Too Much Stick? Not Enough Carrot?
Testing the Presumption of Non-Compliance

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ABSTRACT

This paper reports the findings of an evaluation study of the 2006-2007 Sacramento Municipal Utility District (SMUD) Residential HVAC[1] Retrofit program. The program's savings calculations assumed that 96 percent of non-participant retrofits in their territory are not complying with California's ambitious 2005 energy code to some degree[2].

The evaluation study included comprehensive performance testing and cooling season long system monitoring of 60 program participant homes and 50 homes that had recently replaced their HVAC systems but did not participate in the program. Additionally, a telephone market survey was conducted to estimate the annual HVAC unit replacement rate in SMUD's service territory as well as to identify qualified non-participants. The evaluation team visited the building departments that have jurisdiction over SMUD's territory to determine whether non-participants identified through the survey had pulled a building permit for their HVAC unit replacement.

Using the non-participant units as a baseline, SMUD's TIER 1[3] participating units save 532 kilowatt-hours (kWh) per year. Approximately 62 of the 532 kWh/yr are attributed to equipment efficiency, and the remaining savings is ascribable to tighter ducting systems, closer to optimal refrigerant charge and system airflow, and better system sizing.

The results of the market survey show that there are approximately 7000 non-participant annual AC replacements in SMUD territory. If all of these 7000 replacements would have overall system performance similar to SMUD's TIER 1 participant units, there is a potential savings of 3,724,000 kWh per year, only accounting for a single year's savings of a single year's AC replacement population.

Introduction

Although most, if not all, jurisdictions in California require a permit for air conditioning system replacement, it is generally accepted that not all contractors pull a permit in every case (Pennington 2007). Not only is there the cost and hassle associated with acquiring a permit, but the contractor then must abide by local codes, be subject to inspection requirements, as well as the California energy code mandates. The penalty for non-compliance in many jurisdictions is

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[1] HVAC is defined as Heating, Ventilation, and Air Conditioning in general terms but in the context of the program refers to residential high efficiency package and split air conditioners and heat pumps with a capacity of five tons or less.

[2] The program savings calculations also assumed 70 percent of units require charge adjustment and 80 percent require duct sealing remediation.

[3] Program TIER 1 AC split systems units qualified with minimum system equipment efficiencies of 14 SEER and 12 EER. Program TIER 1 AC packaged units qualified with minimum system equipment efficiencies of 14 SEER and 11 EER. Program TIER 2 required higher minimum equipment efficiencies.

typically double the permit fee which does not take into account the costs of inspections and time spent during the submission process. For many contractors, this is sufficient incentive to not pull a permit for a simple AC change-out.

In 2006, the Sacramento Municipal Utility District (SMUD) revamped their residential air conditioner retrofit program, largely in response to October 2005 code revisions in California building code and the federal manufacturing requirement, effective January 2006, for residential systems to have a minimum efficiency of SEER 13. Besides requiring the homeowner to purchase higher efficiency units, the program also required duct leakage testing on the air distribution system serving the replaced units and a combination of refrigerant charge verification and system airflow verification, or thermal expansion valve (TXV) installation verification on the replaced units in order qualify for a rebate.

Typically, energy efficiency program estimates of measure level energy savings use a minimally code compliant installation for the baseline. In the case of this program, SMUD program planners used a baseline installation that was worse than code for their calculations. Their fundamental assumption was that 96 percent of the HVAC replacements in their service territory were not being permitted unless they were program participants. Diagnostic testing for HVAC replacements was a component to the 2005 revisions to California energy code, Title 24 Part 6, which program planners believed reduced the code compliance rate compared with the compliance rate prior to the revisions. Their assumed rate of compliance October 2005 Title 24, was estimated as 20 percent. Given the aggressive nature of the new AC replacement requirements, SMUD program planners then assumed that the initial reaction to the new rules would result in 80 percent of those 20 percent of replacements complying before the code changes would no longer comply, resulting in a mere 4% compliance rate. However, they acknowledged that the market research study would better determine the actual level of compliance.

A secondary assumption was that the non-permitted systems, since they were not subject to diagnostic testing, suffered performance deficiencies as a result. If correct, this meant that the non-participating baseline replacements of air conditioners in their service territory performed much worse than a minimally compliant replacement.

By assuming a baseline below code minimum, a proper impact evaluation of the program also needed to incorporate a baseline study of SMUD customers that had replaced their air conditioners in the same time period as the program participants and had not participated in the program. The baseline study component necessitated a large scale effort by the evaluation team to identify, survey, and perform diagnostic testing on a sample of non-participants in order to test the assumption of non-compliance as well as assess the performance of the non-participating HVAC unit replacements.

Background

Responding to revelatory studies that documented deficiencies in ducting systems, refrigerant charge, and airflow in residential air conditioners, the California Energy Commission included compliance paths and credits for measures addressing these deficiencies in the 2001 and 2005 code revisions (Hammarlund et al. 1992, Jump, Modera &Walker 1996, Palani, Haberl &O'Neal. 1992; Palmiter & Francisco 1994, Parker et al. 1997; Rodriguez 1995). Over these last two revision cycles, compliance paths and credits for residential space cooling added duct leakage testing and a combination of refrigerant charge and system airflow (RCA) performance testing to assure optimal system performance. The duct leakage testing component assured that duct leakage rates are below an acceptable maximum, and the RCA testing to assure that the refrigerant charge of the unit is within manufacturer specifications and the airflow of the system is sufficient.

In 2001, revisions to California's energy code, Title 24 Part 6, included a new requirement that all newly-installed central residential air conditioners and heat pumps to be 1) field tested either to verify correct refrigerant charge and system airflow or 2) be verified to have a thermostatic expansion valve (TXV). A third option was to have an air conditioner or heat pump with a SEER of 12 or greater.

In the authors' personal experience providing residential compliance documentation services, when a homeowner or contractor was confronted with the 2001 code choices of complying through high SEER, refrigerant charge and airflow testing, or TXV verification, the refrigerant charge and airflow testing option was never taken. This along with the experiences of compliance documentation professionals that we have spoken with as well as discussions with a small sample of mechanical contractors, all agreed that the compliance option of refrigerant charge and airflow testing were rarely, if ever, taken under the 2001 code, (Mowris, Blankenship & Jones 2004). When presented with the compliance options, most homeowners choose the higher efficiency unit. When questioned, their stated reasoning was that they expected this expensive system will work optimally as installed, and the test will only verify this. Thus, the refrigerant charge and airflow test did not add value to the installation in their minds. Conversely, the higher efficiency air conditioner was perceived as providing a clear and tangible benefit. Even if there was a higher incremental cost associated with a higher efficiency air conditioner, they felt as if they were getting a return on their investment that a charge and airflow test, from their perspective, did not provide. In some cases, the homeowners and contractors the authors have spoken with did opt for the TXV inspection path. The 2001 code language was vague about who was qualified to complete the TXV inspection and some installation contractors believed that they were able to perform the TXV verification themselves.

Likewise, many agreed that a only a small minority of HVAC unit replacements were not being permitted as required and the ancillary code requirements for HVAC units were being ignored in nearly all of these non-permitted replacements.

In 2005, revisions to California's energy code included a number of new features designed to reduce space conditioning energy consumption by increasing the implementation of measures that, at the time, were rarely implemented throughout the state. The individuals that championed duct testing and refrigerant charge/system airflow into code argued the benefits of these measures on societal level while acknowledging that they were not as far up on the adoption curve and might not have been as market-ready as typical codes and standards enhancements. The sub-population that had their systems tested could easily be described as "early adopters" and during the public comment process some questioned whether these measures were mature enough to be codified, as most code revision targeted more mature measures with much greater market penetration.

In the 2005 code revisions, air conditioner replacement compliance option TXV inspection could only be verified by a certified HERS rater. The single most ambitious revision to the 2005 code included duct pressurization testing requirements for the distribution systems serving the replaced systems. This standard was applied to a subset of the 16 California thermal zones (CTZ), essentially, the zones with high cooling loads, CTZ 2 and 9-16. In CTZ 2, 12, and 16 the duct pressurization tests could be avoided by installation of a natural gas furnace with an

AFUE of 92 or higher or installation or a SEER 14/EER 12 rated air conditioner or better, along with RCA testing and increased duct insulation.

Therefore, in order to comply with 2005 energy code requirement SMUD's service territory, all of it in CTZ 12, homeowners were required to have Manual J heat load calculations, and

- Duct testing to assure acceptable leakage rates with the results verified by a HERS rater
- Or a SEER 14/EER 12 rated air conditioner with either a refrigerant charge and system airflow test or TXV verification performed by a HERS rater
- Or a 92 AFUE furnace

These code revisions were considered ambitious since it was widely agreed that not all contractors were pulling building permits for air conditioner replacements before these requirements were in effect. There was some concern that adding more hurdles to the permitting process would further drive down permitting rate and as a consequence, the compliance rates for air conditioner replacements, given the somewhat complicated and costly activities and equipment needed to achieve this new compliance,

Many of HVAC contractors the authors have spoken to think of the energy code as simply a burden and pulling a permit for an AC replacement as an unnecessary bureaucratic headache with no benefit, either personal or societal. Therefore it is not surprising that many contractors and homeowner choose not to pull a permit for air conditioner and furnace replacement. The typical homeowner is replacing their space-conditioning equipment because it has failed and now they must buy another one. The mindset often is that "I am getting space conditioning equipment, which will perform the same way regardless if it is permitted or not". Since there are considerable costs to the homeowner, the homeowner believes the installed equipment to be working optimally and also believes that any testing will only verify the optimal performance of the unit. If homeowners and contractors see no added value in diagnostic testing, they will be willing to "fly under the radar" in order to avoid paying for these services with no perceived benefits.

Therefore the assumed non-compliance rate of baseline replacements in SMUD territory was important to determine since many traded off the duct testing component in favor of high efficiency furnaces. SMUD assumed that the homeowners and contractors that avoided the duct testing had similar leakage rates as non-compliant and non-permitted replacements. Likewise, since the high efficiency air conditioner package with RCA testing or TXV verification and increased duct insulation was assumed to be a less popular compliance path, most non-participating system replacements were assumed to have charge deficiencies whether they were permitted or not.

Not surprisingly most homeowners appeared to prefer the least expensive option, and one with tangible value and an associated payback. This was the high efficiency furnace path in climate zones where that path was available.

Understanding this, SMUD program designers required duct performance testing and TXV verification or RCA testing in order to be eligible for the rebate in their residential AC replacement program. These "above code" requirements assures electric savings, even if the homeowner complied with code a high efficiency furnace option, an option that trades away electric savings in favor of natural gas savings.

The Program

The SMUD Residential HVAC program has multi-tiered rebate options based on system efficiency, as shown in Figure 1. The program's Tier 1 had the minimal equipment efficiency requirement for participation and the lowest rebate. Each successive tier required more efficient equipment and, in turn, provided a greater rebate. Most participants fell into Tier 1 and Tier 2. Tier 3 was only for central split systems and Tier 4 was only for evaporative cooled condensing systems with five gallon per ton water requirement or less.

In addition to the basic equipment efficiency requirements, the participant needed to submit a copy of the building permit for the replacement work, testing verification form completed by the HERS rater (CF-4R) and, the contractor installation compliance certificate (CF-6R). These documents assured compliance with the new energy code requirements. A permit alone does not assure compliance as many building departments throughout California have been found to have issued permits for jobs with documentation indicating non-compliance. (Khawaja et al. 2007)

Figure 1. Program Requirements by Tier and Associated Rebate Amounts

Tier	SEER		EER		HSPF		TXV or RCA Required	Title 24 & Duct Sealing	Rebates
	Split	Package	Split	Package	Split	Package			A/C and H/P
1	14.0	14.0	12.0	11.0	8.5	8.0	Yes	Yes	$400
2	15.0	14.0	12.5	12.0	8.5	8.0	Yes	Yes	$500
3*	16.0	-	13.0	-	-	-	Yes	Yes	$650
4**	-	-	14.5	-	-	-	Yes	Yes	$1100

Source: Sacramento Municipal Utility District

The program has been well subscribed. According to program tracking documentation, 4424 units were rebated during 2006 with similar numbers for 2007. In 2006, SMUD drafted a request for proposals for an evaluation of this program. Since the program energy and demand savings estimates assumed a low compliance rate among the non-participant populations, a study of non-participants was necessary to establish a realistic baseline. The non-participant population consisted of single family dwelling occupants that had their air conditioners replaced in 2006 or later. A secondary research question that SMUD included in the evaluation study was the annual replacement rate of air conditioner in their service territory.

The Evaluation

The impact evaluation of the program consisted of several components and included process and market research elements. SMUD was interested in determining the approximate number of systems replaced annually in their service territory. This research question dovetailed nicely into the impact evaluation effort of on-site assessment for determination of baseline system performance. The same telephone survey used to determine annual HVAC replacement rate could be used for identification of non-participants for recruitment in the study. Nearly two thousand random calls were made to SMUD's single family electric accounts in order to identify 147 non-participants and recruit 50 for on-site measurements, with one site having two units replaced. For allowing the evaluation team to evaluate their system, customers were given $50 to compensate for their time and inconvenience and were provided an immediate summary of results from the evaluation team's diagnostic tests. Likewise, all of these diagnostics, except the duct and infiltration tests were repeated for the participant sample of 61 units at 60 homes, as one site had two rebated systems. Program documentation of the results of previously performed duct testing and infiltration tests were used to inform the analyses for the participants.

The evaluation team also visited all of the building departments with jurisdiction over SMUD service territory. Every non-participant air conditioner replacement identified in the study was cross-checked to see if a building permit was pulled for the job. Fourteen of the 51 site-assessed non-participant systems had permits, corresponding to a permitting rate of 25 percent. A source of potential bias for this estimate is that owners of permitted installations may be more likely to allow the evaluation team on-site than owners of non-permitted system. If this bias was present in the analysis, this would inflate the permitting rate estimate. Nevertheless, a 75 percent non-permitted rate is considerable and represents lost opportunities. In total, of the 147 non-participants identified through the random dial telephone survey, 49 were found to be permitted, which estimates the non-permitted rate at 67 percent.

On-site, both the participants and non-participants had their units checked to determine if the system was properly charged by measuring various refrigerant operating temperatures and pressures at steady-state, after at least 15 minutes of constant operation. Systems with TXVs have manufacturer specified targets for subcooling, which is the difference between condenser saturation temperature and the temperature of the liquid leaving the condenser. Systems without TXVs have targets for superheat, which is the temperature of the refrigerant leaving the evaporator less the saturation temperature of the evaporator. The target superheat was taken from an industry standard table based upon refrigerant type, condenser entering dry-bulb temp temperature, and evaporator entering wet-bulb temperature. The measured values were compared with the target in order to assess the refrigerant charge of the unit. No remediation of charge deficiencies were made to the tested units.

The refrigerant charge testing showed greater deficiencies in the participant sample as the majority of participant system indicated overcharge as shown in Table 1. However, a greater proportion of the non-participants did not have TXVs installed and seven of those eleven non-TXV systems were found to be undercharged. Based on laboratory testing, non-TXV systems have a much greater loss of efficiency from charge deficiency than TXV equipped systems (Davis, 2001a, Davis 2001b).

Table 1. Charge Assessment of the Tested Systems

Study Group	Sample Size	Low Charge	Proper Charge	High Charge
Participants	57	4%	35%	61%
Non-Participants	45	29%	42%	29%

Participant and non-participant system airflow was measured using a TrueFlow™ orifice plate flow grid and DG-700 differential pressure gauge from Energy Conservatory. Figure 2 shows measured system airflow versus the airflow needed to be minimally compliant with the Title 24 testing criterion, 400 cfm per ton of the nominal rated cooling capacity. All points below the line shown represent sites with measured airflow lower than the minimally compliant value. Those points above the line have measured airflows above the minimally compliant value. From the graph, it appears that many of the participant systems may have taken the TXV verification option, as many systems had inadequate airflow that would not have passed an airflow verification test. The non-participant sample had very few systems above the minimally compliant range; this shows that the participants have better airflow compliance on the whole. However, overall the average rates of normalized system airflow for participants and non-participants were quite similar, 347 and 339 cfm per ton, respectively.

Figure 2a. Participant System Airflow Results

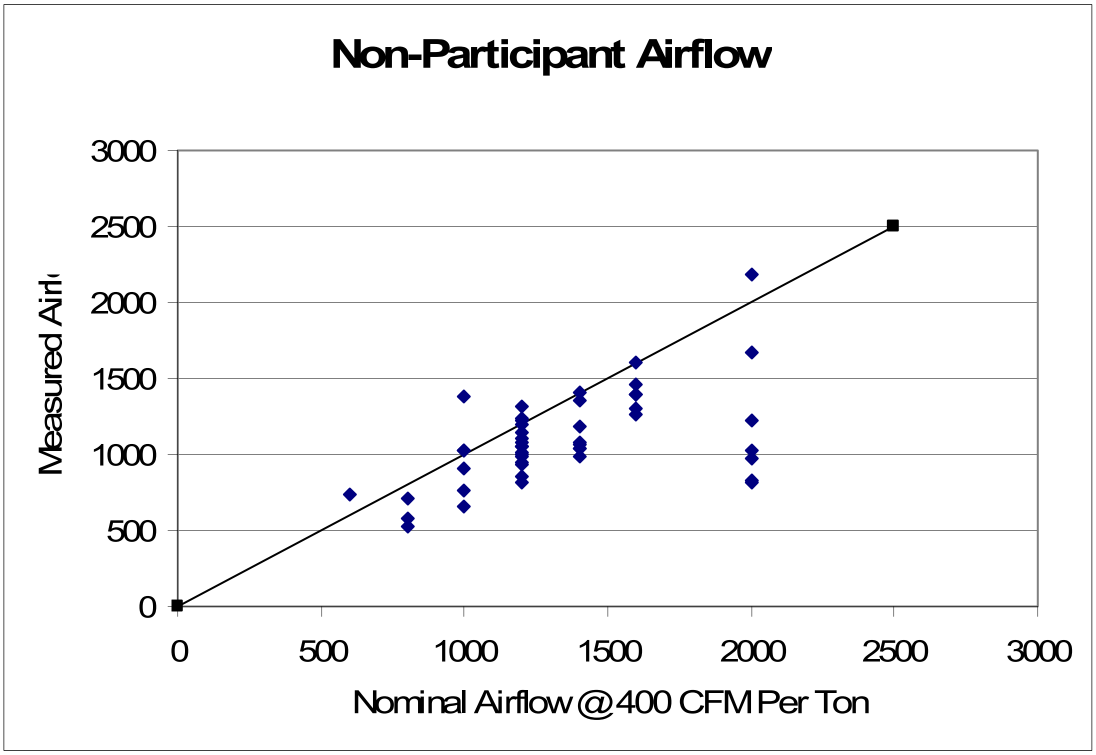
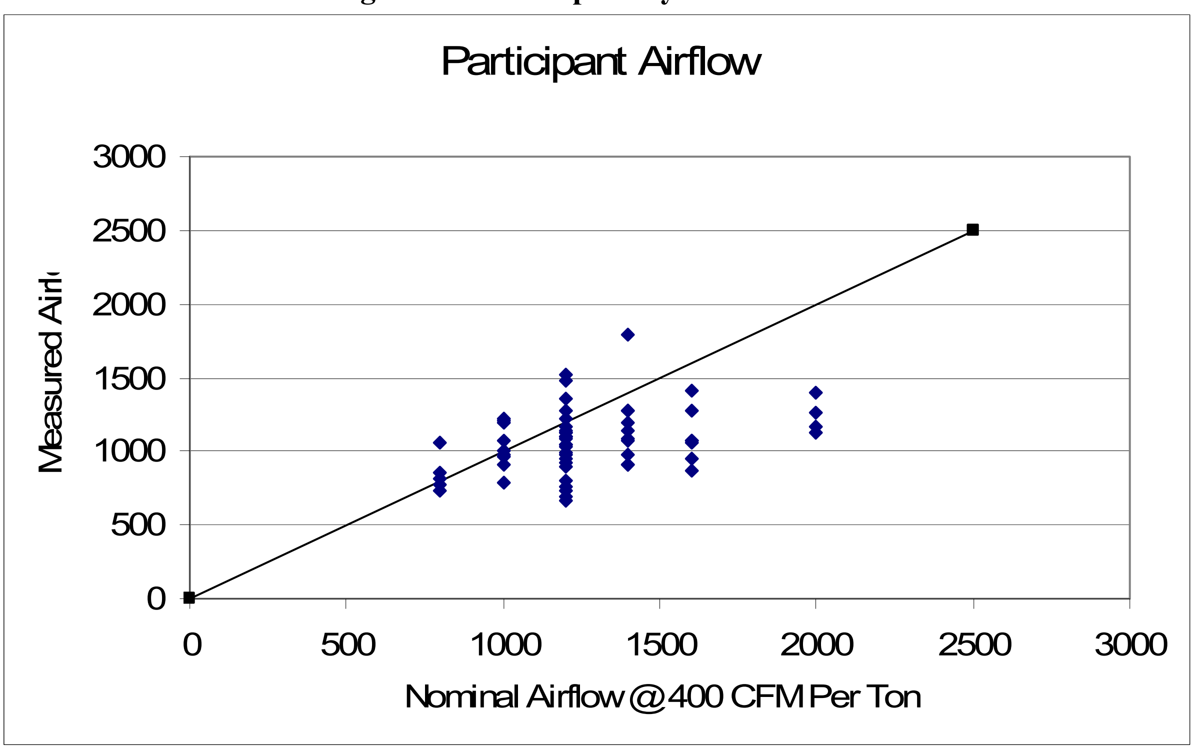
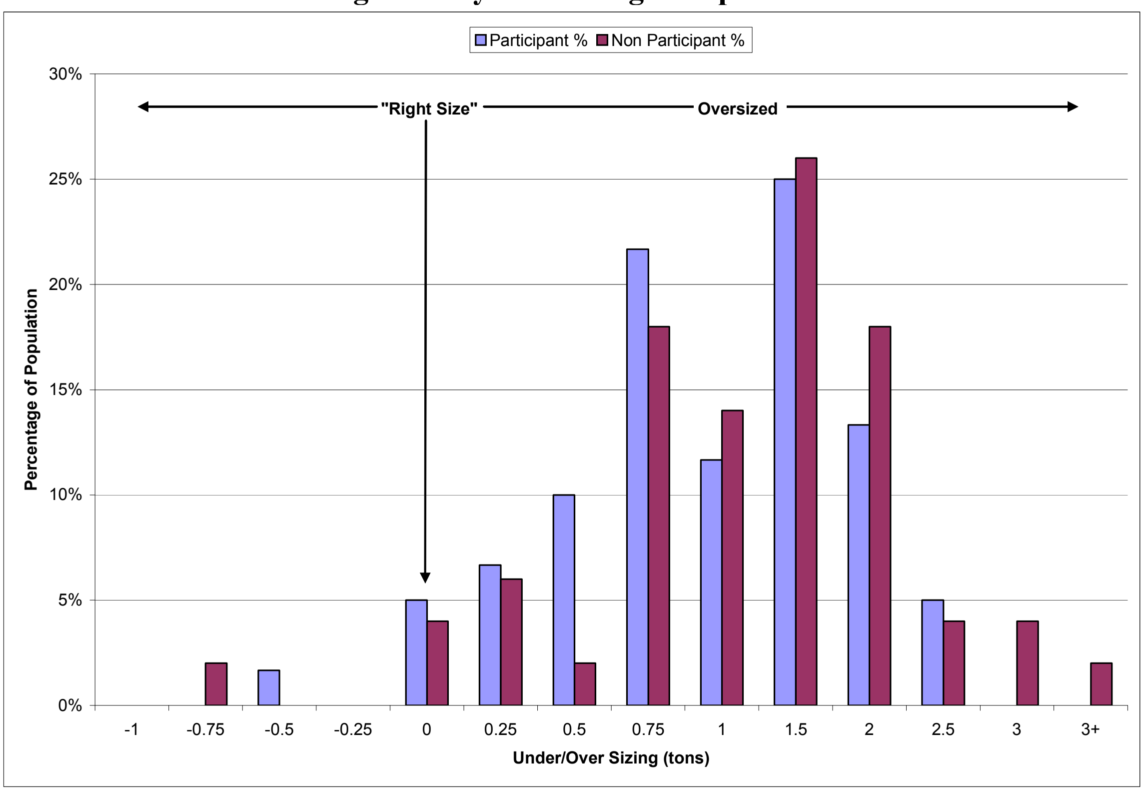


Figure 2b. Participant System Airflow Results



A building envelope survey sufficient to perform Manual J sizing calculations was conducted on each participant and non-participant home. Also for non-participants, a blower door was used to estimate infiltration and the results of the infiltration test were used in the system sizing calculations. The evaluation team performed an analysis to compare the actual cooling unit size to the proper cooling unit size. The proper cooling unit size was determined through the Air Conditioning Contractors of America's Manual J method (Rutkowski 2008). This method is the American national standard for residential heating and cooling load calculations. The actual size of the unit was found using unit model numbers collected on-site. Figure 3 presents the results. To find the difference in sizing, the Manual J recommended size was subtracted from the actual size, in tons. Therefore, a negative value indicates under sizing, whereas a positive value represents over sizing. The chart shows that over 90 percent of all units were oversized. Approximately 2 percent of all units were undersized, while only 5 percent of units were sized correctly. Surprisingly, the results are similar for both participants and non-participants. It is unknown whether contractors were using the Manual J method incorrectly, adding tonnage to Manual J to reduce callbacks, or not performing the heat load calculations at all.

Figure 3. System Sizing Comparison



Source: RLW Analytics (2008)

Additionally for non-participants, a duct leakage to outside test was performed with a combination of a blower boor and Duct Blaster™ duct pressurization tool. Finally, the blower door was disconnected to perform a total leakage test, which is most commonly used by contractors and HERS raters to determine duct performance compliance. Although the leakage to outside metric is a better indication of duct system performance, total leakage was tested for comparisons with groups with no available leakage to outside data.

Non-participants were found to have significantly more duct leakage as characterized by the leakage to outside metric, as illustrated in Table 2. The total leakage value includes leakage inside the envelope, while leakage to outside includes only leakage to the outside the building envelope, which is most relevant to energy usage of HVAC systems.

Table 2. Average Measured System Airflow and Duct Leakage

Study Group	Sample Size	Airflow (CFM/tom)	Leakage to Outside %
Participants	61	347	6%
Non-Participants	51	339	14%

The non-participants sample was further examined by comparing permitted and non-permitted units. Both groups have similar total leakage averages, yet the average leakage to outside is lower for non-permitted non-participants, as shown in Table 3. A possible driver of this discrepancy is the small sample of permitted non-participant systems.

Table 3. Normalized Average Total Leakage and Leakage to Outside per Ton

Non-Participant Sector	Sample Size	Total Leakage (cfm/ton)	Leakage to Outside (cfm/ton)
Permitted	14	82	56
Non-Permitted	37	86	46

To measure energy usage of participants and non-participants, spot power measurements were made and a current logger was installed on each package unit, or condensing unit if the unit was a split system. Additionally, combination humidity/temperature loggers were placed in the return and supply air stream to estimate system output for the cooling season. These loggers remained in place for the duration of the cooling season and were retrieved in late October and early November of 2007.

In order to calculate the energy and demand impacts of the program, data from performance testing and monitoring were fed into a regression to determine the annual usage for each system in the participant sample and the corresponding usage if the load was being met using a system having average non-participant performance characteristics. Essentially, the annual savings of each participant system was calculated as the difference between actual annual usage and the usage for the same load using the overall non-participant baseline system efficiency. The analysis results and original program estimates are presented in Table 4 and Table 5 on a per unit basis.

The baseline model was produced from the non-participant data and an overall estimate of savings was calculated using ratio estimation, comparing the total usage from individual participant sites to the estimates from the baseline non-participant model for a similarly sized home, based on Manual J cooling loads, during the same period of time. The overall estimates of savings were then projected up to a full year to produce an estimate of annual savings. Separate analyses were conducted to obtain specific estimates of peak demand savings, as well as computing the share of energy and demand savings that were due to program-influenced changes in equipment efficiency.

Table 4. Program per Unit Energy Saving Impacts

Program Participant Sector (TIER)	Program Estimated Savings (kWh/yr)	Total Measured Savings (kWh/yr)	Realization Rate
TIER 1	430	532	124%
TIER 2	436	557	128%

Table 5. Program per Unit Peak Demand Saving Impacts

Program Participant Sector (TIER)	Program Estimated Savings (kW)	Total Measured Savings (kW)	Realization Rate
TIER 1	0.633	0.47	75%
TIER 2	0.686	0.49	72%

Although the compliance rate assumptions used in calculating the program savings estimates were aggressive, the estimates themselves are somewhat conservative with regard to energy savings. The coincident peak demand savings had a lower realization rate than the energy savings, which was mostly due to duct leakage savings having little influence during peak periods.

Tables 6 and 7 show the program anticipated and evaluated savings by component. For Tier 1 systems the measured efficiency savings of 62 kilowatt-hours (kWh) were greater than anticipated. The savings due to minimal duct leakage, proper refrigerant charge and airflow, and appropriate system sizing were about 460 kWh for both Tiers. Note that any savings from proper sizing or adequate system airflow should be minimal given the similar results for participants and non-participants. The SMUD program actually achieved more than expected savings by requiring permits and duct testing without taking into account high efficiency equipment.

Table 6. Program Estimated Energy Savings by Component

Program Participant Sector (TIER)	Total Estimated Savings (kWh)	Efficiency Savings (kWh)	Duct Leakage Savings (kWh)	RCA Savings (kWh)
TIER 1	430	34	297	99
TIER 2	436	57	297	83

Table 7. Measured Energy Savings by Component

Program Participant Sector (TIER)	Total Measured Savings (kWh/yr)	Efficiency Savings (kWh/yr)	Duct Leakage, RCA and Sizing Savings (kWh/yr)
TIER 1	532	62	460
TIER 2	557	98	459

An interesting finding is revealed when participant savings are calculated using separate baselines from the permitted and non-permitted performance data as shown in Table 8. Although there are some savings for participants compared to permitted non-participants, the savings compared to non-permitted participants is nearly four times that of the permitted participant baseline. Note that the permitted non-participant baseline was generated from a sample of just 17 homes, but the potential for dramatic differences between permitted and non-permitted system performance shows a need for future study.

Table 8. Measured Energy Savings Compared with Alternative Baselines

	Total Measured Savings (kWh/yr)	
Program Participant Sector (TIER)	**Permitted baseline**	**Non-permitted baseline**
TIER 1	180	714
TIER 2	189	747

The results of the mass market survey indicate that approximately 7,000 non-participant air conditioner replacements in SMUD territory on an annual basis. Using the estimated permitted rate of 33 percent, the lost opportunities or potential savings are shown in Table 9. Note that these estimates represent first-year savings for a single-year's AC change-out population. When considering the lifetime savings of these newly replaced units could persist for ten, twenty, even thirty years the total missed opportunity is tremendous.

Table 9. Annual Potential Energy Savings

Sector	Annual Population	Tier 1 Energy Savings per Unit (kWh/yr)	Annual Population Potential Savings (kWh/y)
Non-Permitted	4,667	714	3,332,000
Permitted	2,333	180	420,000
Total Non-Participants	7,000	532	3,724,000

The Tier 1 savings per unit are estimates the annual savings that would be realized if the group under consideration would have overall system efficiency similar to SMUD's Tier 1 participants.

This illustrates the crux of the problem and its consequences. The savings attributable to SMUD's program are largely due to the poor overall performance of the non-participant units. Although we have only a small sample of permitted non-participant's units, preliminary results indicate that the permitted non-participants are performing with overall system efficiencies that are closer to the participant population than the non-permitted non-participant population. This would indicate that the majority of the potential savings are to be realized under the current market.

Conclusions

The results of a random survey of SMUD's single family accounts and a building department cross-check of all respondents that had recently replaced an air conditioner estimated the compliance rate of air conditioner replacements at 33%. With an estimated annual population of over 4600 units per year, this non-compliant majority represents a massive lost opportunity to realize energy savings. However, the compliance rate was considerably better than SMUD's gloomy assumption of a mere 4% rate of compliance before the study was performed. Somewhat surprisingly, the unit energy savings were better than program predictions even though the compliance rate was eight times greater than the program planning assumptions. This was largely due to the poor performance of non-participant systems.

These analyses of field and survey data show a great potential for cooling savings in air conditioner replacement installations from better quality control relative to system air flow correction, proper sizing, and refrigeration charge adjustment and especially duct leakage correction in California cooling climates. However, at present, the majority of opportunities to realize this potential at system change-out are currently being missed, largely due to a high volume of system replacements that are not permitted and thus do not comply with California's energy code, Title 24 part 6.

Even permitted units are not complying with system sizing requirements, an additional lost potential at the time of replacement. The situation will likely continue until the benefits of proper equipment sizing and testing and sealing ducts, in particular, become more apparent to the HVAC contractor and the homeowner. At this time, the majority of homeowners and installation contractors are not seeing any "carrot" that compensates for the time and money required to pull a permit and perform the required tests.

Likewise, if there are repercussions to not pulling a building permit for an AC replacement, they are not well known and certainly are not commonly feared. An inefficient ducting system, oversized unit, and poorly charged air conditioner are not desirable, but they can easily go unnoticed. Without any real specter of a "stick" for non-compliance and in the absence of more obvious carrot, potential savings will continue to be missed.

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