Each of these blocks is symmetric, and the element $(i, i+j)$ is the correlation between ϵ_i and ϵ_{i-j}. We can therefore use the variation across the 50 states to estimate each element of this matrix, and use this estimated matrix to compute standard errors. Under the assumption that there is no heteroskedasticity, this method will produce consistent estimates of the standard error as N (the number of groups) goes to infinity (Kiefer [1980]).

[23] To generate staggered laws, we randomly choose half of the states to form the treatment group and randomly choose a passage date (uniformly drawn between 1985 and 1995) separately for each state in the treatment group.

Table VII investigates how well this technique performs in practice in the CPS and AR(1) Monte Carlo studies. The method performs well when the number of states is large (N=50). The rejection rate we obtain in this case is 5.5 percent in the CPS (row 2) and 7 percent in the Monte Carlo simulations (row 9). Its power when N=50 is comparable to the power of the block bootstrap method. In the Monte Carlo study based on the empirical distribution of the CPS, we reject the null of no effect in 24 percent of the simulations when there is a 2 percent effect.

However, as Table VII also indicates, this method performs more poorly for small sample sizes. As the number of states drop, the rejection rate of the null of no effect increases. For N=10, this correction method leads us to reject the null of no effect in 8 percent of the cases; for N=6, the rejection rate is 15 percent.

IV.E. Arbitrary Variance-Covariance Matrix

One obvious limitation of the empirical variance-covariance matrix method discussed above is that it is only consistent under the assumption of cross-sectional homoskedasticity, an assumption that is likely to be violated in practice for many data sets. However, this method can be generalized to an estimator of the variance-covariance matrix which is consistent in the presence of *any* correlation pattern within states over time. Of course, we cannot consistently estimate each element of the variance-covariance matrix in this case, but we can use a generalized White-like formula to compute the standard errors (White [1984], Arellano [1987] and Kezdi [2002]).[24] This estimator for the variance-covariance matrix is given by:

$$W = (V'V)^{-1} \left(\sum_{j=1}^{N} u_j' u_j \right) (V'V)^{-1}$$

where N is the total number of states, V is matrix of independent variables (year dummies, state dummies and treatment dummy) and u_j is defined for each state to be:

$$u_j = \sum_{t=1}^{T} e_{jt} v_{jt}$$

[24] This is analogous to applying the Newey-West correction (Newey and West [1987]) in the panel context where we allow for all lags to be potentially important.

where e_{jt} is the estimated residual for state i at time t and v_{jt} is a row vector of dependent variables (including the constant).[25] This estimator of the variance-covariance matrix is consistent for fixed panel length as the number of states tends to infinity [Kezdi 2002].[26]

In Table VIII, we investigate how well this estimation procedure performs in practice in finite samples. Despite its generality, the arbitrary variance-covariance matrix does quite well. The rejection rate in data drawn CPS is 6.3 percent when N=50 (row 2). With respect to power, we saw in Tables II and IV that with the correct covariance matrix, the rejection rate in the case of a 2 percent effect was 78 percent in a Monte Carlo simulation with no auto-correlation and 32 percent in AR(1) data with $\rho = .8$. The arbitrary variance-covariance matrix comes near these upper-bounds, achieving rejection rates of 74 percent (row 10) and 27.5 percent (row 9) respectively.

Again, however, rejection rates increase significantly above 5 percent when the number of states declines: 11.5 percent with 6 states (row 8), 8 percent with 10 states (row 6). The extent of the over-rejection in small samples is comparable to that obtained for the empirical variance-covariance matrix correction method, less extreme than with block bootstrap, but higher than with the time series aggregation.

IV.F. Summary

Based on Monte Carlo simulations, this section has reviewed the performance of several standard correction methods for serial correlation. The results we obtain are in accord with the previous literature. First, "naive" parametric corrections, which do not take into account the bias in the estimation of the auto-correlation parameters in short time series, perform poorly (Nickell [1981]). Furthermore, the time series lengths typical to DD applications are generally too short to reliably estimate more flexible data generating processes and mis-specification of the process leads to inconsistent standard errors (Greene [2002]).

Second, the arbitrary and empirical variance-covariance matrix corrections perform well in large

[25] This is implemented in a straightforward way by using the cluster command in STATA and choosing entire states (and not only state-year cells) as clusters.

[26] Note that the resulting variance-covariance matrix is of rank $TN - N$. The standard error of the coefficient of the state dummies is not identified in this model. However the other terms of the variance-covariance matrix are identified and consistently estimated as N goes to infinity.

samples, but not as well when the number of groups becomes small. The small sample bias in the White standard errors were already noted in MacKinnon and White [1985], who perform Monte Carlo simulations of this estimator, as well as of alternative estimators with better finite sample properties. Also, Bell and McAffrey [2002] compute the small sample bias of the White standard errors. They show that this bias is larger for variables that are constant or nearly constant within cluster (which is the case of the treatment variables in the DD model). Kezdi [2002] performs Monte Carlo simulations to evaluate the small sample properties of the Huber-White and the empirical variance-covariance estimators of the standard errors in a fixed effect model with serial correlation. Both estimators perform well in finite sample when N equals 50, but are biased when N equals 10.

Finally, aggregating the time series information performs well even for small number of states, which reflects the fact that the significance threshold can be adjusted for the small effective sample size (Donald and Lang [2001]). However, these aggregation techniques have relatively low power.

V. Conclusion

Our study suggests that, because of serial correlation, conventional DD standard errors may grossly understate the standard deviation of the estimated treatment effects, leading to serious over-estimation of t-statistics and significance levels. Since a large fraction of the published DD papers we surveyed report t-statistics around 2, our results suggest that some of these findings may not be as significant as previously thought if the outcome variables under study are serially correlated. In other words, it is possible that too many false rejections of the null hypothesis of no effect have taken place.

We have investigated how several standard estimation methods help deal with the serial correlation problem in the DD context. We show that block bootstrap can be used to compute consistent standard errors when the number of groups is sufficiently large. Moreover, we show that a few techniques that are readily available in standard econometrics packages also provide viable solutions for the applied researcher. Collapsing the data into pre- and post- periods produce consistent standard errors, even when the number of states is small (though the power of this test declines fast). Allowing for an arbitrary auto-correlation process when computing the standard errors is

also a viable solution when the number of groups is sufficiently large.

We hope that our study provides some motivation for the practitioners that estimate DD models to more carefully examine residuals as well as perform simple tests of serial correlation. Because computing standard errors that are robust to serial correlation appears relatively easy to implement in most cases, it should become standard practice in applied work. We also hope that our study will contribute in generating further work on alternative estimation methods for DD models (such as GLS estimation or GMM estimation of dynamic panel data models) that could be more efficient in the presence of serial correlation.

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TABLE I
Survey of DD Papers[a]

Number of DD papers	92	
Number with more than 2 periods of data	69	
Number which collapse data into before-after	4	
Number with potential serial correlation problem	65	
Number with some serial correlation correction	5	
GLS	4	
Arbitrary variance-covariance matrix	1	
Distribution of time span for papers with more than 2 periods	**Average**	16.5
	Percentile	**Value**
	1%	3
	5%	3
	10%	4
	25%	5.75
	50%	11
	75%	21.5
	90%	36
	95%	51
	99%	83
Most commonly used dependent variables	**Number**	
Employment	18	
Wages	13	
Health/medical expenditure	8	
Unemployment	6	
Fertility/teen motherhood	4	
Insurance	4	
Poverty	3	
Consumption/savings	3	
Informal techniques used to assess endogeneity	**Number**	
Graph dynamics of effect	15	
See if effect is persistent	2	
DDD	11	
Include time trend specific to treated states	7	
Look for effect prior to intervention	3	
Include lagged dependent variable	3	
Number with potential clustering problem	80	
Number which deal with it	36	

[a]Notes: Data comes from a survey of all articles in six journals between 1990 and 2000:*the American Economic Review*; *the Industrial Labor Relations Review*; *the Journal of Labor Economics*; *the Journal of Political Economy*; *the Journal of Public Economics*; and *the Quarterly Journal of Economics*. We define an article as "Difference-in-Difference" if it: (1) examines the effect of a specific intervention and (2) uses units unaffected by the intervention as a control group.

TABLE II
DD Rejection Rates for Placebo Laws[a]

A. CPS DATA

	Data	$\hat{\rho}_1$, $\hat{\rho}_2$,$\hat{\rho}_3$	Modifications	Rejection Rate No Effect	Rejection Rate 2% Effect
1)	CPS micro, log wage			.675	.855
				(.027)	(.020)
2)	CPS micro, log wage		Cluster at state-year level	.44	.74
				(.029)	(.025)
3)	CPS agg, log wage	.509, .440, .332		.435	.72
				(.029)	(.026)
4)	CPS agg, log wage	.509, .440, .332	Sampling w/ replacement	.49	.663
				(.025)	(.024)
5)	CPS agg, log wage	.509, .440, .332	Serially uncorrelated laws	.05	.988
				(.011)	(.006)
6)	CPS agg, employment	.470, .418, .367		.46	.88
				(.025)	(.016)
7)	CPS agg, hours worked	.151, .114, .063		.265	.280
				(.022)	(.022)
8)	CPS agg, changes in log wage	-.046, .032, 002		0	.978
					(.007)

B. MONTE CARLO SIMULATIONS WITH SAMPLING FROM AR(1) DISTRIBUTION

	Data	ρ	Modifications	Rejection Rate No Effect	Rejection Rate 2% Effect
9)	AR(1)	.8		.373	.725
				(.028)	(.026)
10)	AR(1)	0		.053	.783
				(.013)	(.024)
11)	AR(1)	.2		.123	.738
				(.019)	(.025)
12)	AR(1)	.4		.19	.713
				(.023)	(.026)
13)	AR(1)	.6		.333	.700
				(.027)	(.026)
14)	AR(1)	$-.4$		.008	.7
				(.005)	(.026)

[a]Notes:

a. Unless mentioned otherwise under "Modifications," reported in the last two columns are the OLS rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is at least 200 and typically 400.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. In rows 3 to 8 of Panel A, data are aggregated to state-year level cells after controlling for demographic variables (4 education dummies and a quartic in age). For each simulation in rows 1 through 3, we use the observed CPS data. For each simulation in rows 4 through 8, the data generating process is the state-level empirical distribution of the CPS data that puts a probability of 1/50 on the different states' outcomes (see text for details). For each simulation in Panel B, the data generating process is an AR(1) model with normal disturbances chosen to match the CPS state female wage variances (see text for details). $\hat{\rho}_i$ refer to the estimated auto-correlation parameter of lag i. ρ refers to the auto-correlation parameter in the AR(1) model.

c. All regressions include, in addition to the intervention variable, state and year fixed effects. The individual level regressions also include demographic controls.

d. Standard errors are in parenthesis and are computed using the number of simulations.

TABLE III
Varying N and T[a]

	Data	N	T	Rejection Rate No Effect	Rejection Rate 2% Effect
	A. CPS DATA				
1)	CPS aggregate	50	21	.49	.663
				(.025)	(.024)
2)	CPS aggregate	20	21	.39	.54
				(.024)	(.025)
3)	CPS aggregate	10	21	.443	.510
				(.025)	(.025)
4)	CPS aggregate	6	21	.383	.433
				(.025)	(.025)
5)	CPS aggregate	50	11	.20	.638
				(.020)	(.024)
6)	CPS aggregate	50	7	.15	.635
				(.017)	(.024)
7)	CPS aggregate	50	5	.078	.5
				(.013)	(.025)
8)	CPS aggregate	50	3	.048	.363
				(.011)	(.024)
9)	CPS aggregate	50	2	.055	.28
				(.011)	(.022)
	B. MONTE CARLO SIMULATIONS WITH SAMPLING FROM AR(1) DISTRIBUTION				
10)	AR(1), ρ=.8	50	21	.35	.638
				(.028)	(.028)
11)	AR(1), ρ=.8	20	21	.35	.538
				(.028)	(.029)
12)	AR(1), ρ=.8	10	21	.3975	.505
				(.028)	(.029)
13)	AR(1), ρ=.8	6	21	.393	.5
				(.028)	(.029)
14)	AR(1), $\rho = .8$	50	11	.335	.588
				(.027)	(.028)
15)	AR(1), ρ=.8	50	5	.175	.5525
				(.022)	(.029)
16)	AR(1), ρ=.8	50	3	.09	.435
				(.017)	(.029)
17)	AR(1), ρ=.8	50	50	.4975	.855
				(.029)	(.020)

[a]Notes:

a. Reported in the last two columns are the OLS rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells after controlling for the demographic variables (4 education dummies and a quartic in age). For each simulation in Panel A, the data generating process is the state-level empirical distribution of the CPS data that puts a probability of 1/50 on the different states' outcomes (see text for details). For each simulation in Panel B, the data generating process is an AR(1) model with normal disturbances chosen to match the CPS state female wage variances (see text for details). ρ refers to the auto-correlation parameter in the AR(1) data generating process.

c. All regressions also include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

e. N refers to the number of states used in the simulation and T refers to the number of years.

TABLE IV
Parametric Solutions[a]

	Data	Technique	Estimated $\hat{\rho}_1$	Rejection Rate No Effect	Rejection Rate 2% Effect
		A. CPS DATA			
1)	CPS aggregate	OLS		.49	.663
			(.025)	(.024)	
2)	CPS aggregate	Standard AR(1) correction	.381	.24	.66
				(.021)	(.024)
3)	CPS aggregate	AR(1) correction imposing ρ=.8		.18	.363
				(.019)	(.024)
		B. OTHER DATA GENERATING PROCESSES			
4)	AR(1), ρ=.8	OLS		.373	.765
				(.028)	(.024)
5)	AR(1), $\rho = .8$	Standard AR(1) correction	.622	.205	.715
				(.023)	(.026)
6)	AR(1), $\rho = .8$	AR(1) correction imposing ρ=.8		.06	.323
				(.023)	(.027)
7)	AR(2),$\rho_1 = .55$ $\rho_2 = .35$	Standard AR(1) correction	.444	.305	.625
				(.027)	(.028)
8)	AR(1)+ white noise $\rho = .95$, noise/signal=.13	Standard AR(1) correction	.301	.385	.4
				(.028)	(.028)

[a]Notes:

a. Reported in the last two columns are the rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells, after controlling for the demographic variables (4 education dummies and a quartic in age). For each simulation in Panel A, the data generating process is the state-level empirical distribution of the CPS data that puts a probability of 1/50 on the different states' outcomes (see text for details). For each simulation in Panel B, the distributions from which the data are drawn are chosen to match the CPS state female wage variances (see text for details). "AR(1)+ white noise" is the sum of an AR(1) plus an i.i.d. process, where the auto-correlation for the AR(1) component is given by ρ and the relative variance of the components is given by the noise to signal ratio.

c. All regressions include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

e. The AR(k) corrections are implemented in stata using the "xtgls" command.

TABLE V
Block Bootstrap[a]

	Data	Technique	N	Rejection Rate No Effect	Rejection Rate 2% Effect
		A. CPS DATA			
1)	CPS aggregate	OLS	50	.43	.735
				(.025)	(.022)
2)	CPS aggregate	Block Bootstrap	50	.065	.26
				(.013)	(.022)
3)	CPS aggregate	OLS	20	.385	.595
				(.022)	(.025)
4)	CPS aggregate	Block Bootstrap	20	.13	.19
				(.017)	(.020)
5)	CPS aggregate	OLS	10	.385	.48
				(.024)	(.024)
6)	CPS aggregate	Block Bootstrap	10	.225	.25
				(.021)	(.022)
7)	CPS aggregate	OLS	6	.48	.435
				(.025)	(.025)
8)	CPS aggregate	Block Bootstrap	6	.435	.375
				(.022)	(.025)
		B. AR(1) DISTRIBUTION			
9)	AR(1), ρ=.8	OLS	50	.44	.70
				(.035)	(.032)
10)	AR(1), ρ=.8	Block Bootstrap	50	.05	.25
				(.015)	(.031)

[a]Notes:

a. Reported in the last two columns are the rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200. The bootstraps involve 400 repetitions.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells after controlling for the demographic variables (4 education dummies and a quartic in age). For each simulation, we draw each state's vector from this data with replacement. See text for details. The AR(1) distribution is chosen to match the CPS state female wage variances (see text for details).

c. All CPS regressions also include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

TABLE VI
Ignoring Time Series Data[a]

	Data	Technique	N	Rejection Rate No Effect	Rejection Rate 2% Effect
		A. CPS DATA			
1)	CPS agg	OLS	50	.49	.663
				(.025)	(.024)
2)	CPS agg	Simple aggregation	50	.053	.163
				(.011)	(.018)
3)	CPS agg	Residual aggregation	50	.058	.173
				(.011)	(.019)
4)	CPS agg, staggered laws	Residual aggregation	50	.048	.363
				(.011)	(.024)
5)	CPS agg	OLS	20	.39	.54
				(.025)	(.025)
6)	CPS agg	Simple aggregation	20	.050	.088
				(.011)	(.014)
7)	CPS agg	Residual aggregation	20	.06	.183
				(.011)	(.019)
8)	CPS agg, staggered laws	Residual aggregation	20	.048	.130
				(.011)	(.017)
9)	CPS agg	OLS	10	.443	.51
				(.025)	(.025)
10)	CPS agg	Simple aggregation	10	.053	.065
				(.011)	(.012)
11)	CPS agg	Residual aggregation	10	.093	.178
				(.014)	(.019)
12)	CPS agg, staggered laws	Residual aggregation	10	.088	.128
				(.014)	(.017)
13)	CPS agg	OLS	6	.383	.433
				(.024)	(.024)
14)	CPS agg	Simple aggregation	6	.068	.07
				(.013)	(.013)
15)	CPS agg	Residual aggregation	6	.11	.123
				(.016)	(.016)
16)	CPS agg, staggered laws	Residual aggregation	6	.09	.138
				(.014)	(.017)
		B. AR(1) DISTRIBUTION			
17)	AR(1), ρ=.8	Simple aggregation	50	.050	.243
				(.013)	(.025)
18)	AR(1), ρ=.8	Residual aggregation	50	.045	.235
				(.012)	(.024)
19)	AR(1), ρ=.8, staggered laws	Residual aggregation	50	.075	.355
				(.015)	(.028)

[a]Notes:

a. Reported in the last two columns are the rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells after controlling for demographic variables (4 education dummies and a quartic in age). For each simulation, we draw each state's vector from this data with replacement. See text for details. The AR(1) distribution is chosen to match the CPS state female wage variances (see text for details).

c. All regressions also include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

TABLE VII
Empirical Variance-Covariance Matrix[a]

	Data	Technique	N	Rejection Rate No Effect	Rejection Rate 2% Effect
	A. CPS DATA				
1)	CPS aggregate	OLS	50	.49	.663
				(.025)	(.024)
2)	CPS aggregate	Empirical variance	50	.055	.243
				(.011)	(.021)
3)	CPS aggregate	OLS	20	.39	.54
				(.024)	(.025)
4)	CPS aggregate	Empirical variance	20	.08	.138
				(.013)	(.017)
5)	CPS aggregate	OLS	10	.443	.510
				(.025)	(.025)
6)	CPS aggregate	Empirical variance	10	.105	.145
				(.015)	(.018)
7)	CPS aggregate	OLS	6	.383	.433
				(.025)	(.025)
8)	CPS aggregate	Empirical variance	6	.153	.185
				(.018)	(.019)
	B. AR(1) DISTRIBUTION				
9)	AR(1), rho=.8	Empirical variance	50	.07	.25
				(.017)	(.030)

[a]Notes:

a. Reported in the last two columns are the rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells after controlling for demographic variables (4 education dummies and a quartic age). For each simulation, we draw each state's vector from this data with replacement. See text for details. The AR(1) distribution is chosen to match the CPS state female wage variances (see text for details).

c. All regressions include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

TABLE VIII
Arbitrary Variance-Covariance Matrix[a]

	Data	Technique	N	Rejection Rate No Effect	Rejection Rate 2% Effect
	A. CPS DATA				
1)	CPS aggregate	OLS	50	.49	.663
				(.025)	(.024)
2)	CPS aggregate	Cluster	50	.063	.268
				(.012)	(.022)
3)	CPS aggregate	OLS	20	.385	.535
				(.024)	(.025)
4)	CPS aggregate	Cluster	20	.058	.13
				(.011)	(.017)
5)	CPS aggregate	OLS	10	.443	.51
				(.025)	(.025)
6)	CPS aggregate	Cluster	10	.08	.12
				(.014)	(.016)
7)	CPS aggregate	OLS	6	.383	.433
				(.024)	(.025)
8)	CPS aggregate	Cluster	6	.115	.118
				(.016)	(.016)
	B. AR(1) DISTRIBUTION				
9)	AR(1), ρ=.8	Cluster	50	.045	.275
				(.012)	(.026)
10)	AR(1), ρ=0	Cluster	50	.035	.74
				(.011)	(.025)

[a]Notes:

a. Reported in the last two columns are the rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells after controlling for the demographic variables (4 education dummies and a quartic in age). For each simulation, we draw each state's vector from this data with replacement. See text for details. The AR(1) distribution is chosen to match the CPS state female wage variances (see text for details).

c. All regressions also include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

UNPUBLISHED APPENDIX

TABLE IX
Results by Year of Law[a]

Data	Technique	Year	Rejection Rate	
			No Effect	2% Effect
CPS aggregate	OLS	1985	.453	.658
			(.025)	(.024)
CPS aggregate	OLS	1986	.42	.688
			(.025)	(.023)
CPS aggregate	OLS	1987	.5	.638
			(.025)	(.024)
CPS aggregate	OLS	1988	.43	.678
			(.025)	(.024)
CPS aggregate	OLS	1989	.44	.655
			(.025)	(.024)
CPS aggregate	OLS	1990	.48	.658
			(.025)	(.024)
CPS aggregate	OLS	1991	.438	.705
			(.025)	(.023)
CPS aggregate	OLS	1992	.383	.68
			(.024)	(.024)
CPS aggregate	OLS	1993	.31	.743
			(.023)	(.022)
CPS aggregate	OLS	1994	.433	.623
			(.025)	(.024)
CPS aggregate	OLS	1995	.328	.66
			(.024)	(.024)

[a]Notes:

a. Reported in the last two columns are the rejection rates of the null hypothesis of no effect (at the 5 percent significance level) on the intervention variable for randomly generated placebo interventions as described in text. The data used in the last column was altered to simulate a true 2 percent effect of the intervention. The number of simulations for each cell is typically 400 and at least 200. Each row represents a different fixed year for the law.

b. CPS data are data for women between 25 and 50 in the fourth interview month of the Merged Outgoing Rotation Group for the years 1979 to 1999. The dependent variable is log weekly earnings. Data are aggregated to state-year level cells after controlling for the demographic variables (4 education dummies and a quartic in age). For each simulation, we draw each state's vector from this data with replacement. See text for details.

c. All regressions also include, in addition to the intervention variable, state and year fixed effects.

d. Standard errors are in parenthesis and are computed using the number of simulations.

Southern California Edison
2015-2017 ESA-CARE App A.14-11-007

DATA REQUEST SET A.14-11-007-ORA-SCE-004 (2015)

To: ORA
Prepared by: Anthony Abeyta
Title: CARE Program Manager
Dated: 01/23/2015

Question 04.a-c & e:

High Users

a. Please provide a table that shows the number of customers in 2013 and 2014, who used 400% or more of baseline in one month, two months, or three months, more than three months, within 2013-2014 (four separate columns). Please indicate the number of verification requests sent per column, the number of non-responders per column, a number of verified ineligible and the number verified eligible per column.

Customers using 400% or more of baseline in 2013-2014	One month	Two Months	Three Months	More than Three Months
Total number of customers in each category				
Verification requests sent out				
Verified ineligible				
Verified eligible				
Non-Response				

b. Is there an administrative cost differential between verifying high users and verifying the other customers that are identified from the probability model? Please quantify the High User response to verification requests in a new table, including a breakout of response to the "sign up for ESA" requirement, in Excel table format [i.e., columns that represent:1) those that responded and are not eligible, 2) responded eligible and do not want ESA, 3)responded, are eligi ble and want ESA, 4) those who already have ESA measures, 5)non- responders.] Please use monthly 2014 data. Indicate the numbers that were de-enrolled for each column.

2014 High User Verification Results	Responded, not CARE eligible	Responded, eligible but don't want ESA	Responded, eligible, and want ESA	Eligible, ESA treated prior to verification	Non-re s
January					
February					
March and rows for rest of 2014 months					
Totals de-enrolled in 2014 per group					

c. Of the CARE high -use customers who have agreed to be treated with the ESA program after PEV, how many have decreased their energy use below the 400% baseline threshold? Are there any attempts to isolate the effects of ESA intervention? If so, describe.

e. Provide and quantify High User customer reasons (specify whether the customer gave reasons or SCE staff generated reasons) for not wanting to participate in ESA. Explain SCE's strategy and related cost to increase ESA participation by High Users.

Response to Question 04.a-c & e:

Q4a: SCE's response is in the worksheet labeled "Q4a" of the attached file. This table incorporates the revised table format prescribed in an email from Alice Glasner of ORA to John Fasana on February 2, 2015. During the development of this response, SCE recognized that the verification figures in this response are within ten percent of the data in CARE Tables 3A & 3B in the ESA and CARE monthly reports. SCE is reviewing the underlying data for both data sets and will supplement these responses if necessary.

Q4b: The administrative cost differential between a High Usage (HU) and Traditional (TR) Post Enrollment Verification (PEV) is not available, as SCE does not track TR PEV and HU PEV costs separately. The requested monthly 2014 data is included in the worksheet labeled "Q4b" of the attached file.

Q4c: As shown in attachment Q4b, 105 CARE High Usage customers agreed to be treated with the ESA Program after PEV. While the CARE High Usage customers who agreed to be treated under the ESA Program likely achieved energy reductions following treatment, all continued to have at least one month where their energy usage exceeded 400% of baseline during the monitoring period following treatment. SCE has not attempted to isolate the effects of ESA

Program intervention from other factors, including weather that affect energy usage.

Q4e: Of the 410 CARE High Usage customers shown in attachment Q4b, who responded to High-Use PEV that were CARE eligible, and did not participate in the ESA Program, the reasons given for their non-participation are shown in the table below (also in the worksheet labeled "Q4e" of the attached file):

SCE Response to Data Request A.14-11-007_ORA_SCE_007 (2015) Question 4e

Reason for High-Usage Customer Non-Participation in ESA Program	Number of Responses
ESA contractor unable to make contact	178
Unable to obtain landlord/owner authorization	94
Not interested in participating	81
Disconnected or incorrect phone numbers	33
Moved	11
Over income	10
Closed account	3
Total	410

SCE expects to increase ESA Program participation of High Usage customers by updating CARE HU PEV materials regarding ESA participation. The cost to update these materials is expected to be minimal, because such costs are already included as part of standard CARE material updates.

nths Over 4	PG&E	SCE	SDG&E
1	46296	58,300	**4,648**
2	19293	27,921	**2,634**
3	12224	19,621	**1,891**
4+	25722	48,939	**3,673**

Subtotals &	**3 or more**	**37946**	**68560**	**5564**
Percentages	**Total**	**103535**	**154781**	**12846**
	% 3 or mor	**37%**	**44%**	**43%**