Sacramento Municipal Utility District

Residential HVAC Program Evaluation

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Prepared for:

SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.℠

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1. Executive Summary

RLW Analytics, in partnership with The Benningfield Group (The Evaluators) completed an evaluation of Sacramento Municipal Utility District's (The District's) Residential HVAC program (Program). This program offers monetary incentives for installation of above code efficiency units combined with performance testing. The program's savings calculations asserts an assumption that 96% of non-participant retrofits in their territory are not complying with California's ambitious 2005 energy code to some degree.

California 2005 energy code, Title 24, requires that all retrofit air conditioning systems have a thermostatic expansion valve (TXV) installed and verified by a HERS certified inspector, or have refrigerant charge and airflow testing performed on the unit. Additionally, the ducting system that serves the replaced unit must be tested to assure the duct leakage is below the allowable threshold. There are alternatives to duct testing that are often cheaper to implement. Figure 1 is taken from the 2005 Title 24 Residential Manual and shows the two alternatives available for replacements in climate zone 12. Duct testing requirement can be avoided by installing a high efficiency furnace of .92 AFUE at the same time as the cooling system replacement. It can also be avoided by installing a combination of high efficiency heating and cooling systems and duct insulation. It should be noted that there is no alternative for the installation of a TXV or RCA testing requirement.

Table 8-3 – Alternatives to Duct Sealing

	Option 1	Option 2	Option 3
Climate Zone	0.92 AFUE	SEER-14 & EER-12, with either TXV or refrigerant charge measurement, plus Increased Duct Insulation	SEER-14 & EER-12 with either TXV or refrigerant charge measurement, plus either 0.92 AFUE or 0.82 AFUE with Increased Duct Insulation
CZ2	Yes	No	Yes
CZ9	No	No	Yes
CZ10	No	Yes	Yes
CZ11	No	No	Yes
CZ12	**Yes**	**No**	**Yes**
CZ13	No	Yes	Yes
CZ14	No	No	Yes
CZ15	No	Yes	Yes
CZ16	Yes	No	Yes

1. Increased duct insulation refers to an additional R-4 insulation wrap on existing ducts and R-8 duct insulation for all new ducts.2. Package systems may use Option 2 or 3 without meeting the requirement for a TXV (or refrigerant charge measurement)
Note - There are no duct sealing requirements in climate zones 1 and 3-8.

Figure 1: Alternatives to Duct Sealing[1]

The Program estimated (ex-ante) energy and demand savings assume that a small percentage of HVAC units are permitted as required and that the duct testing compliance option is not often taken. These theories were tested by the study's

[1] 8.4.2, 8-16, Table 8-3, 2005 Title 24 Residential Compliance Manual

unprecedented volume of diagnostic testing of non-participant homes, an effort that required the Evaluators' survey team to contact over two thousand surveys to identify non-participants. In addition to measuring energy and demand impacts, the permitting and compliance rate of the identified non participants is reported on, and reasons for noncompliance are detailed.

The evaluation study includes comprehensive performance testing and cooling-season-long system monitoring of over 100 participating homes and non-participating homes that had recently replaced their HVAC systems. Additionally, HVAC contractors were surveyed to determine their perspective on code requirements and how it has affected their activities.

Survey and On-site Findings

The following tables present the average characteristics of the metered samples. Size and type of units did not differ considerably between participants and non-participants. The majority of all systems were 3 ton split air conditioners. As is expected, the average nameplate EER was found to be significantly higher for participants than non-participants. Very few heat pumps were found in the metered sample or in the pool of program participants as a whole.

Group	N	Tonnage	EER
Non-Parts	51	3.3	10.35
Parts	61	3.2	12.14

Table 1: Average Characteristics of Metered Sample

System Type	Participants (n=61)	Non-Participants (n=51)
Split A/C	67%	75%
Package A/C	21%	20%
Split HP	8%	6%
Package HP	3%	0%

Table 2: Metered Sample System Types

The results of on-site performance testing yielded average airflow within instrumentation accuracy for the two groups. Participants were slightly higher on average but both groups were lower than the Title 24 minimum of 400 CFM/ton. Non-participants were found to have significantly more duct leakage as measured by the leakage to outside metric. The total leakage includes leakage inside the envelope while leakage to outside includes only leakage outside the envelope which is most relevant to energy usage of HVAC systems. Note the differences in these metrics for the two groups of non-participants, permitted and non-permitted, which have similar total leakage averages yet leakage to outside is significantly lower for non-permitted non-participants. This is most likely due to the difference in sample sizes. The most likely driver of this discrepancy is

the location of the air handler in the samples, which if inside the envelope would lead to larger differences between total leakage and leakage to outside.

Group	N	Airflow (CFM/ton)	Leakage to Outside %
Non-Parts	51	339	14%
Parts	61	347	6%

Table 3: Average Measured System Airflow and Duct Leakage

Non-Participants	N	Average Total Leakage / Ton	Average Leakage to Outside / Ton
Permited	14	82	56
Non-Permitted	37	86	46

Table 4: Average Total Leakage and Leakage to Outside per Ton

On-site refrigerant testing was conducted at all sites and provided the evaluators with the number of units under charged, over charged and properly charged. RLW was unable to quantify the degree to which systems were under or overcharged. Such quantification requires the system's charge to be corrected by adding or removing charge. Both participant and non-participants yielded similar results. Only 35%-44% of units proved to be properly charged within instrumentation accuracy.

Group	N	% Properly Charged
Participant TXV	57	35%
Non-Participant TXV	34	44%
Non-Participant Non-TXV	11	36%

Table 5: Percent of Systems Properly Charged

The Air Conditioning Contractors of America's Manual J method[2] was used to determine whether systems had been properly sized for the cooling load on the building. Both participant and non-participants were sized on average one ton larger than what Manual J load sizing calculations predict.

Group	Average Manual J Tonnage	Average Installed Tonnage
Participant	2.3	3.2
Non-Participant	2.3	3.3

Table 6: Average Sizing Characteristics

Survey Results for Market Size

Previous estimates have indicated that annually 5 percent of the District's customers replaced their A/C units in 2006 and 2007, which would result in between 150 and 300 customers identified from the pool of 6,000. If 300 customers were identified, only 1 in

[2] Hank Rutkowski. Manual J Residential Load Calculation. March 2006. 8th edition.

5 would have to agree to participate in the monitoring of their A/C unit. However, after exhausting this first pool the desired 60 non-participant candidates had not yet been recruited. Two additional pools of non-participants were included to arrive at a total pool of 7384. Slightly less than 1% of this total, 56, were identified as recipients of the District's rebate and were excluded from recruitment, but included in the total market size. From data gleaned from surveys with the general population it was determined that the 2006-07 market size on August 22, 2007 was estimated to be around 3 percent of the District population and 9 percent of the single family air conditioning market.

	Quantity	% of Sample	% of A/C Market
No Central A/C	171	3%	7%
Central A/C Not Replaced in 06/07	1781	27%	77%
Participant Size	56	1%	2%
Non-Participant Size	143	2%	6%
Total A/C Replacements	199	3%	9%

Table 7: Percent of Market with A/C replacements as of 8/22/2007

Population	2006-2007 Estimated Quantity
Central A/C	273,152
Participant Size	8,550
Non-Participant Size	15,268
Total A/C Replacements	23,819

Table 8: Estimated Populations

Analysis Results

Of the 60 participant sites where testing and metering was conducted, 50 were included in the analysis. Of the 50 non-participant sites, 44 were included in the analysis. The primary reason for excluding a site from the analysis was due to some type of problem with the A/C logger data. Additionally, because of the issues with some A/C logger timestamps, if the data from the return or supply loggers was suspect, there was no way to cross check the data from the A/C logger and therefore, the site was excluded. Overall, a very conservative approach was taken with the data. Because the sample size was so small, it was deemed better to include only data that was known to be good, rather than risk biasing the results of the analysis by using suspect data.

The total unit energy savings (kWh) resulting from the end-use meter data analysis is presented in Table 73 and Table 76. The efficiency savings resulted from comparisons of participant usage to the SEER 13, EER 11 baseline. The total savings less the efficiency savings were termed the "compliance" savings which were proportioned into duct sealing savings and RCA savings based on the performance testing, detailed analyses and engineering judgment. The savings based on three additional baseline scenarios are presented in the report body. These scenarios include equipment savings

based on the actual average EER of all non-participants, average EER of permitted non-participants, and average EER of non-permitted non-participants.

Ex-post (Measured Savings)	Total Savings kWh	Error Bound	Relative Precision
TIER 1	502	64.7	12.9%
TIER 2	525	67.7	12.9%

Table 9: Ex-post Error Bound & Relative Precision

Ex-post (Measured Savings)	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
TIER 1	502	59	355	89
TIER 2	525	92	346	87

Table 10: Ex-post Energy Savings

Similarly, the total unit demand savings (kW) resulted from end use meter data analysis of the peak period defined to be 4PM-7PM on the three hottest consecutive days. Participant peak demand profiles were also compared to the EER 11 baseline to develop efficiency savings and compliance savings were proportioned into duct leakage and RCA demand savings.

Ex-post (Measured Savings)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	0.439	0.258	0.163	0.041
TIER 2	0.459	0.414	0.057	0.014

Table 11: Ex-post Demand Savings

For comparison to the measured savings the ex-ante energy and demand savings per unit are shown in a similar format in Table 12 and Table 13. These savings apply all the assumptions and factors outlined in the ex-ante savings description and weight the estimated percentage of packaged and split systems to arrive at one estimate.

Ex-ante Net (Program Estimate)	Total 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 12 Ex Ante kWh Savings per Unit

Ex-ante Net (Program Estimate)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	0.633	0.188	0.289	0.156
TIER 2	0.686	0.266	0.289	0.131

Table 13 Ex Ante kW Savings per Unit

The realization rate is 1.17-1.20 for total energy savings (kWh) as presented in Table 14. This means the evaluation found the per unit savings to be approximately 18.5% higher than the utility's estimates. The result is likely due to the higher efficiency savings than estimated, significant duct leakage in the non participant sample and the higher percentage of TXV installed on participant systems.

	Ex-ante kWh Savings	Ex-post kWh Savings	Realization Rate
TIER 1	430	502	1.17
TIER 2	436	525	1.20

Table 14 kWh Realization Rate

However, the realization rate for the peak demand (kW) savings is 0.67-0.69, meaning the evaluated savings are lower than the ex-ante estimates. This result may be attributable to over sizing in both participant and non-participant systems and shows the duct system deficiencies had little impact on peak. The peak demand savings are presented in Table 15.

	Ex-ante kW Savings	Ex-post kW Savings	Realization Rate
TIER 1	0.633	0.439	0.69
TIER 2	0.686	0.459	0.67

Table 15 kW Realization Rate

The savings methodology is based on measuring participant and baseline (non-participant) energy consumption and peak demand kW. The non-participant HVAC replacements were assumed to be what a participant would have done absent the Program, which is the goal of a net savings assessment. Traditional net savings factors are developed, Table 16, but are not applied to unit savings comparisons. The factors developed from participant surveys may not be applicable to the measured net savings and are not applied in the analysis results. Freeridership was developed as equipment freeridership and compliance freeridership to provide the District with these estimates. It is recommended that only the equipment freeridership be applied to equipment efficiency savings by the District and duct sealing compliance freeridership should be considered but not applied. The duct sealing compliance freeridership has a great deal of uncertainty given that many customers learned about the code requirements from program participating contractors yet said they would have had ducts tested without the District rebates. Application is further complicated by the fact that repair rates are not tracked and some identified "duct sealing freeriders" may not have had any duct repairs at all.

Score Type	Average Freeridership Score
Equipment	28.7%
Duct Sealing Compliance	38.0%

Table 16 Freeridership Scores

Conclusions

The District Residential HVAC incentive program realized much of the estimated program savings. The key component was that participant systems have higher efficiencies and have significantly less distribution system (duct) leakage. Other important conclusions were drawn from the data and analyses including:

- Participants save energy due to high efficiency equipment, higher presence of TXV, and significantly less duct leakage compared to non-participants
- High efficiency equipment saves significant demand
- Participants are complying using TXV credit as many participants have high charge (low subcooling compared to target)
- Both participants and non-participant systems are oversized compared to Manual J
- About one third of non-participant systems are permitted and half of those had duct testing upon installation
- The Program has about one third of the District-wide market share and replacement market is closer to 3.5 to 4 percent annually
- Program participants acquire multiple bids for changeouts more so than non-participants

Recommendations

Recommendations for the program implementation process were gleaned from the results and respondents' comments by the Evaluators. These recommendations reflect opinions and interpretations in some cases, but all are valuable considerations to be taken into account in program development.

- The program requires and confirms duct testing compliance and should explore expansion of requirements, verifications, and incentives to address sizing, refrigerant charge, and system airflow.
- Train contractors to ensure systems are sized properly and have factory specified charge and airflow. Show the benefits of using SMUD program to ensure all jobs are compliant and use the selling point of all the additional savings the customers receive beyond the equipment.
- Require documentation of Manual J sizing.
    - Require or offer design assistance for right sizing
    - Offer additional incentive for documentation of Manual J that is verified by third party such as a HERS rater
- Require documentation of "pre" conditions and contractor scope of work, to determine duct seal and RCA repair rates. Document when TXV was added by contractors and when TXV was factory installed.
- Use a checklist required for each rebate to include the above elements with itemized costs for testing, repairs, HERS inspection costs, equipment cost, and other material costs.
- Ensure that both SMUD and the appropriate building department both have copies of the permit and forms CF-4R and CF-6R.
- Compile all program collected data in one database including: itemized costs, scope of work, permit information, Manual J documentation, removed equipment information, installed equipment information, HERS verification data, duct and RCA repairs. These data could be used in future evaluation to develop savings per installed tonnage based on actual repairs made and their costs.
- Supply customers with a dictionary of HVAC terms and acronyms and a description of the permitting process explained in both technical and laymen terms including:
    - Description of unit types: Spilt, Packaged, Heat Pumps.
    - What to expect with regards to building compliance including cost of permits and building department verification requirements.
    - Title-24 trade offs.
    - Why duct testing and sealing and refrigerant charge and air flow are just as important as the unit they choose.
    - Benefits of early HVAC retirement.
    - What to expect and what not to expect if they are to rely on their home warrantee to cover the replacement.
    - Why obtaining bids from at least three contractors is advisable.

Contractors, as do residential customers, feel that the District can aid in the HVAC replacement process. Some of the questions and suggestions that could be addressed include the following:

- Why rebate amounts may increase or decrease over the years and what the incentive covers.
- Why customers should expect to pay $100 for a financing application fee and what that fee covers.
- Post the financing application on the Disitrict's website and allow contractors to submit the application electronically.
- Post city and county permit forms as a PDF on the website to be easily downloaded or provide URL links to permit departments.
- Work with city and county officials to provide applications electronically if they are not doing so already and make permit fees comparable.
- Help with incursion of additional scope of inspection, "whole house" not HVAC only, and difficulty making appointments with Building Inspectors.

Possible Missed Opportunities

Although the District may intend to reach every customer replacing an A/C unit, there does appear to be possible missed opportunities that would require a slightly different marketing approach. Those missed markets include the following:

- Home Warranty Replacements
- Rental Property Replacements
- Early Retirement Replacements

2. Introduction and Background

Introduction

RLW Analytics, in partnership with The Benningfield Group, (The Evaluators) completed an evaluation of Sacramento Municipal Utility District's (The District's) Residential HVAC program. This program offers monetary incentives for installation of above code efficiency units combined with performance testing. The Program's savings calculations asserts an assumption that 96% of non-participant retrofits in their territory are not complying with California's ambitious 2005 energy code to some degree.

California 2005 energy code, Title 24, requires that all retrofit air conditioning systems have a thermostatic expansion valve (TXV) installed and verified by a HERS certified inspector, or have refrigerant charge and airflow testing performed on the unit. Additionally, the ducting system that serves the replaced unit must be tested to assure the duct leakage is below the allowable threshold. There are alternatives to the duct testing requirement that vary by climate zone.

The Program estimated (ex-ante) energy and demand savings assume that only a small percentage of HVAC units are believed to be permitted as required and that the duct testing compliance option is not often taken. These theories were tested by the study's unprecedented diagnostic testing of non-participant homes, an effort that required contacting over two thousand households to identify non-participants. In addition to measuring energy and demand impacts, the permitting and compliance rate of non participants is reported on, and reasons for noncompliance are detailed.

The evaluation study includes comprehensive performance testing and cooling-season long system monitoring of over 100 participating homes and non-participating homes that had recently replaced their HVAC systems. Additionally HVAC contractors were surveyed to determine their perspective on code requirements and how it has affected their activities.

Program Background

The District's Residential HVAC Program (Program) has been offering incentives to encourage the installation of higher efficiency replacement HVAC systems since the early 1990s. Although the Program has been well subscribed, the District believes that participants represent a minority of the HVAC replacement market within the District's service territory. It is estimated that program participants represent one quarter to one third of the total replacement market. Given that residential air conditioning is the primary contributor to peak system demand, the District would like to increase Program market share.

Changes to California's Title 24 Building Efficiency Standards have created additional procedures and expenses for homeowners and HVAC contractors. Effective October 2005, duct leakage testing or allowed alternatives, an installed TXV or refrigerant charge and airflow testing, and Manual J sizing calculations are requirements. These

requirement must be verified by a HERS rater and documented and signed-off by the rater and a building official.

While encouraging savings, these developments represent market barriers to program participation. The District had always believed that the majority of A/C and heat pump replacements in their service territory are being performed without permits and that these obstacles have increased non-permitted installations. In fact, Program savings estimates are now calculated with assumed non-compliance rate of 96%.

Program Description

The Residential HVAC Program provides incentives to homeowners for installing a split system or packaged high efficiency air conditioner (AC) or heat pump in an existing residence. There are four tiers of participation depending on the efficiency of the unit and beginning with a $400 rebate for a 14 SEER/ 12 EER AC, 8.5 HSPF split heat pump or 8.0 HSPF packaged heat pump. Only split system A/C units are eligible for Tier 3 and only evaporative cooled A/C units are eligible for Tier 4 rebates. The large majority of participants fall into either the Tier 1 or Tier 2 category.

The Program requires that all replacements submit the proper permits along with a CF-6R, the contractor compliance form, in order to be eligible for incentives. To assure electric savings, the Program requires duct leakage testing for all systems regardless of furnace efficiency. The Program also requires that refrigerant and airflow verification be performed with the only exception being if the unit is installed with a TXV. Manual J sizing calculations must be performed to ensure right sizing. Lastly, a HERS rater must provide a CF-4R to the building department for compliance certification.

Program Evaluation Development

In the early planning stages the evaluation sought to determine energy and demand impacts by monitoring a group of program participant and non-participant replaced air conditioners and heat pumps. The approach identified the poor relative precision of direct comparisons of average usage. The approach also was based on targeted approaches to identify and measure non-participant systems. The original evaluation also included a simplified market assessment and detailed approach to determine freeridership. Decisions were made to increase scope to strive to meet the CA protocols Enhanced level of rigor for impact evaluations, bolster market assessment, and develop a model of usage to mitigate statistical uncertainty.

The Evaluators developed a possible additional task of using the Princeton Scorekeeping Model Regression Technique (PRISM) applied to weather normalization on the population to adjust the results of a targeted non-participant sample to the population of non-participants. A decision was made that since the study was now undertaking a random dial survey to assess the market size and characteristics, of non-participant replacements could also be recruited from the large mass market survey. RLW ended up with a completely random sample of non-participants that did not utilize such a usage adjustment that would have been necessary if the sample were potentially biased through age of home targeting. The evaluation did use PRISM-like techniques to develop annual profiles from metered data which is described in the methodology.

A key limitation of the approach was an inability to directly report on the RCA and Duct Seal repair rates because the participant documentation only shows final passed test values. Since most non-participants weren't tested the duct repair rate was estimated based on the frequency that would have passed. For RCA if airflow and charge were similar for parts and non-participants, then the real difference may be that parts and permitted non-participants have more TXVs and what is termed "RCA savings" is really due to more TXVs not better charging practices. It is impossible to quantify the magnitude of under and over charge since the Evaluators did not add or remove charge to the systems. It should be noted that the scope of this evaluation was not designed to address heating savings.

3. Methodologies

The Evaluators developed methodologies to determine program net savings. The goals were to sample both participant and non-participant sites, perform efficiency tests, collect reliable site and meter data, and to perform substantial analysis on the data collected. The savings methodology is based on measuring participant and baseline (non-participant) energy consumption and peak demand kW. The non-participant HVAC replacements were assumed to be what a participant would have done absent the Program, which is the goal of a net savings assessment. The components of savings are tied directly to what the baseline market is installing without rebates. Importantly, the assumed program savings are driven by the Program incenting code compliance through high efficiency rebates and financing. The net savings for the Program are these measured savings, plus participant spillover if any. Simplified, these savings are the difference between participant energy consumption and the energy required for non-participant systems to satisfy participant load. Freeridership and market issues were addressed through a battery of questions asked of program participants and non-participants. Finally, equipment incremental costs were analyzed by collecting on-site invoice data, interviewing contractors, and mining other data sources.

Program estimated per unit savings and embedded assumptions are denoted as *ex-ante* and evaluated savings and methodologies are called *ex-post*.

This section presents an overview of the evaluation focused on ex-ante and ex-post savings estimates, market objectives and code objectives. The overview is followed by the detailed steps required to achieve these goals including:

1. Evaluation overview
2. Sampling
3. Engineering methodology
4. Data collection
5. Energy and demand data analysis
6. Freeridership analysis
7. Cost analysis

Evaluation Overview

The District's Residential HVAC Program provides incentives to homeowners for installing a split system or packaged high efficiency air conditioner (AC) or heat pump (HP) in an existing residence. The Program requires that all replacements submit the proper permits to the District, including a CF-6R Installation Certification form, in order to be eligible for incentives. Additionally, a HERS rater must provide a CF-4R Certification of Field Verification and Diagnostic Testing form to the building department for compliance certification, which may be performed on only one out of every seven replacements per contractor. After January 2006, all participants were required to receive HERS verification. However, not all participants submitted the proper forms to SMUD or the

appropriate building department. From mining of the HERS registries over 50% of participants were shown to have had their ducts directly tested for verification.

To assure electric savings, the Program requires duct leakage testing for all systems regardless of furnace efficiency. The Program also requires that refrigerant charge and airflow (RCA) testing be performed unless the unit is installed with a TXV and that Manual J sizing calculations were used to properly size the system. All documentation is in the form of the standard Title 24 documents described above.

Total Gross Unit Savings

The savings methodology is based on measuring participant and baseline (non-participant) energy consumption and peak demand kW. The components of savings are tied directly to what the baseline market is installing without rebates. Therefore, the ex post gross unit savings are, in essence, net unit savings.

Ex-Ante

The following describes the Program's ex-ante deemed gross savings methodology. Total gross savings are attributable to savings due to increased equipment efficiency, tighter sealed ductwork, and properly charged units with adequate airflow. The duct system and RCA unit savings are adjusted according to assumed repair rates.

Both duct and RCA testing are required for participation in the Program. Some systems pass these tests on the first attempt and do not require additional work such as duct sealing repairs or the addition or removal of refrigerant. Assumed repair rates for each of these tests were 0.80 for duct systems, that is, 80% of ducting systems will need some type of remediation to get below the allowable leakage threshold. Similarly the Program assumed a 0.70 repair rate, that is, 70% of all participants will require either a refrigerant charge or airflow adjustment to meet Program targets.

The equation below shows how ex-ante gross savings were calculated.

Total gross unit savings *= equipment unit savings + (duct-system unit savings * repair rate) + (RCA unit savings * repair rate).*

Ex-Post

An on-site survey and short-term monitoring were conducted at 60 participant and 50 non-participant homes. The monitoring obtained values at 10-minute intervals for condenser current draw (amps), supply/return enthalpy (Btuh), and indoor and outdoor temperatures. Instantaneous measurements were also taken of airflow across the evaporator coil (CFM), system subcool/superheat, and condensing unit and fan true RMS power (kW). Manual J surveys were conducted to determine the heat load of the home. For non-participants measurements of home infiltration and duct leakage to outside were also taken.

The evaluation directly estimates savings due to more efficient equipment from participant load profiles compared to code or non-participant equipment baseline. The difference between these savings and total savings compared to non-participant baseline is compliance savings. Compliance savings was proportioned into Duct Leakage and RCA savings using engineering estimates based on on-site test data.

Total gross unit savings (measured) = equipment efficiency savings (measured) + compliance savings

Where compliance savings is proportioned as follows,

Compliance savings = Duct Leakage Savings (Average proportion of cooling reduction due to leakage to outside) + RCA Savings (Average proportion of cooling reduction due to inadequate refrigerant charge and presence of TXV)

Equipment Efficiency Savings

Evaporator coil + condenser EER at ARI test conditions were obtained from a nameplate lookup for all participants and non-participants visited. The measured system performance was compared to standard performance curves at the system's ARI efficiency as well as the baseline EER of 11 and non-participant baseline EER of 10.35.

Duct Leakage

Duct leakage was measured for the 50 non-participants that were visited. Leakage to outside on the supply side of ductwork decreases cooling delivered to space and leakage on the return side increases the amount of heat the coil must remove from the return air decreasing system performance.

RCA

Airflow and refrigerant charge was measured for all participants and non-participants visited. All additional savings not attributable to equipment efficiency or duct leakage are ascribed to RCA.

System Sizing

Manual J heat load calculations from the home survey and/or data from compliance documents were used to determine whether units were properly sized. Effects of improper equipment sizing were not quantified.

Total Net Unit Savings

The savings methodology is based on measuring participant and baseline (non-participant) energy consumption and peak demand kW. The non-participant HVAC replacements were assumed to be what a participant would have done absent the Program, which is the goal of a net savings assessment. Traditional net savings factors are developed but are not applied to unit savings comparisons. The factors developed from participant surveys may not be applicable to the measured net savings and are not applied in the analysis results. Freeridership was developed as equipment freeridership and compliance freeridership to provide the District with these estimates. It is recommended that only the equipment freeridership be applied to equipment efficiency savings by the District and duct sealing compliance freeridership should be considered but not applied. The duct sealing compliance freeridership has a great deal of uncertainty given that many customers learned about the code requirements from program participating contractors yet said they would have had ducts tested without the District rebates. Application is further complicated by the fact that repair rates are not tracked and some identified “duct sealing freeriders” may not have had any duct repairs at all.

Ex-Ante

Net-to-Gross Ratio (NTG)
Ex-ante freeridership and spillover rates for the Program were both assumed to be zero; therefore the net-to-gross ratio was assumed to be one.

Title 24 Compliance Rate (T24)
Initial compliance is assumed to be 0.04. This assumption implies that 96% of these retrofits would not be compliant with 2005 energy code in the absence of program participation.

Total net unit savings *= total gross unit savings * NTG * T24 * T&D,*
where T&D = line-loss savings = 1.060 for energy and
= 1.0766 for peak load.

Ex-Post

Permitted Ratio & Compliance Ratio
Data was obtained from the building departments to determine the percentage of participants' and identified non-participants' replacements that were permitted and code compliant. The three California HERS registries were cross referenced to determine the percentage of sites that were performance tested.

Participant Sample & Normalized Results
In order to obtain comparable results energy consumption must be normalized. From tracking data and on-site nameplate data collection A/C nominal tonnage was obtained and used to normalize energy consumption. Tonnage was also used as a stratification variable for participants.

Freeridership & Spillover
A self reported methodology was combined with direct measurement of net savings. Participants were surveyed regarding the impact of the rebate and system efficiency on their purchasing decision. Participant savings are a comparison of A/C usage to that of replacements outside the program (non-participant usage). Site level participant spillover was investigated through surveys and on-site.

Freeridership
Although the net savings result directly from analysis of A/C usage measurements, participants were asked a battery of questions to estimate program freeridership. The freeridership can be categorized into equipment freeridership, where a participant would have purchased the same efficiency unit absent the Program, and compliance freeridership, where the participant would have complied with current code without program intervention. Any equipment freeridership should correspond with a considerable proportion of high efficiency equipment found among the non-participant sample. Likewise, compliance freeridership would be present in the unlikely event that considerable compliance was found in the non-participant sample.

Spillover

The Program assumed replacement on burnout; however it is possible that the Program may have influenced the timing of the replacement. In this case, the spillover savings are the early retirement savings until the unit would have been replaced upon failure. Rebates and financing may have different effects on timing as well. This may be the only quantifiable spillover savings for the Program. Although other spillover may exist, it is difficult to isolate since the majority of savings is realized by program participants complying with current code.

District Survey and Market Objectives

A critical component of this research is to better understand the decision-making process that homeowners utilize when selecting replacement HVAC systems. Following are the six survey objectives addressed during the homeowner and contractor surveys:

- How homeowners select contractors to perform the replacement,
- The energy efficiency options that contractors offer to prospective customers,
- The degree to which homeowners consider energy efficiency in their selections,
- Information sources homeowners rely upon in their decisions,
- How homeowners evaluate how much to spend on the replacement system, and
- The effect of rebates and financing on the purchasing decision.

Market Size

Random customers were surveyed to determine the size of the replacement market. Participants were screened out of the random customer sample by cross referencing with Program tracking data. Customers who replaced their air conditioning systems in 2006 and 2007 were identified as non-participants.

Cost

All recruited sites were asked to provide HVAC invoices and contractors were asked about typical costs. The goal of this task was to determine what amount of a customer's cost was attributed to the measure and what amount was attributed to labor. We were not able to obtain itemized invoices but rather total job costs. Fortunately the Evaluators were able to utilize other sources to form estimates regarding equipment and labor costs. The DEER Database houses estimates for base equipment cost, measure equipment cost, incremental equipment cost, labor cost, and installed cost for a variety of measures.

CEC Survey Questions

Due to the Title 24 compliance related claimed savings and issues surrounding compliance, the California Energy Commission was engaged to provide meaningful feedback to the study. Some questions were added to the contractor surveys from

comments received from the CEC. Those questions asked HVAC contractors the following:

1. *Out of this total [A/C retrofits] what percentage did you pull permits?*

2. *Can you tell us what is required when replacing HVAC systems under the 2005 Residential Title 24 requirements for Sacramento County?*

3. *We would like you to estimate the costs and time added due to recent codes and standards changes. Please quantify the direct cost to the customer and time requirements for the following:*
    - *How often do you install a TXVs on changeouts? What is the additional cost?*
    - *How often do you check RCA on a changeouts? What is the additional cost?*
    - *Whose testing procedures do you use to check RCA?*
    - *Do you own a duct blaster?*
    - *What percentage of the non-permitted/permitted jobs do you use it on*
    - *How long does the duct test take? What do you charge?*
    - *How long does it take for you to seal the ducts to meet code and what do you charge?*
    - *What percentage of the time do you install R-410A compared to R22 in a changeout and what is the extra cost?*
    - *How often do you have a HERS rater involved in your changeouts? What is the added cost to the homeowner?*

Sample Design

The targets of the sample design were homes that had central air-conditioner or heat pump replacements from 2006 to date. These installations can be classified as three distinct groups.

Group One - Participant Installations

This group replaced their air conditioner or heat pump in 2006 or 2007, filed a permit through the building department, and followed additional Program requirements to receive the District's incentive.

The Evaluators obtained Program tracking data and drew a random sample of program participants. A letter with the District's letterhead was issued to each sample home. This letter informed participants they have been selected for an evaluation. The letter offered a number for the participant to call if they were interested in being included in the evaluation. About five days after letters were sent out the Evaluators made calls to selected participants and referenced the letter to demonstrate that the call is important and not a sales solicitation.

The Evaluators' recruitment team conducted telephone surveys covering freeridership and purchasing decisions with the Program participants and scheduled an on-site inspection and meter installation with homeowners willing to take part in the study. On-site visits for this component of the study took place between the months of April and July.

Group Two - Permitted Non-Participant Installations

This group replaced their air conditioner or heat pump in 2006 or 2007. They filed a permit through the building department, but did not receive the District's incentive.

To identify Group Two, Permitted Non-Participants Installers, the Evaluators' team obtained installation permits from the District's Six Building Code Departments. By obtaining permit data RLW accomplished three tasks:

1) Estimate the fraction of replacements that were permitted and compare the number of HVAC replacements occurring to the District's estimates, 14,000 units a year, and eventually to the evaluation's estimate of market size.
2) Obtain a non-biased sample of installers.
3) Supplementing this effort with a query request to the three certified HERS provider registries helped identify testing and compliance rates.

Group Three - Non-Permitted Non-Participant Installations
This group replaced their air conditioner or heat pump in 2006 or 2007, but did not file a permit through the building department. This group was not eligible for the District's incentive.

The Evaluators' recruitment team conducted telephone surveys covering spillover and purchasing decisions with the non-participants in Group Two and Group Three. When able, recruiters scheduled on-site inspections and meter installations with non-participants. A nominal monetary incentive ($50) was given to study participants as compensation for the amount of time members of the Evaluators' on-site team spent inside their home.

The District's assumption for code compliance rate is that only 4% of non-participants are permitted by the building department and compliant. Based on studies conducted by the Benningfield Group[3], the evaluation team felt that the group of permitted non-participants had a much greater market share although the proportions were unknown. These studies also suggest that not all permitted replacements are compliant meaning that the District's assumption for compliance may be justified, but, at least in Sacramento County, many non-compliant replacements are permitted.

Mining the HERS registry

The Evaluators sampled the HERS registries for Sacramento area sites that were not program participants. This data was compared to the participant data and permit data to identify additional program non-participants who appear to be code compliant, but who may not have obtained a building permit. It was not expected that many sites would be identified with this method, but the HERS registry data is easily available and so should be thoroughly cross referenced for maximum use.

[3] In a recent study analyzing the effectiveness of code compliance statewide, Benningfield Group reviewed permits from nine jurisdictions, including the city of Elk Grove.

Participant Sampling

The first issue was the acquisition and assessment of the Program tracking data. Those data were used to extrapolate savings for the Program and were used as a sampling frame for selecting participants. In order to determine a participant sampling plan, a good idea of the participant population and the expected savings was necessary.

The Evaluators obtained savings estimates for 60 participants. In determining the appropriate sample size, a coefficient of variation of 0.6 was assumed. The coefficient of variation (denoted *cv*) describes the variation in a single variable. As an example, this study expects to estimate the actual savings per system. With a *cv* of 0.6, this represent a scenario where there is a moderate amount of variation in the savings estimate, where the actual savings vary around the mean savings by 60%.

RLW recently completed a draft of the CA Energy Star New Homes evaluation for which over 100 A/C systems were metered. This evaluation utilized the metered data from CEC climate zone 12 to compute the coefficient of variation for planning purposes. While it is possible to propose smaller sample sizes based upon estimates of a lower *cv*, the Evaluators opted to use a *cv* based upon recently collected data from a research study.

Planning the participant sample size with a *cv* of 0.6, a sample size of 60 participants gives a relative precision of ± 12.6% of participant usage at the 90% level of confidence assuming that there is independence among the sites. Less variation was introduced in this study due to the fact that all but one participant had only one incented unit.

Non-Participant Sampling

The identification of non-participants was a difficult endeavor. Almost 1,800 Mass Market Surveys were performed in order to target 50 eligible non-participants willing to participate in the study. Initial planning of the non-participant sample size with a *cv* of 0.6, called for a sample of 60 non-participants giving a relative precision of ± 12.6% of non-participant usage at the 90% level of confidence assuming that there is independence among the sites. Due to the extreme difficulty recruiters faced when finding qualifying non-participants willing to participate in the study, recruiting was discontinued at a final sample of 50 non-participants.

Engineering Methodology

Measuring System Deficiencies

The higher equipment efficiency of rebated units accounts for only a small portion of Program savings. The Residential HVAC program seeks to eliminate three potential system installation deficiencies and claims these as energy and demand savings over typical installations. The deficiencies are all addressed by the 2005 Title 24 Standards and program savings are primarily due to increased compliance with the standards. The tests for these deficiencies include refrigerant charge testing, system airflow testing and duct leakage testing.

The system deficiencies addressed by the Program all detract from cooling delivered to the space and should have minimal direct impacts on unit power draw in the short term.

The deficiencies have energy and average demand impacts as units must run longer to compensate for poor performance in terms of the rate that heat is removed from homes with improperly installed units. If those longer runtimes are still within the peak period then there are peak savings in terms of average power draw over the peak period.

The system testing procedures to be used by the A/C installer and any evaluator of the District Residential HVAC program are clearly defined in the Residential ACM Manual. The procedures are outlined in the following appendices of the Residential ACM:

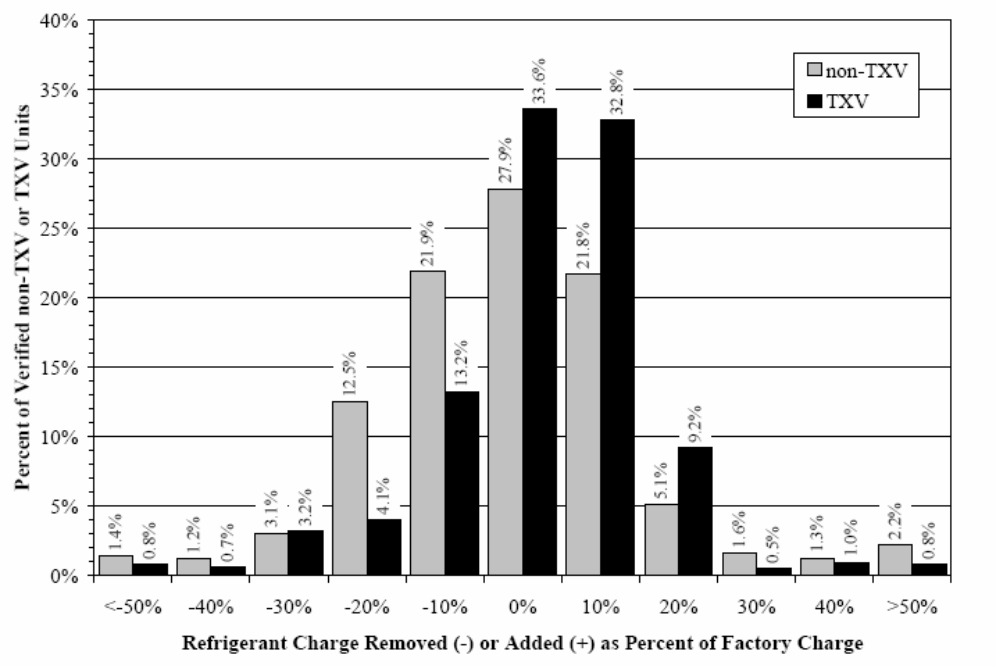
- Appendix RC – Procedures for Field Verification and Diagnostic Testing of Air Distribution Systems;
- Appendix RD – Procedures for Determining Refrigerant Charge for Split System Space Cooling Systems without Thermostatic Expansion Valves;
- Appendix RE – Field Verification and Diagnostic Testing of Forced Air System Fan Flow and Air Handler Fan Watt Draw;

Improper unit sizing savings are not claimed by the Program, but data collected in the study may be sufficient to determine if further study is warranted to quantify sizing savings. Lower effective system efficiency due to the typical installation deficiencies described above could also contribute to a tendency to install oversize units.

Refrigerant Charge Test

The 2005 Energy Efficiency Standards currently allow equivalent credit for refrigerant charge testing and the presence of a thermal expansion valve (TXV)[4]. The presence of TXV, however, does not guarantee that the system was properly charged at the time of installation. Figure 2 shows that at least 66% of units are improperly charged regardless of the presence of TXV.

[4] 151 (f) (7) (Table 151C), 2005 Title 24 Energy Efficiency Standards



Source: Mowris, Robert J. et al. 2004
Note axis is reversed from most other studies. (-) indicates overcharging; (+) indicates undercharging

Figure 2: Improper Charging Relative to Presence of TXV

This evaluation's approach called for refrigerant charge testing at all sites whether or not data were available. Simply following the standards protocol and verifying the presence of TXV would mean several non-participant systems would get credit for proper refrigerant charge since most SEER 13 systems have TXV installed at the factory. It is also known that TXVs save energy and mitigate the effects of improper charge in testing under laboratory conditions.

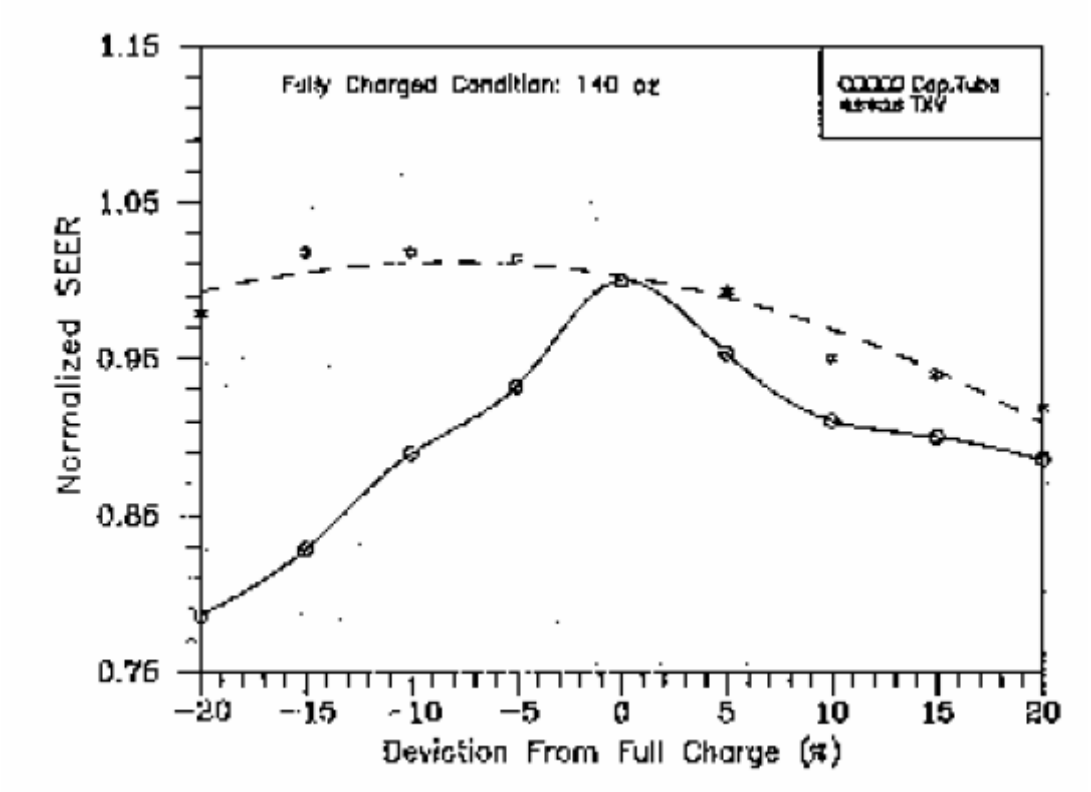


Figure 3: Normalized SEER for capillary tube and TXV systems at various charging conditions (Farzad & O'Neal, 1993)

Furthermore, the amount of system under or over charge cannot be quantified without adding or removing charge from the deficient system and measuring the amount added or removed. If the refrigerant charge is corrected by the study team at the time of meter installation then the effects of improper charge will not be seen in the metered data. Because of this values of superheat for non-TXV and subcooling for TXV units were measured to compare the level of charge between units. An additional study option not included in this evaluation scope would have been to include another site visit after installation to properly charge units that were found to be deficient. This would quantify the amount of under or over charging and lead to direct data on the effect on the remediation on system performance.

Airflow Test

This study's approach called for airflow measurements to be taken at all sites both participant and non-participant. The airflow measurements were compared to the Title 24 standards as well as incorporated into calculations of cooling delivered to the interior of the home. Airflow measurements were made using a CEC approved method of flow grid measurement. The 2005 Energy Efficiency Standards require that a system must provide a minimum airflow of 400 cubic feet per minute per installed ton of cooling (cfm/ton) over a wet coil and 450 cfm/ton over a dry coil.

The standards also require that the duct system be designed to meet the airflow rate with the available external static pressure from the air handler at that airflow.

Total Duct Leakage Test

Our approach included duct testing for non-participants only. Since program participants were required to get duct sealing, the team was confident that the duct performance data available via Program tracking, HERS registry, or building department are accurate and reliable. Since remedial action should have been taken on systems not meeting the standard, all participating systems should be within a few percentage points of the standard. The Evaluators used actual leakage data if available or assumed that the leakage to outside for participants had a mean value equal to the 2005 standard. Most participants complied under option A below.

The standards' requirements for duct leakage depend on the types of changes the ducts undergo when the system is replaced. The meaningful requirements are as follows:

> *i. If the new ducts form an entirely new duct system directly connected to the air handler, the measured duct leakage shall be less than 6% of fan flow; or*
> *ii. If the new ducts are an extension of an existing duct system, the combined new and existing duct system shall meet one of the following requirements:*
>
> > *a. the measured duct leakage shall be less than 15% of fan flow; or*
> > *b. The duct leakage shall be reduced by more than 60% relative to the leakage prior to the equipment having been replaced and a visual inspection shall demonstrate that all accessible leaks have been sealed; or*
> > *c. If it is not possible to meet the duct sealing requirements of Subsections a. or b., all accessible leaks shall be sealed and verified through a visual inspection by a certified HERS rater.* [5]

New and extended HVAC ducts have different requirements. In addition, the leakage to outside metric may have been used for participant or non-participant site compliance. There are also other compliance options that utilize a smoke test. The evaluation performed leakage to outside and total leakage tests on non-participants, while participant permit form contained the test method and compliance option in most cases.

Collecting Cooling End Use Energy Data – Load Monitoring

Spot measurements and short term metering were conducted at all participant and non-participant homes during the cooling season. The amperage draw of each central air conditioning condenser unit was logged at the electrical disconnect. This value is representative of all power consumed for the outdoor components including compressor, condenser fan, and control circuits.

Spot amperage readings were also taken at the evaporator fan to quantify the evaporator fan power. This, in conjunction with instantaneous readings of voltage and power factor, was used to calculate kilowatt and kilowatt hour energy use for cooling.

[5] 149 (b) (2) (D), 2005 Title 24 Energy Efficiency Standards

For instances where multiple air conditioning units were found at a site, all units were tested and monitored.

True electrical power is the product of voltage, power factor, and current. Generally, voltage variation over time at any location is relatively small. For this study it is assumed the voltage will be steady over the monitoring period. It is often assumed that power factor variation is relatively small. Since there was not enough supporting data the Evaluators felt it was in the best interest of the District to have a pilot phase of the study to include true RMS power monitoring early on in the project. While it was cost prohibitive to have true power meters at over 100 sites, the pilot phase helped determine if power factor fluctuations are relatively small or large. Monitoring equipment was left in-place at pilot sites to collect additional data throughout the study period to help inform the larger data sets.

Instantaneous power, voltage, and power factor measurements were not taken until the air-conditioning unit reached steady state operation. For this reason, the measurement is taken after all other home testing and surveying to allow this warm up to occur while performing other work on site. Note that blower fan current and run time data were not collected by the data logger in a split system.

Understanding and Comparing Cooling Energy Use

As discussed previously, two parameters that are the primary drivers of air conditioning performance are condenser air entering temperature and evaporator inlet enthalpy. The outdoor dry bulb temperature and indoor wet bulb temperature allowed for air conditioning bi-quadratic performance curves to be compared directly to the load monitoring data.

Airflow measurements were made using a CEC approved method of flow grid measurement, a fixed orifice plate and differential pressure gauge. By combining instantaneous airflow measurements with logged time series enthalpy data the Evaluators estimated cooling delivered at each site. This data allowed for important comparisons of system output at peak conditions to charge test data and system sizing.

In addition, a home envelope survey collected information sufficient to calculate heat load and size cooling equipment. The heat load for the home from ACCA Manual J was calculated, and the air conditioning power draw and the amount of cooling delivered to the conditioned space were measured. These estimates were then compared and used to determine the effects of improper charge, duct leakage, and low system airflow on the ability of the system to meet the building load.

Data Collection

For this effort, data was collected from both program participants and non-participants. Data collection consisted of on-site engineering inspections, performance diagnostic testing, and short term metering. The purpose of the on-site data collection was to develop an independent estimate of the energy savings associated with the installed measures. Described below are the data collection activities:

Participants and Non-Participants

The air conditioner study period extended at a minimum from August 20th through October 11th in all locations. For all of the participant sites and for the majority of the non-participant sites meters were installed before the first of August. This provided data for the bulk of the cooling season for all sites.

On-site inspection

An inspection was done to verify installed equipment type, quantities and system components. Name plate data was collected from the condensing unit, evaporator coil, and air handler unit. The site surveyor then conducted a heating and cooling load sizing audit. The following home survey data was collected for the purpose of verifying the contractor's sizing calculations.

- Home location
- Home orientation
- Number of stories
- Conditioned floor area and volume measurements
- Framing type and exterior framing properties
- Fenestration and skylight frame areas, material and efficiency properties (low-e, SHGC, U-value if available)
- Foundation type
- Attic insulation level, presence of radiant barrier, and roof color
- Duct system location

Refrigerant Charge Test

Instantaneous temperature and pressure data was captured with a Honeywell Service Assistant® tool. This system is a refrigerant manifold gauge set and a temperature sensor array connected to a handheld computer using proprietary software. It is capable of recording data down to a five second sampling rate. The measurements were:

- Outside dry bulb temperature
- Refrigerant liquid line temperature
- Refrigerant discharge line pressure
- Refrigerant suction line temperature
- Refrigerant suction line pressure
- Condenser discharge air temperature

The condenser discharge air temperature was measured with a Fluke digital thermometer. Air temperature sensors were placed in or near the center of the airstreams at points where the air is well mixed. Refrigerant tube surface mounting sensors were placed on the suction and liquid lines, covered with flexible refrigerant line insulation, and held firmly in place with straps. When the unit reached steady state, as determined by non-changing temperature readings (normally about 10-15 minutes), the Honeywell Service Assistant was used to take simultaneous temperature and pressure readings.

Test accuracy for refrigerant pressure measurements is ± 2% of measurement.

System Airflow

To measure airflow of residential air handlers, a TrueFlow® air handler flow meter was used. The flow meter measures air flow from the system fan by an orifice metering plate that is installed at the air handler cabinet or in a filter slot as close to the air handler blower as possible. Most residential systems have a filter slot at the return grille or a filter slot built into the blower compartment directly upstream of the blower. The metering plate can be installed in either of these locations. If there are multiple returns a metering plate must be installed at each one simultaneously. Once the metering plate is in place, the system fan is turned on and the entering air velocity and the exiting air velocity through the metering plate are measured to obtain fan air flow using a digital differential pressure gauge. Five readings were taken and recorded over a period of about 10 minutes.

Test accuracy is ± 7% of flow measurement (cfm) using the DG-700 digital manometer (± 1%). Actual accuracy can be worse if there is unknown bypass and potential flow stratification issues particularly in packaged units.

Power Testing

At each site all premise air conditioner units underwent a spot power, voltage, amps, and power factor reading with a calibrated Fluke® power meter. Once each unit reached steady state operation the readings were recorded. For split systems where the air handler was not hardwired, spot amperage readings were also taken at the evaporator fan to quantify the evaporator fan power.

Test accuracy for the Fluke meter is ± 2.5% of the reading.

Load Monitoring

The amperage draw of each central air conditioning condenser unit is logged at the electrical disconnect. This value is representative of all power consumed for the outdoor components including compressor, condenser fan, and controls.

The air conditioner monitoring approach utilized the OWL 400 data logger with a 0-2.5 Vdc output 50 amp split core current transducer (CT). This monitoring configuration operated by converting the analog signal of the 50 amp CT to a digital signal usable by the OWL 400. The amp to digital conversion approach was utilized because the OWL 400 is capable of recording 32,767 readings whereas most other data loggers in the class of the Owl 400 utilize a CT with current output have significantly less memory. This was important because the configuration enabled the Evaluators to capture the entire cooling season without having to retrieve data and re-launch the logger mid-project. This data logging configuration did not require any invasive procedures (cutting or splicing) into the existing equipment or wiring. Figure 4 shows the typical Owl 400 data logger installation.

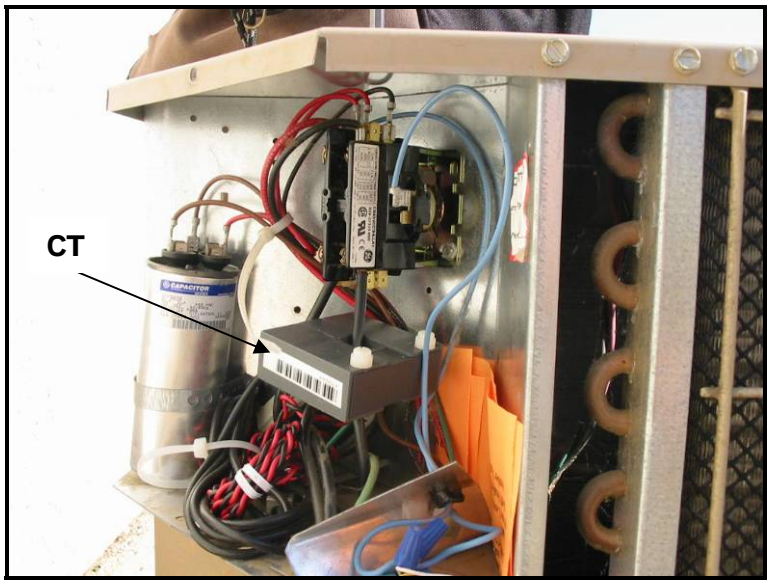


Figure 4: Air Conditioner Condenser Data Logger Installation

The Owl 400 data loggers were configured to instantaneously sample the current draw every eight seconds, store the sampled data in temporary memory, and record the average of the eight second readings at ten minute intervals. The ten minute monitoring interval allowed the Evaluators to capture up to 228 days of cooling run-time data. The data loggers were configured to stop recording data when the memory reached capacity to avoid overwriting previously collected data. Five-minute interval data would have been preferred by the evaluation team to capture cycling behavior. In homes with multiple air conditioners, data loggers were installed on each unit even if only one system was replaced.

Test accuracy for this OWL logger is ± 1% of full scale

Temperature Logging

Ambient air temperature and humidity was acquired from HOBO Microstation weather stations that were deployed at two selected sites within District territory. Temperature and humidity at the unit was logged with HOBO U10 Temp/RH loggers placed in the supply and return airstreams and combined with airflow measurements to estimate the amount of cooling delivered to the space. A HOBO Temp logger was placed at the indoor thermostat to measure indoor temperature.

Test accuracy for temperature measurements is ± 1 ºF. Actual accuracy of wetbulb measurements follows a curve as moisture evaporates or is ± 2.5% of relative humidity when an RH sensor is used.

Non-Participants Only

Infiltration

To measure the infiltration of a home the evaluation team used the Minneapolis Blower Door™. The Minneapolis Blower Door™ uses a fan and frame assembly that is

temporarily sealed into an exterior doorway. The testing is performed at a pressure difference of 50 Pa (0.2 inches of water column) to create a slight pressure difference between the inside and outside of the house. By measuring the airflow that is required to maintain 50 Pa, the air tightness of the house can be gauged. RLW measured infiltration using a digital pressure gauge. The test is performed at least three times to ensure reasonable and consistent measurements.

Test accuracy for the blower door flow calibration is ± 3% using the DG-700 digital manometer (± 1%).

Total Duct Leakage

To measure the HVAC system total duct leakage, a Minneapolis Duct Blaster® was used. The Minneapolis Duct Blaster® measures the amount of leakage in the duct system by pressurizing the ducts with a calibrated fan and simultaneously measuring the air flow through the fan. The duct blaster fan is connected directly to the duct system in a house, typically at a central return, or at the air handler cabinet. The remaining supply registers and grilles are taped off. The duct system is then pressurized to 25 Pa in relation to the house and duct system leakage is measured using a digital pressure gauge. The test is performed at least three times to ensure reasonable and consistent measurements.

Test accuracy for the duct blaster flow calibration is ± 3% using the DG-700 digital manometer (± 1%).

Duct Leakage to Outside

To measure the HVAC system duct leakage to outside, a Minneapolis Duct Blaster® in conjunction with the Minneapolis Blower Door™ were used. The Minneapolis Blower Door™ uses a fan and frame assembly that is temporarily sealed into an exterior doorway and the house is then pressurized to 25 Pa in relation to outside. The duct blaster fan is connected directly to the duct system in a house, typically at a central return, or at the air handler cabinet. The remaining supply registers and grilles are taped off. The duct system is then equilibrated to the house pressure by pressurizing the ducts to 0 Pa. The fan airflow required to maintain duct pressure is the system leakage outside the thermal envelope of the home. The test is performed at least three times to ensure reasonable and consistent measurements.

Test accuracy for the blower door flow calibration is ± 3% using the DG-700 digital manometer (± 1%). Test accuracy for the duct blaster flow calibration is ± 3% using the DG-700 digital manometer (± 1%).

Energy and Demand Savings Analysis

A baseline model was estimated 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 during the same period of time. The overall estimates of savings thus obtained 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.

Data Preparation

In order to ensure accurate and reliable results from the analysis, it was necessary to perform a variety of quality control measures with the data. Of the handful of issues that were discovered during the analysis, the most challenging was that of incorrect timestamps recorded on a number of loggers. In order to preserve the data with bad timestamps, the kW data was compared to estimated capacity values based on ambient temperature as well as supply and return temperatures. From this profile, the offset of the bad timestamps were discovered and adjusted accordingly.

Another issue with the data was misleading A/C data caused by the use of heat pumps. Because heat pumps can be used for both cooling and heating, the loggers recorded energy use for both purposes. By evaluating a number of variables such as ambient and return temperature, the Evaluators were able to develop a rough characterization of energy usage for sites with heat pumps and based on these usage characteristics, remove the heating-based usage from the data.

Additionally, a series of quality control steps were taken to check for missing data and outliers. Utilizing a combination of automated QC routines and data visualization tools, any abnormalities in the data were flagged and either fixed or removed from the analysis, depending on the nature of the problem.

Of the 60 participant sites where testing and metering was conducted, 50 were included in the analysis. Of the 50 non-participant sites, 44 were included in the analysis. The primary reason for excluding a site from the analysis was due to some type of problem with the A/C logger. Additionally, because of the issues with some A/C logger timestamps, if the data from the return or supply loggers was suspect, there was no way to cross check the data from the A/C logger and therefore, the site was excluded. Overall, a very conservative approach was taken with the data. Because the sample size was so small, it was deemed better to include only data that was know to be good, rather than risk biasing the results of the analysis by using suspect data.

Savings Estimation

A baseline model was estimated from the non-participant data and an overall estimate of savings was calculated using ratio estimation comparing the total normalized usage from individual participant sites to the estimates from the baseline non-participant normalized usage model. The overall estimates of savings thus obtained 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.

Weather Regions

HOBO Microstation weather stations were deployed at two selected sites within District territory splitting the participant and non-participant sites into North and South regions. Originally, the analysis was to be performed separately on these two regions. After examining the ambient temperature data, it was determined best to combine the regions for the analysis—there was not a large enough difference between the two to indicate that there would be considerable improvements in precision from stratifying. Figure 5 and Figure 6 show the North and South ambient temperature profiles. The profiles follow the same relative pattern; however, the South profile covers a slightly wider range than the North profile. The average absolute difference between the two profiles was 3.3 F.

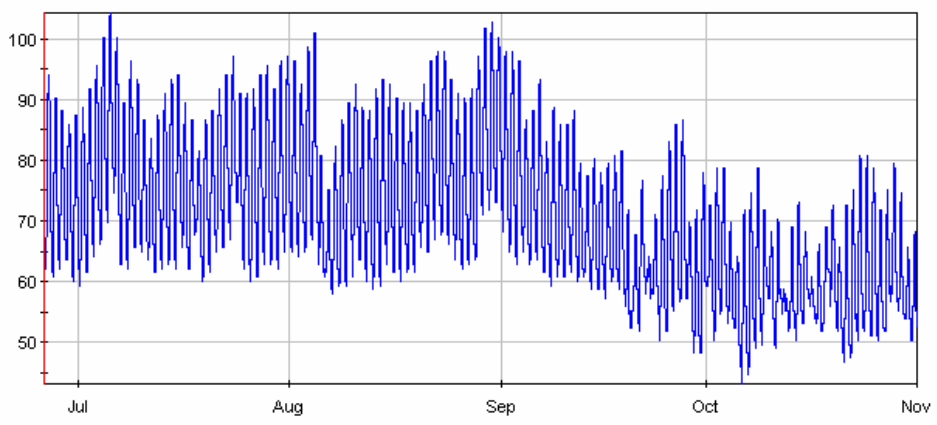


Figure 5: North Ambient Temperature Profile

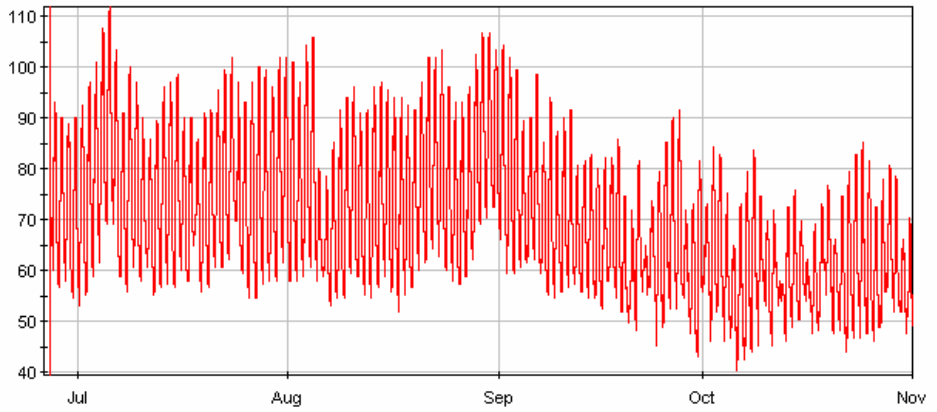


Figure 6: South Ambient Temperature Profile

Normalization Techniques

In order to limit the effects of potential sources of bias on the results of the analysis, a normalization factor was used to make the usage data more comparable. The primary source of concern over bias in the results was related to potential differences in the average house size as well as the heating and cooling characteristics of the households between the non-participant and participant sites. Because this study is measuring the savings from A/C usage, the normalization factor cannot be related to characteristics of

the A/C unit without introducing a potential source of bias. For example, if results were normalized by tonnage, oversized units would appear to have lower normalized usage levels and undersized units would appear to have higher normalized usage levels compared to their properly sized counterparts. Instead of using an equipment based normalization factor, the evaluation team utilized a factor created by the ACCA called Manual J load factor to estimate the appropriate size of an A/C unit for a household based on characteristics such as square footage, insulation levels, and types of windows. By normalizing by the Manual J load factor, usage levels from different households can be compared without introducing bias based on the difference in cooling characteristics between the two households.

Non-Participant Baseline

The first step in the analysis was to create a non-participant baseline. The kW usage was normalized against the Manual J load factor. The baseline was assembled from the average non-participant normalized usage for each recorded timestamp. For example, all non-participant data points for kW usage recorded at 2:30 on August 2, 2007 were averaged to represent the non-participant baseline usage at that particular date and time. One issue that needed to be addressed was that of variable periods of recorded data per site. In order to limit the greater-than-average influence of sites with longer periods of recorded data, the Evaluators only included non-participant baseline estimates that were averaged from a minimum of 10 sites worth of data. The resulting profile ranged from 7/1/07 to 10/15/07. This range of dates was sufficient enough to capture both the savings from high usage summer months as well as low usage fall months. The temperature profiles in Figure 5 and Figure 6 show a relatively steep decline in ambient temperatures between September and October.

Ratio Estimation

The second step in the analysis was to use ratio estimation to produce an overall savings ratio estimate. Each participant site was matched against the period of time from the non-part baseline profile that corresponded with its recorded data, and the total usages for both were calculated. For example, if site A had 10 days of recorded data in July, the total usage of that site is calculated and compared to total usage during the same 10 days of the baseline model. Once the totals were calculated for the participant sites and paired with the corresponding baseline totals, an overall ratio of participant usage over non-participant usage was calculated.

Annualizing the Savings Estimate

In order to annualize the savings estimate, it was necessary to develop an estimate of annual non-participant baseline usage. Due to the nature of A/C usage, the evaluation team decided that the best method was to create a regression model of average daily non-participant usage against the peak daily temperature. While this method ignores the detailed characteristics of the temperature profile, it allows for a better regression model estimate compared to using non-averaged data. Figure 7 shows a scatter plot

between the average daily non-participant usage and the peak daily temperature. The Adjusted R-squared value for the regression was 0.78, which implies that the resulting regression equation is a fairly good approximation of the data.[6]

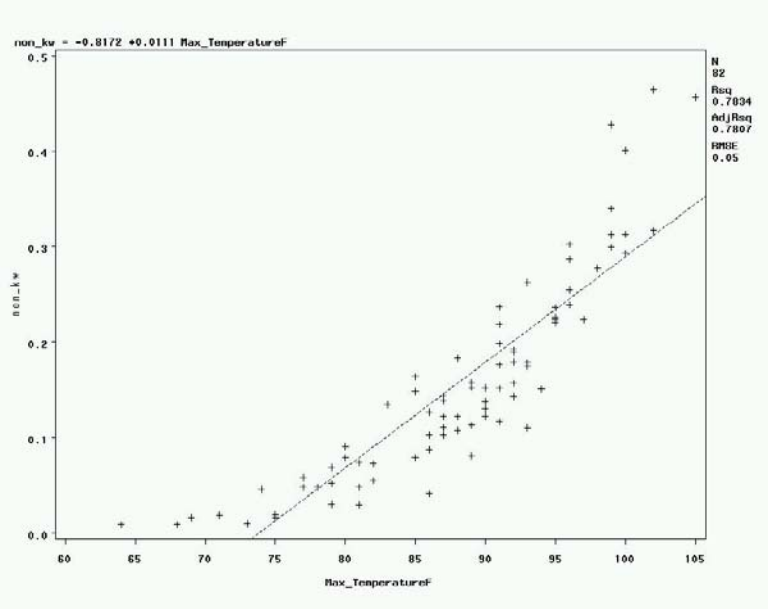


Figure 7: Average Daily Usage and Peak Daily Temperature

In order to create a more accurate yearly profile, a cut point was set to limit the usage in cooler months. It is quite common for users to turn off their A/C units during winter months, regardless of temperatures. In light of this, all predicted A/C usage during the months of January, February, November and December were set equal to zero, regardless of the prediction estimates.

Once the yearly temperature profile was estimated, the savings ratio was used to estimate a corresponding participant profile estimate. The difference between these two profiles was calculated and the average difference was the average daily savings.

Precision Estimate

Moving beyond the original precision estimates outlined in the sampling section, the precision reported was calculated based on actual variation in the sample. In order to estimate the error associated with the savings analysis model, it was necessary to make the assumption that the non-participant baseline created from the average of the non-participant data had no error associated with it—that it is a precise and unbiased estimate of baseline A/C usage. Essentially, this estimate of error is the measurement of the variation of savings of the participant sites included in the analysis compared to a standard, error free baseline.

[6] An adjusted R-squared value of 1 implies a perfect fit and a value of 0 implies no correlation.

From the estimate of error, a value for relative precision is produced. The relative precision was calculated at the 90% confidence level. The following formula shows the calculation of the error for each data point (total site level participant usage vs. comparable baseline usage):

$$e_i = y_i - \hat{B}\, x_i ,$$

where $\hat{B}$ is the overall savings ratio calculated in the analysis, x_i are the participants' overall usages, and y_i are the corresponding non-participant baseline usages. The errors are used to compute the standard error.

$$se\left(\hat{B}\right) = \left(\frac{1}{\hat{X}}\right)\sqrt{\sum_{I=1}^{n} e_i^2} \text{ , where } \hat{X} = \sum_{i=1}^{n} x_i$$

The standard error is used to compute the error bound at the 90% confidence interval as well as the relative precision.

$$eb\left(\hat{B}\right) = 1.645\; se\left(\hat{B}\right), \text{ and } rp = \frac{eb\left(\hat{B}\right)}{\hat{B}},$$

where $eb\left(\hat{B}\right)$ is the error bound and rp is the relative precision, both at the 90% level of confidence. The error bound represents the range from the sample mean in which there is a 90% probability that the true population mean lies within this range. The relative precision is the percentage of the error bound compared to the mean estimate.

Peak Analysis

The criteria for peak usage used in this analysis called for the three hottest consecutive weekdays between 4 pm and 7 pm. After evaluating the temperature data, August 29-31, 2007 were chosen as the peak days. In order to produce an estimate of savings during this peak usage period, the average usage was calculated for both parts and non-parts by time period and the savings were calculated based on the difference between the two estimated profiles.

Ratio estimation was not used for the peak analysis, as the Evaluators were capable of directly comparing participant and non-participant usage over the defined peak periods.

EER Sensitivity Analysis[7]

[7] Formulae from 4.7.1, (4-20), 2005 Residential Alternative Calculation Method Approval Manual and DOE-2.2 defaults for RESYS2, documented in "Improving DOE-2's RESYS Routine: User-Defined Functions to Provide More Accurate Part Load Energy Use and Humidity Predictions" August 2000, LBNL-46034 http://gundog.lbl.gov/dirpubs/46304.pdf.

In order to isolate the savings created by the use of higher efficiency units, an EER sensitivity analysis was conducted. A theoretical power curve was calculated from the following set of equations:

$$eernf = 0.790875(1.0452 * eer + 0.0115 * eer^2 + 0.000251 * eer^3)$$

$$syscap = 12000 * tons, \quad eirari = 3.412 * (1/eernf)$$

$$cool\_cap\_ft = 0.87403108 - 0.0011416 * ewb + 0.0001711 * ewb^2 - 0.00296 * odb + 0.00001018 * odb^2 - 0.00005917 * odb * ewb$$

$$cool\_eir\_ft = -1.063931 + 0.03065843 * ewb - 0.0001269 * ewb^2 + 0.015421 * odb + 0.00004973 * odb^2 - 0.0002096 * ewb * odb$$

$$eir = eirari * cool\_eir\_ft, \quad cap = syscap * cool\_cap\_ft$$

$$power = 0.29308324 * eir * cap / 1000$$

where eer is the unit energy efficiency ratio, ewb is the evaporating entering wet bulb temperature and odb is the outdoor dry bulb temperature. Originally, both ewb and odb were calculated from measured temperature data, however in order to get more reliable runtime estimation, the average ewb for the top 25% of non-zero usage levels was used. This smoothed out the power curve and stabilized the runtime estimations. Once the power curve was estimated, a runtime estimate was calculated for each kW measurement by dividing measured kW by estimated power.

$$Runtime = \frac{KW}{Power}$$

After the runtime was calculated for each measurement, a new power curve based on an EER of 11 was calculated for each unit. This new power curve was multiplied by the runtime produced from the original power curve to produce an estimate of kW usage. The estimated kW usage for an EER of 11 was then compared to the original kW measurements in order to estimate the savings due to improvements in unit efficiency. This was done for both participants and non-participants.

$$KW(eer = 11) = Power(eer = 11) * Runtime$$

Figure 8 shows an example of a profile generated from the analysis. The red kW profile and power curve are the hypothetical EER 11 power and kW profiles. The blue profiles represent the original meter data and the power curve created from the original EER rating (in this case, an EER of 12). The difference between the hypothetical kW and the actual kW represent the estimate of savings due to higher unit efficiency.

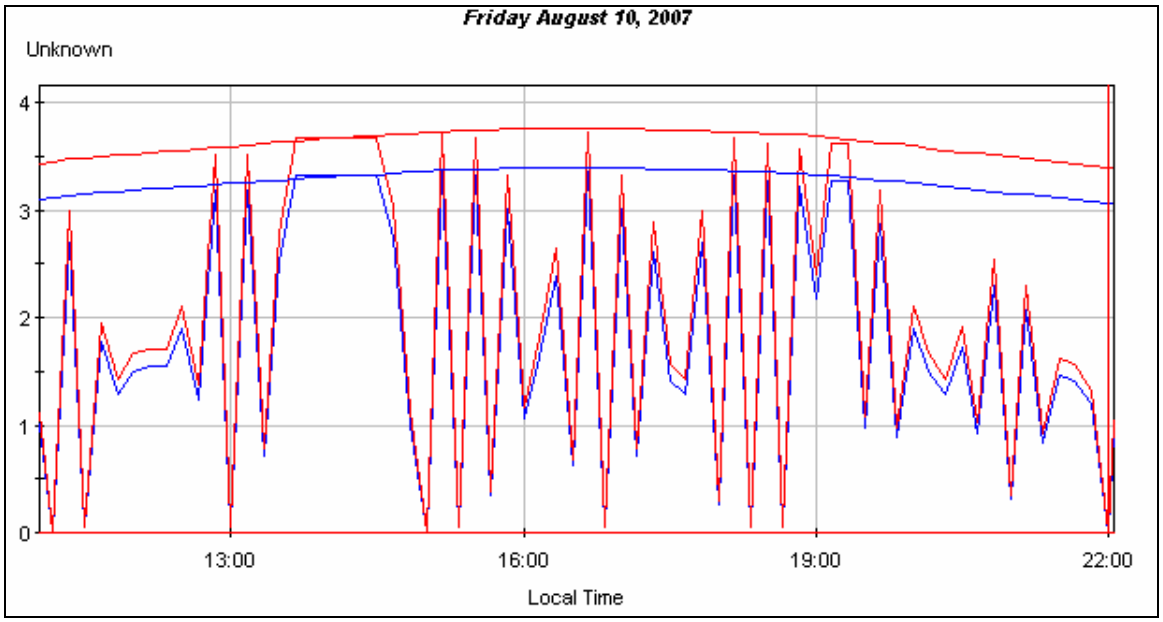


Figure 8: P178 EER Sensitivity Profile

Efficiency Peak Analysis

As with the baseline analysis, a peak analysis was performed using the EER sensitivity model. The period between 4 pm and 7 pm on August 29-31, 2007 was isolated from the rest of the data and a savings estimate was calculated.

Freeridership Analysis

Applying Freeridership

This study's approach to quantifying savings was designed to measure net savings through both participant and non-participant testing and metering. Therefore, the resulting freeridership rate was not applied to the ex-post measured savings. It may be interesting to compare the measurement of net savings with an estimate of adjusted assumed savings with freeridership applied. However, it does not seem reasonable to apply the inverse of freeridership to the measured estimate to yield net savings for the Program. Freeridership was developed as equipment freeridership and compliance freeridership to provide the District with these estimates, though they are not applied to analysis results in this study. It is recommended that only the equipment freeridership be applied to equipment efficiency savings by the District and duct sealing compliance freeridership should be considered but not applied. The duct sealing compliance freeridership has a great deal of uncertainty given that many customers learned about the code requirements from program participating contractors yet said they would have had ducts tested without the District rebates. Application is further complicated by the fact that repair rates are not tracked and some identified "duct sealing freeriders" may not have had any duct repairs at all.

Through questions asked in telephone and on-site surveys the Evaluators attempted to determine the following for each participant:

- How did they find out about the program?
- What was the reason for the replacement?
- What would have been installed in absence of the rebate program?
- When would that equipment have been installed in absence of the rebate program?
- What compliance path would have occurred in absence of the rebate program?

Through measurements in the field and research at the building departments the evaluation team hoped to inform the following assumptions:

- Are baseline systems all 13 SEER?
- Do 80% of the systems need repairs to reach duct leakage targets?
- Do 70% of the systems need RCA remediation?

The freeridership approach is presented in logical and analytical order. A flow diagram of the methodology is presented in Appendix A.

Freeridership Approach

Equipment Freeridership

In quantifying freeridership it is important to understand the program delivery mechanism. The Program is delivered and may be marketed by A/C contractors and also markets itself through mass media. In order to identify the program delivery mechanism, all participants who completed the telephone survey were asked the following question If participants responded that they first became aware of the program through their contractor or through any SMUD source they were given a credit towards their freeridership score.

Phone Q3

How did you first become aware of SMUD's Air Conditioner Rebate program?

1. *Message in SMUD bill*
2. *Air Conditioning Contractor*
    a. *Before, During or After Installation?*
3. *SMUD Bill Pay Website*
4. *In-store Clerk or Advertisement*
5. *Newspaper Ad*
6. *Billboard*
7. *Friend/colleague*
8. *Previous Participation*

50. Other:_____

98. DK/Refused

Some contractors may not present options to the customer, but rather provide one, "this is the best I can give you", quote and the customer accepts it without making a purchasing decision. This scenario was assumed to be the most common. Often, the customer first makes a service call, next discovers that a replacement is necessary and, last, makes the purchase as if it were a "necessary repair" to an essential home component. This case was classified a non-freerider or 0% freeridership factor.

If the contractor presented options to the customer or if the customer learned about the Residential HVAC program through means other than the contractor, this is the point at which a purchasing decision was made and the freeridership estimate truly began.

The rebate and/or financing may motivate the customer towards early retirement instead of replacement on burnout, especially if the customer found out about the program through marketing and not after they called out a contractor for service on the old unit. Although the difference in savings associated with early replacement was not addressed in this evaluation it should be noted that gross savings would change. This case was also considered a non-freerider or 0% freeridership factor.

The following question was asked to determine what options were presented by the contractor:

Field Q9

What options did the contractor offer you when purchasing the unit that helped you decide to purchase the unit you installed? (Circle all that apply)

1. *No options were presented, they only presented the "Best offer"*
2. *ENERGY STAR Rated Unit*
3. *Free Heat Load Calculation (most units are not properly sized)*
4. *Latest technology on the market*
5. *ENERGY STAR Rated Programmable Thermostat*
6. *TXV (thermal expansion valves)*
7. *Routine Maintenance*
8. *Unit that had variable speed air handler*
9. *Duct Sealing and/or Testing*
10. *Upgrade filter system*
11. *Other:*_____
12. Don't Know/Don't Recall

Customers were asked a battery of questions in an attempt to determine what would have been installed absent Program intervention. The questions for rebated and financed customers differed slightly. Participants were asked whether or not they still would have replaced their unit if the rebate or financing had not been available, and, if yes, what level of efficiency equipment they would have installed and when that equipment would have been installed. Refer to Appendix A to see the scores that were attributed to each combination of answers.

Freeridership Questions for Rebated Participants

Field Q1

Had the SMUD rebate not been available, which of the following would you have most likely done?

1. *Still would have purchased a high efficiency higher cost unit like the one installed*
2. *Would have purchased a unit, but a less expensive less efficient unit*

3. *Would have purchased a unit, recommended by the A/C contractor*
4. *Would not have purchased a unit*
5. *Other:_____*

98. DK/Refused

Field Q2

Assuming the rebate had not been available; at what time would you have purchased a new unit?

1. *Same time or sooner (1-6 Mo)*
2. *Several months later (6 Mo- 1Yr)*
3. *One year later*
4. *More than a year later (1-2 years)*
5. *Greater than 2 yrs*

98. DK/Refused

Field Q3

Did you receive a federal tax credit in addition to the SMUD rebate?

1. *Yes*
    a. *How did you lean about the credit?*
        i. *Contractor*
        ii. *Other*
    b. *How influential was the credit in your decision to install 15 SEER or better?*
        i. *Very influential*
        ii. *Somewhat influential*
        iii. *Not very influential*
        iv. *Not at all influential*
2. *No*
3. *Other:_____*
4. *DK/Refused*

Freeridership Questions for Financed Participants

Field Q4

Had the SMUD financing not been available to you, and only the SMUD rebates were available, which of the following would you have most likely done?

1. *Still would have purchased a new unit*
2. *Would have kept the existing A/C in place (Spillover, Confirm Age of Old Unit)*
3. *Other:_____*

98. DK/Refused

Field Q5

Assuming the SMUD financing had not been available; at what time would you have purchased a new unit?

1. *Same time or sooner*
2. *Several months later*
3. *One year later*
4. *More than a year later*

98. DK/Refused

Field Q6

Assuming neither SMUD financing or SMUD rebates had been available, which of the following best describes the efficiency decisions you would have made?

1. *I would have purchased a higher cost higher efficiency unit*
2. *I would have purchased a less expensive less efficient unit*
3. *The same*
4. *Other:_____*

98. DK/Refused

There was further questioning to determine if the responses to the initial freeridership question were reasonable. Reasonability checks were performed by reviewing responses to certain questions and comparing those with the initial freeridership score to identify inconsistencies. When inconsistencies were encountered the freeridership scores were altered accordingly to reflect this.

Participants were asked questions about their purchasing decision in regards to the reason for replacement of the unit (Q7) and information sources used in making the purchasing decision (Q8). For example, a participant's response indicating early retirement was verified if he responded that he replaced his cooling system because he was concerned with how long it would last. Conversely, a participant that purchased the same type of unit as he previously owned and was originally scored as a non-freerider would be labeled as inconsistent and some points would be added to his score.

Field Q7

What was the main reason you recently decided to purchase a new central air-conditioner? (circle all that apply, read only as necessary)

1. *Unit was not functioning properly or was broken*
2. *Unit was still working OK, but I was concerned with how long it would last*
3. *To replace inefficient system with more efficient system*
4. *Needed to replace heating system, cooling system replaced at that time*
5. *Wanted to add central A/C (no central A/C previously)*
6. *Unit was not serving the load needed a second system*
7. *Home Renovation / Making Structural Changes*

98. DK/Refused

Field Q8

What information sources did you rely on when making the decision to purchase your unit? READ ALL (Circle all those that apply)

1. *Installed the same type of unit or manufacturer as we previously owned*
2. *Contractors Recommendations*

3. Manufacturer Brochures/Marketing Material
4. Reputation/Brand Name/Best Seller
5. Word of Mouth
6. SEER/EER rating (Efficiency Level)
7. Utility Website
8. Online Websites ACEEE, ACCA, Department of Energy, Energy Star.gov
50. Other:_____

An additional attitudinal question was asked to confirm the core freeridership responses. By ranking the considerations used in selecting the unit, the Evaluators were further able to identify the importance of financing and energy efficiency to confirm or question the initial score (Q11).

Field Q10
What are the top three considerations you had when selecting an HVAC unit? (Indicate order in which the customer responded) (READ ALL)

#1_____ #2_____ #3____

1. Cost
2. Reliability
3. Features
4. Energy Efficiency
5. Warranty
6. Reputation/Name Brand
7. Contractors Recommendation
8. Financing / Interest Rate
50. Other:
_____

Duct Sealing Compliance Freeridership

To make a final determination of freeridership the evaluation team needed to investigate how influential the program was in participants' decision to pull a permit (Q12) and compliance knowledge, particularly in terms of the duct testing and sealing options (Q13). Those respondents who stated they would have opted for duct testing and sealing without the program were given an initial freerider score of 100%. Those who said they would have opted for the high efficiency furnace were considered an initial non-freerider. Phone Q3 (how did you first become aware of the program?) and inconsistencies in the equipment freeridership analysis were examined to arrive at a final duct sealing compliance freeridership score.

Field Q12
Are you aware as to whether or not you or the contractor filed for a building permit for this replacement?

1. Not Aware
2. Submitted by Homeowner
3. Submitted by Contractor
98. Unsure/Refused

Field Q13

Are you aware of the requirement to have either a high efficiency equipment or duct sealing at the time of A/C change out? Which option did you take?

1. *High Efficiency Furnace (AFUE 90 or greater)*
2. *Duct Testing and Sealing*
3. *No I was not aware of the requirement*
98. *Unsure/Refused*

Originally, a question about contractor selection was to be used to further confirm the determination of whether or not the participant would have been code compliant absent the program (Q9). However, the Evaluators decided that this question was more useful to look at qualitatively. Freeridership scores were presented as an average for each selection methodology so that the District could see from where the majority of freeriders were coming.

Phone Q4

How did you go about selecting a contractor to install your equipment? (Circle All That Apply)

1. *Already knew a reputable contractor who installed or performed maintenance on a previous unit*
2. *Requested multiple bids selected least expensive offer*
3. *Phone Book*
4. *Newspaper AD*
5. *Friend/colleague Recommendation*
6. *Internet Search*
7. *Referred to the SMUD Web site for list of participating contractors*
8. *ACCA (A/C Contractors of America) Website*
50. *Other:* _____
98. *DK/Refused*

RCA Compliance Freeridership

This freeridership rate was not addressed.

Spillover

The Program assumes replacement on burnout; however the program may have influenced the timing of the replacement. This may be the only feasible spillover savings for the Program. The rebates and financing may also have different affects on timing. It should be noted that it is difficult to isolate other forms of spillover since a majority of savings is through non-participant non-compliance.

Through telephone surveys with participant and non-participant questions were asked to determine if spillover existed. Participants were asked about additional energy efficiency

measures that had been installed post-participation in the Program and non-participants who had opted for high efficiency units were questioned about their purchase decisions. However, additional measures need to be attributable to influence from SMUD. Any spillover savings identified through the survey questions need to be quantified by age of equipment replaced and, possibly, performance of the replaced units.

Cost Analysis

All recruited sites were asked to provide HVAC invoices and contractors were asked about typical costs. The goal of this task was to determine what amount of a customer's cost was attributed to the measure and what amount was attributed to labor. The Evaluators were not able to obtain itemized invoices but rather total job costs.

The intent was that auditors would be able to gather detailed, line-item, cost data from contractor invoices. The on-site instruments were geared to collect the following data:

Line Item	Equipment Cost	Labor Cost
Condensing Unit	$	$
Cooling Coil	$	$
Furnace	$	$
Add Duct Runs	$	$
Duct Leakage Test	$	$
Duct Sealing/Repair	$	$
HERS Inspection	$	$
Filtration System	$	$
Other Repairs	$	$

Table 17: Detailed work order cost collection table

Unfortunately, once on-site the auditors discovered that contractors rarely itemize their invoices. Instead, items are often still listed individually but only one total cost is supplied. This made it impossible to use customer invoices for detailed equipment and labor cost delineation.

Fortunately, the Evaluators were able to utilize other sources to form estimates regarding equipment and labor costs. The DEER Database houses estimates for base equipment cost, measure equipment cost, incremental equipment cost, labor cost, and installed cost for a variety of measures. The data is broken down by measure type, efficiency, and size and covers residential HVAC equipment offered by the District's Residential HVAC program. The Program tracking data reported the measure type, efficiency, size, and total customer cost. This data was matched to the DEER measure cost estimates for measures of the same type, efficiency, and size.

The DEER cost data was used to determine what percentage of the total installed cost was associated with the equipment, and what was associated with the labor. The dollar amounts for each were divided by the total installed cost giving the percentage breakdown. Those percentages were then applied to the individual customer's cost to estimate what the equipment and labor costs were to each customer.

4. Survey and On-site Findings

Sample and Population Sizes

All populations were estimated from the random Mass Market Survey except the 2006 participant population was known from the tracking data. The group of all participants was further analyzed and results are presented below.

Group	Estimated 2006-07 Population	2006 Population	Surveyed	Metered	Used in Energy Analysis
Non-Participants	15268	7632 [8]	147	50	44
Participants	8850	4424	97	60	50

Table 18: Sample and Population Sizes

All participants were further analyzed primarily for system efficiency and tonnage. The efficiency distribution and size distribution for specific system types should be gleaned from these data as they are not presented by system type for the metered sample.

SEER Bin	PAC	PHP	SAC	SHP	Grand Total
<13	2				2
13<=SEER<14	83	13		1	97
14<=SEER<15	796	53	1440	281	2570
15<=SEER<16	63	10	1019	210	1302
16<=SEER<17	48	3	213	26	290
17<=SEER<18	1		94	33	128
SEER>=18			23	12	35
Grand Total	993	79	2789	563	4424

Table 19: Participant Population SEER Distribution

EER Bin	PAC	PHP	SAC	SHP	Grand Total
<11	1	1	1		3
11<=EER<12	196	43	5	27	271
12.5<=EER<13	24	2	636	216	878
12<=EER<12.5	760	32	1451	270	2513
13<=EER<14.5	12	1	692	50	755
EER>=14.5			4		4
Grand Total	993	79	2789	563	4424

Table 20: Participant Population EER Distribution

[8] This number was estimated through the Mass Market Survey.

Tonnage Bin	PAC	PHP	SAC	SHP	Grand Total
1.5	2		14	3	19
2	217	14	189	60	480
2.5	119	17	497	148	781
3	399	29	968	211	1607
3.5	85	7	432	64	588
4	139	9	506	71	725
4.5	5	1	33		39
5	26	2	149	6	183
5.5			1		1
6	1				1
Grand Total	993	79	2789	563	4424

Table 21: Participant Population Tonnage Distribution

Metered Sample

The following sections provide a basic summary of participant and non-participant system characteristics of the metered sample followed by detailed discussions of the groups and how those characteristics may have affected results.

Summary Characteristics by Sample Point

Basic characteristics such as system type, refrigerant type, presence of TXV, efficiency and tonnage are compared in the following tables. The nuances of the groups are further described in the detailed sections below.

System Type	N
Split A/C	41
Package A/C	13
Split HP	5
Package HP	2
Refrigerant Type	**N**
R-22	41
R-410A	20
Metering Device	**N**
TXV	44
NON-TXV	2
DK	15

Table 22: Participant System Characteristics

System Type	All	Permitted	Non-Permitted
Split A/C	38	9	29
Package A/C	10	3	7
Split HP	3	2	1
Refrigerant Type	**All**	**Permitted**	**Non-Permitted**
R-22	45	10	35
R-410A	5	4	1
DK	1	0	1
Metering Device	**All**	**Permitted**	**Non-Permitted**
TXV	30	10	20
NON-TXV	9	1	8
DK	12	3	9

Table 23: Non-Participant System Characteristics

Tons	N
2	5
2.5	9
3	26
3.5	10
4	7
5	4
SEER	**N**
13.0	2
14.0	31
14.1	2
14.3	1
14.4	1
14.4	1
14.5	4
15.0	13
15.5	2
16.0	2
16.1	1
16.5	1
EER	**N**
11	2
11.5	1
11.6	2
11.75	1
12	38
12.2	1
12.25	1
12.5	7
13	8

Table 24: Participant System Performance

Tons	All	Permitted	Non-Permitted
1.5	1	0	1
2	3	0	3
2.5	7	1	6
3	18	9	9
3.5	8	0	8
4	7	2	5
5	7	2	5
SEER	**All**	**Permitted**	**Non-Permitted**
10	12	1	11
10.5	1	0	1
12	4	1	3
13	31	10	21
14	2	1	1
16	1	1	0
EER	**All**	**Permitted**	**Non-Permitted**
8.5	12	1	11
9	1	0	1
10	4	1	3
11	31	10	21
12	3	2	1

Table 25: Non-Participant System Performance

Participants

60 participant homes were visited. One home had two replaced HVAC systems incented through the program; therefore 61 units were tested and metered. Following is a breakdown of the system characteristics observed on-site. Table 26 shows that two-thirds of participant homes had split A/C systems with the next most common system being package A/Cs. 67% of systems use R-22 as the refrigerant while the other third uses R-410A. As was expected, the majority of homes, 72%, were proven to have TXVs. In actuality this number is likely to be higher due to the difficulty in verifying the presence of a TXV; the Evaluators were unable to determine the metering device type in 25% of sites.

System Type	n=61
Split A/C	67%
Package A/C	21%
Split HP	8%
Package HP	3%

Table 26: Participant System Type

The variation in participant power factor is shown in Table 27. The average power factor was 0.91 with a minimum of 0.78 and maximum of 0.99.

	Participant PF
Average	0.91
Minimum	0.78
Maximum	0.99

Table 27: Participant Power Factor Variation

Figure 9 shows the distribution of tonnage across all participant systems. Almost half of systems are 3 tons with the majority falling in the 2.5 to 4 ton range. There were very few 2 ton and 5 ton systems.

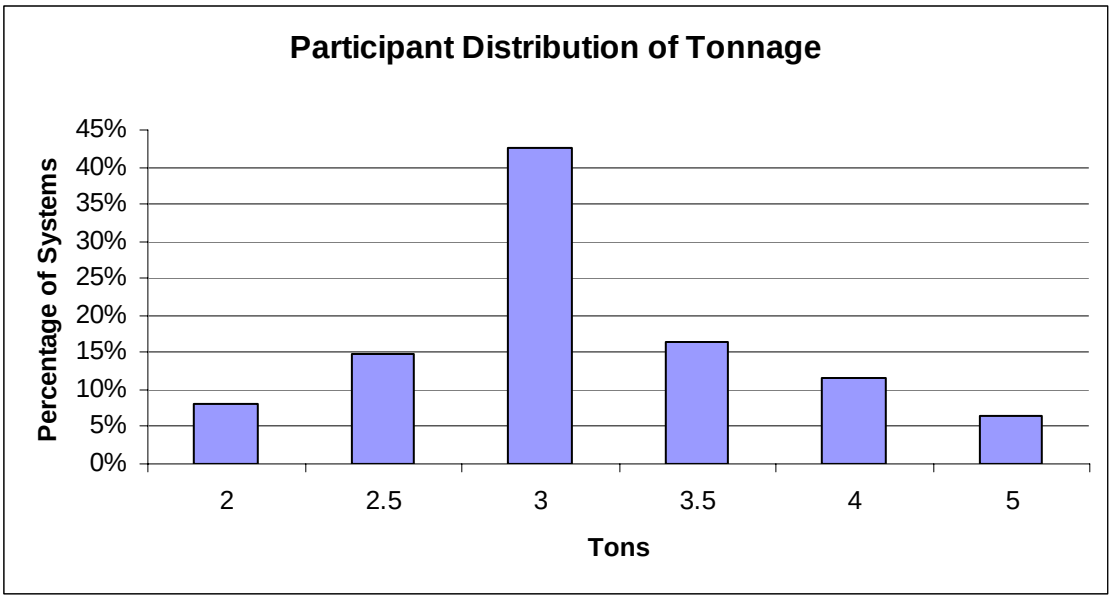


Figure 9: Participant Tonnage of System

The majority of systems were in the 14 to 15 SEER range, as is exhibited in Figure 10. This aligns with requirements for participation except for 2 participants that were found to have systems rated at 13 SEER, below the minimum level required by Tier 1. The size distribution of the participant population as a whole shows numerous package units with efficiencies below the 14 SEER minimum. However, only 2 of these units had EERs below 11, the minimum for package unit participation in Tier 1.

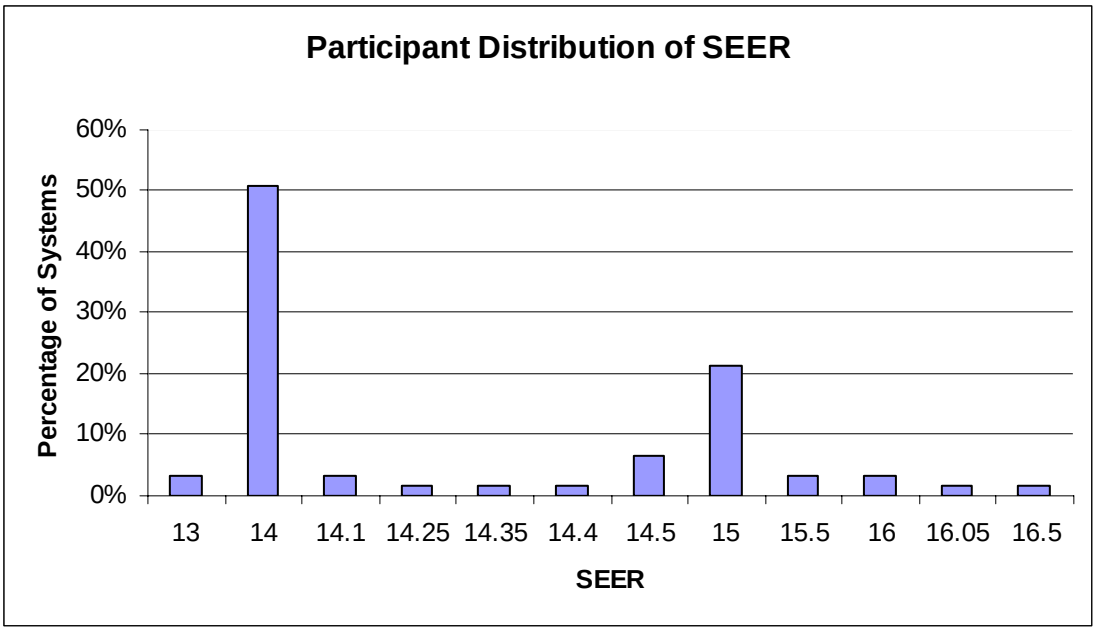


Figure 10: Distribution of Participant SEER

Figure 11 shows that all package systems were over 11 EER, with most at 12 EER. Most split systems were also 12 EER; however, one system was found to be rated at 11 EER, below the minimum level required by Tier 1.

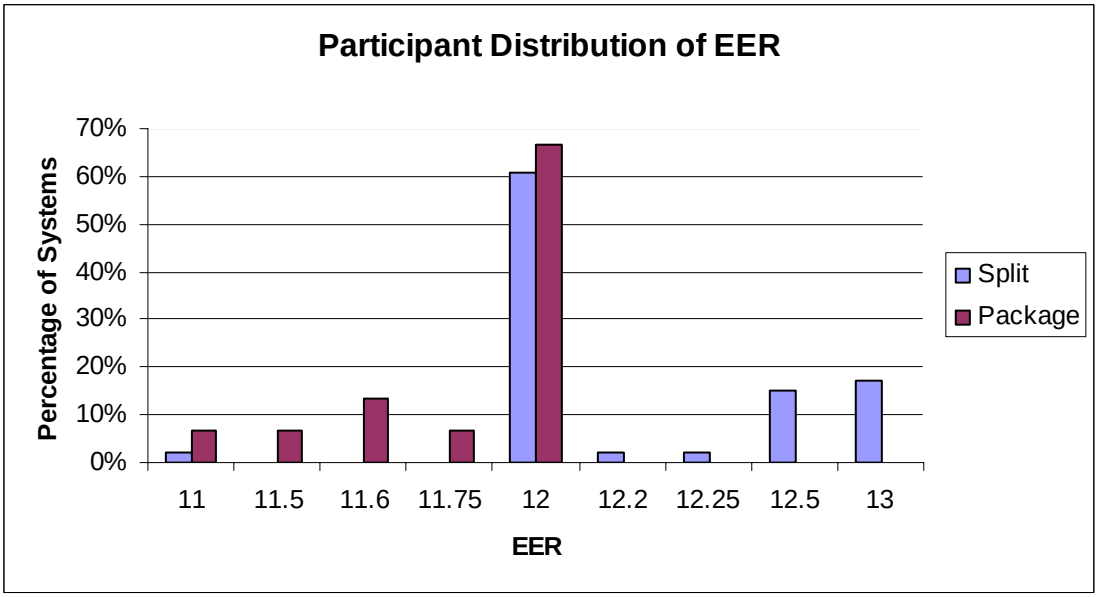


Figure 11: Distribution of Participant EER

Non-Participants

50 non-participant homes were visited. One non-participant home had two HVAC systems replaced; therefore 51 units were tested and metered. Of the 50 homes only

13 of those had applied for and received a permit for the work performed by the contractor. Of those 13, the Evaluators were only able to verify that 4 of those had been directly tested for duct leakage. These results are shown in Table 28 and Table 29.

Non-Participants	N
Permited	14
Non-Permitted	37

Table 28: Non-Participant Permitted Sites

Permitted Non-Participants	N
Directly Tested	4
Not Directly Tested	3
DK	7

Table 29: Permitted Directly Tested Sites

Following is a breakdown of the system characteristics observed on-site by permitted and non-permitted sites. As was seen in the participant population, the majority of systems were split A/C systems. Also of interest is that 71% of permitted systems and 95% of non-permitted systems used R-22 as the refrigerant; R-410A was used in the remaining systems. 71% of permitted homes and 54% of non-permitted systems were equipped with a TXV. As would be assumed, a larger percentage of permitted sites than non-permitted sites used R-410A and used a TXV.

System Type	Permitted n=14	Non-Permitted n=37
Split A/C	64%	78%
Package A/C	21%	19%
Split HP	14%	3%

Table 30: Non-Participant System Type

The variation in non-participant power factor is shown in Table 31. These results are very similar to those for the participant sample.

	Non-Participant PF
Average	0.90
Minimum	0.78
Maximum	0.98

Table 31: Non-Participant Power Factor Variation

As was seen with participants, most non-participants systems were 3 ton systems. However, non-permitted systems exhibit a wider range in installed systems from 2.5 to 5 tons.

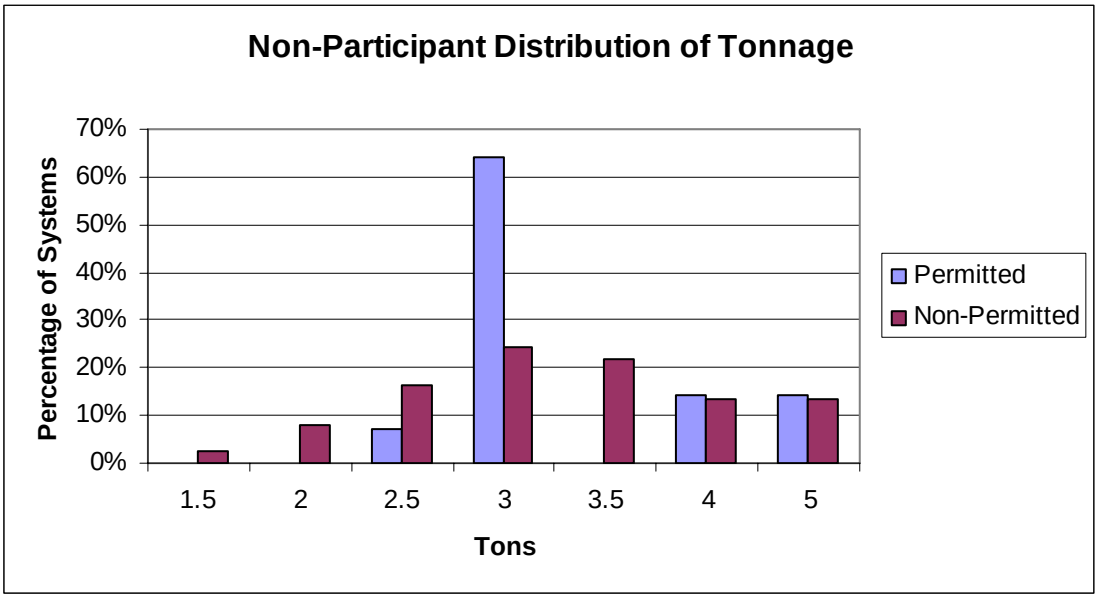


Figure 12: Non-Participant Tonnage of System

The average SEER rating for permitted non-participants was higher than for non-permitted non-participants, as shown in Figure 13. There were two permitted non-participants with units below the Title-24 minimum of 13 SEER.

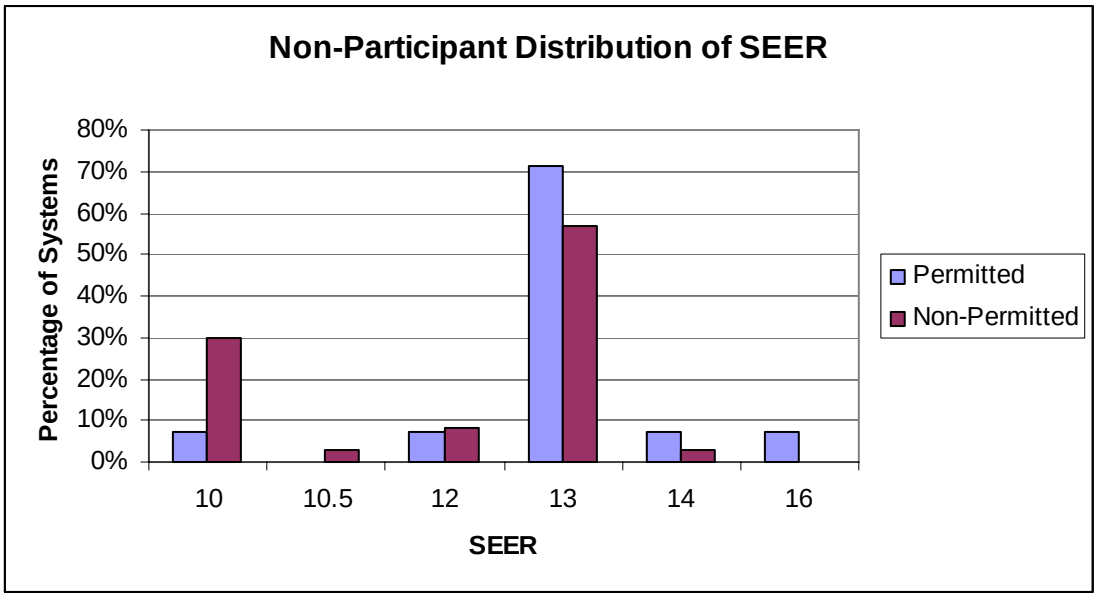


Figure 13: Distribution of Non-Participant SEER

Figure 14 shows a similar distribution for EER across non-participants as for SEER.

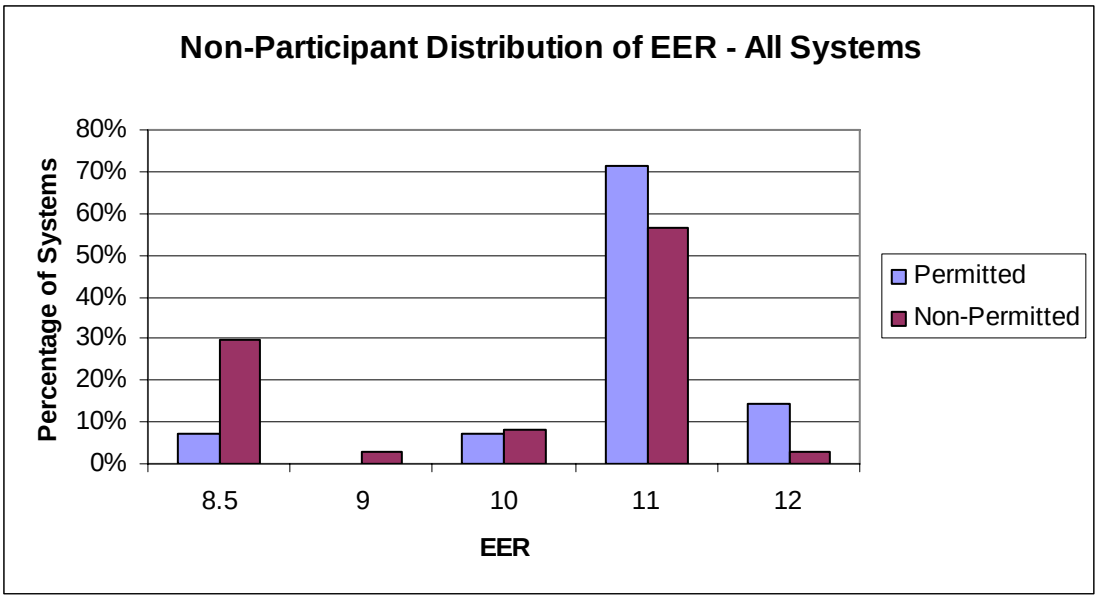


Figure 14: Distribution of Non-Participant EER

Test Findings

Airflow

The 2005 Energy Efficiency Standards state that systems should be able to provide 400 cfm/ton of airflow over a wet evaporator coil and 450 cfm/ton over a dry evaporator coil. All of the measurements for this evaluation were performed with the evaporator coil wet.

Figure 15 shows measured airflow versus nominal airflow for participant systems. All points below the line shown represent sites with measured airflow lower than nominal. Those points above the line have measured airflows above the nominal value.

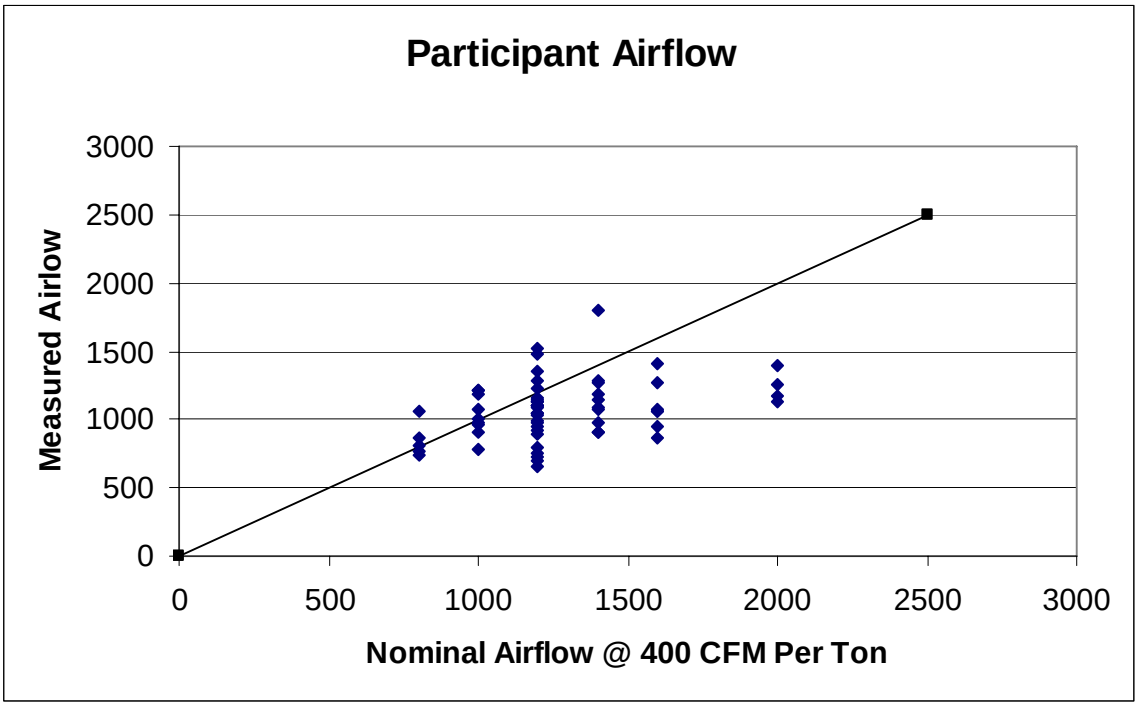


Figure 15: Participant Airflow

Figure 16 shows the same comparison except for non-participants. As can be seen, more non-participants than participants have systems with measured airflow lower than what is acceptable by code.

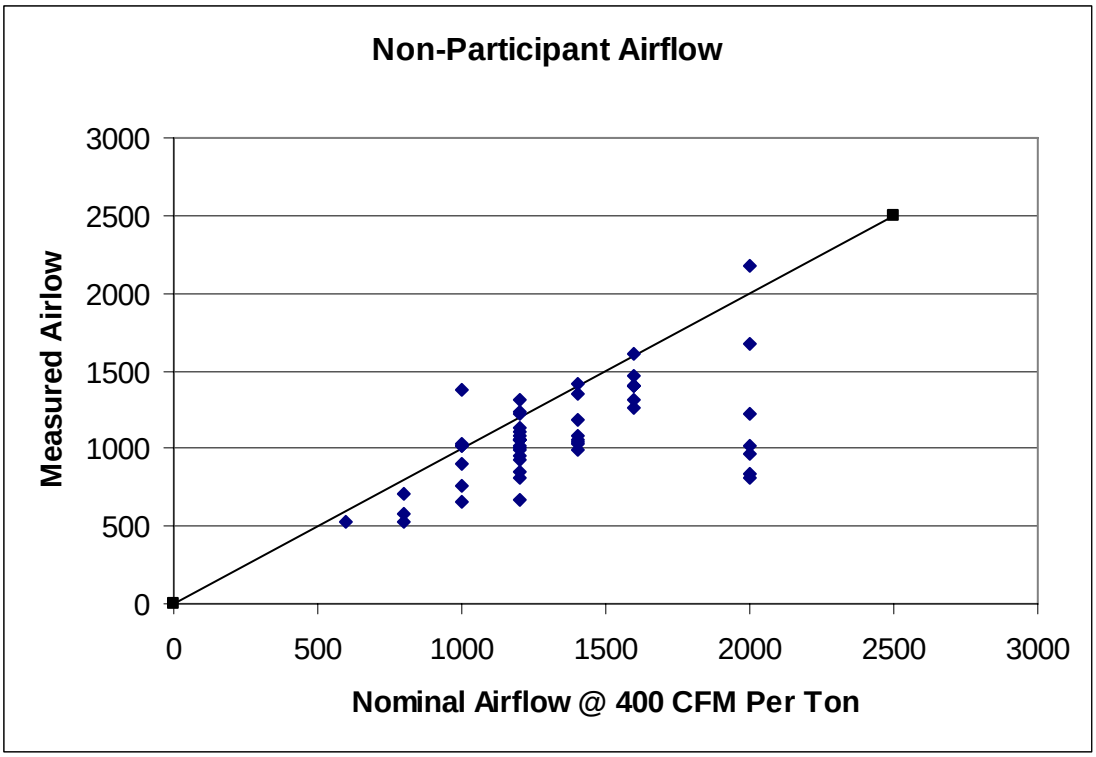


Figure 16: Non-Participant Airflow

Refrigerant Charge

The 2005 Energy Efficiency Standards currently allow equivalent credit for refrigerant charge testing and the presence of a thermal expansion valve (TXV). Although the presence of TXV does not guarantee that the system was properly charged at the time of installation, it does mitigate the effects of improper charge as is shown in Table 32 and Table 33. The efficiency impacts are gleaned from prior research on the impact of changing charge on system efficiency.

Refrigerant charge conditions were measured for all participant and non-participant units. Slightly over one-third of participant units equipped with TXVs were properly charged, 2 units were under charged and the remaining was over charged. Recall from the section on metered sample findings that the majority of participants units were equipped with TXV metering devices. Units equipped with TXVs that are under or over charged have only a 3% decrease in system efficiency.

Participants		
TXV	**N**	**% Effect on SEER/EER**
Low Charge	2	-3%
Proper	20	0%
High Charge	35	-3%

Table 32: Participant TXV Refrigerant Charge Results

Non-Participants		
TXV	**N**	**% Effect on SEER/EER**
Low Charge	6	-3%
Proper	15	0%
High Charge	13	-3%

Table 33: Non-Participant TXV Refrigerant Charge Results

Conversely, as shown in Table 34, the effect of incorrect charging has a much greater effect on units with a fixed orifice metering device. These systems experience a 13% decrease due to under charging and 7% decrease to over charging.

Non-Participants		
NON-TXV	**N**	**% Effect on SEER/EER**
Low Charge	7	-13%
Proper	4	0%
High Charge	0	-7%

Table 34: Non-Participant Non-TXV Refrigerant Charge Results

Duct Leakage

Total duct leakage was measured for all surveyed non-participants and was obtained from the CF-4R for participant homes. Initially, The District did not require duct leakage testing of program participants. Therefore, leakage data was only available for 37 out of the 60 participant homes visited. The majority of participants did not install new duct systems and complied under the requirement that total leakage be less than 15% of airflow. Only 8 participants complied with 6% total leakage which is required when a completely new distribution system is installed. Reliable duct leakage test data was obtained for 48 out of the 50 non-participant homes.

As can be seen in Figure 17, the leakage for non-participant systems is significantly larger than for participant systems. Average participant total leakage is around 38 cfm/ton. Average non-participant leakage is over twice as large at slightly over 90 cfm/ton. Additional points representing the participant average are presented in the figure for perspective.

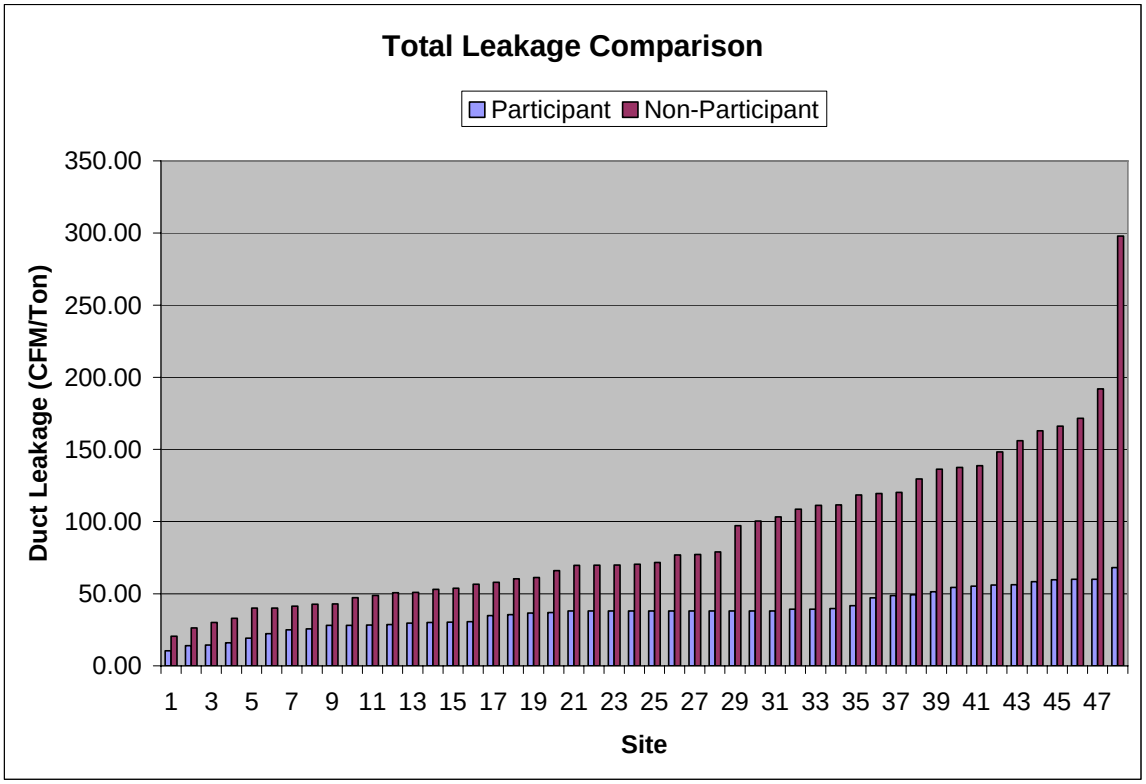


Figure 17: Total Leakage Comparison

The tables below illustrate average leakage for non-participants separated out by permitted and non-permitted systems. Note the small sample sizes for most of the following groups. Permitted systems had a slightly lower average total leakage per ton than non-permitted systems; however, the average leakage to outside is slightly higher for permitted sites.

Non-Participants	N	Average Total Leakage / Ton	Average Leakage to Outside / Ton	Average Leakage to Outside
Permited	14	82	56	210
Non-Permitted	37	86	46	194

Table 35: Leakage Averages for Non-Participants

Permitted Non-Participants	N	Average Total Leakage / Ton	Average Leakage to Outside / Ton	Average Leakage to Outside
Directly Tested	4	103	57	222
Not Directly Tested	3	51	37	111
DK	7	84	64	245

Table 36: Leakage Averages for Permitted Non-Participants

Figure 18 and Figure 19 show the distribution of total leakage per ton and leakage to outside per ton for permitted and non-permitted sites. Additional points representing the permitted average are presented in the figures for perspective. These figures show that regardless of permitting outside the program, duct system leakage varies widely from site to site and duct sealing savings exist over the entire non-participant baseline.

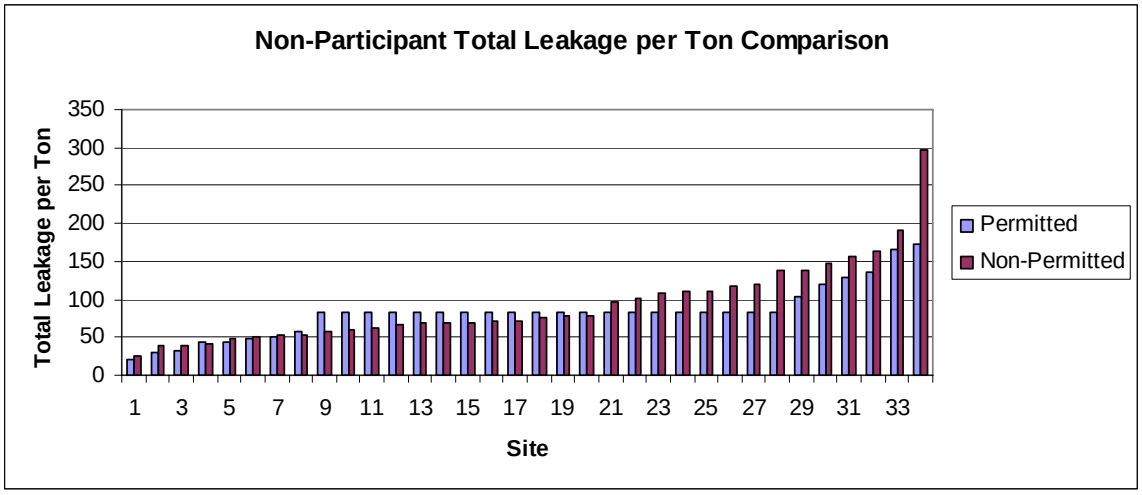


Figure 18: Non-Participant Total Leakage per Ton Comparison

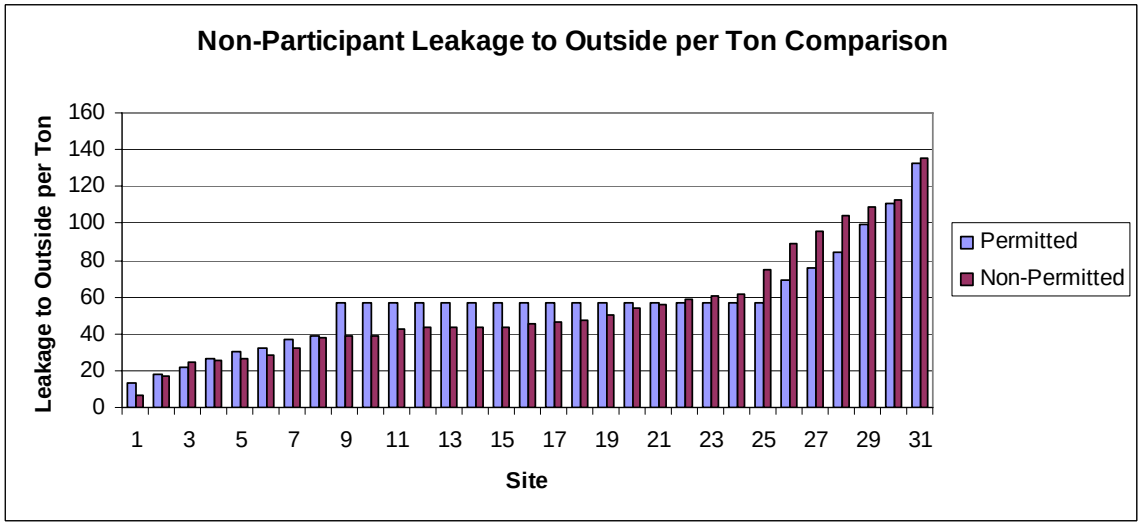


Figure 19: Non-Participant Leakage to Outside per Ton Comparison

System Sizing

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.[9] This method is the American National Standard for residential heating and cooling load calculations. The actual size of the unit was found using the model numbers collected on-site. Figure 20 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% of all units were oversized. Approximately 2% of all units were undersized while only 5% of units were sized correctly. Surprisingly, given the right sizing Program requirement, the results are similar for both participants and non-participants. When meeting the same load, an oversized unit typically uses a lot more energy than a properly sized unit. This means that there is a large potential for savings due to sizing the cooling units properly.

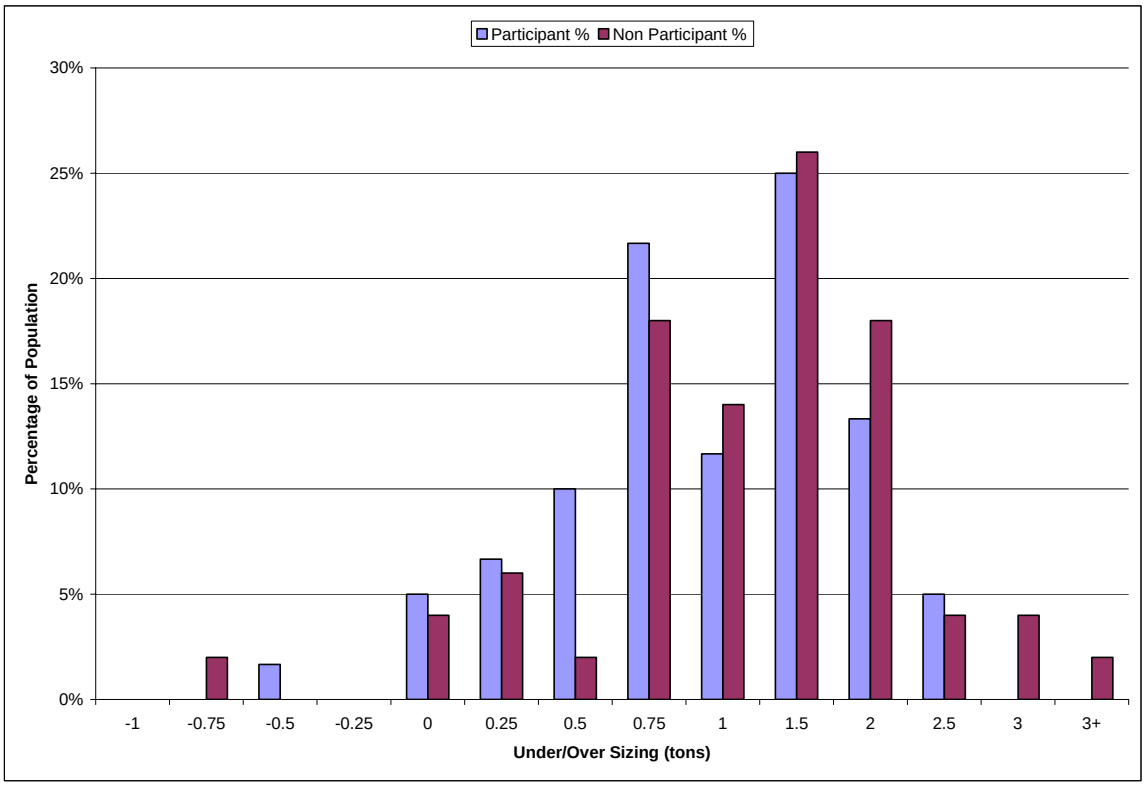


Figure 20: Cooling System Sizing Comparison

Figure 21 plots the Manual J recommended unit size and the actual installed unit size in tons. These trend lines can be compared to the ideal sizing line, shown in yellow. Both participant and non-participant trend lines lie above the ideal sizing line signifying that the majority of units are oversized.

[9] Hank Rutkowski. Manual J Residential Load Calculation. March 2006. 8th edition.

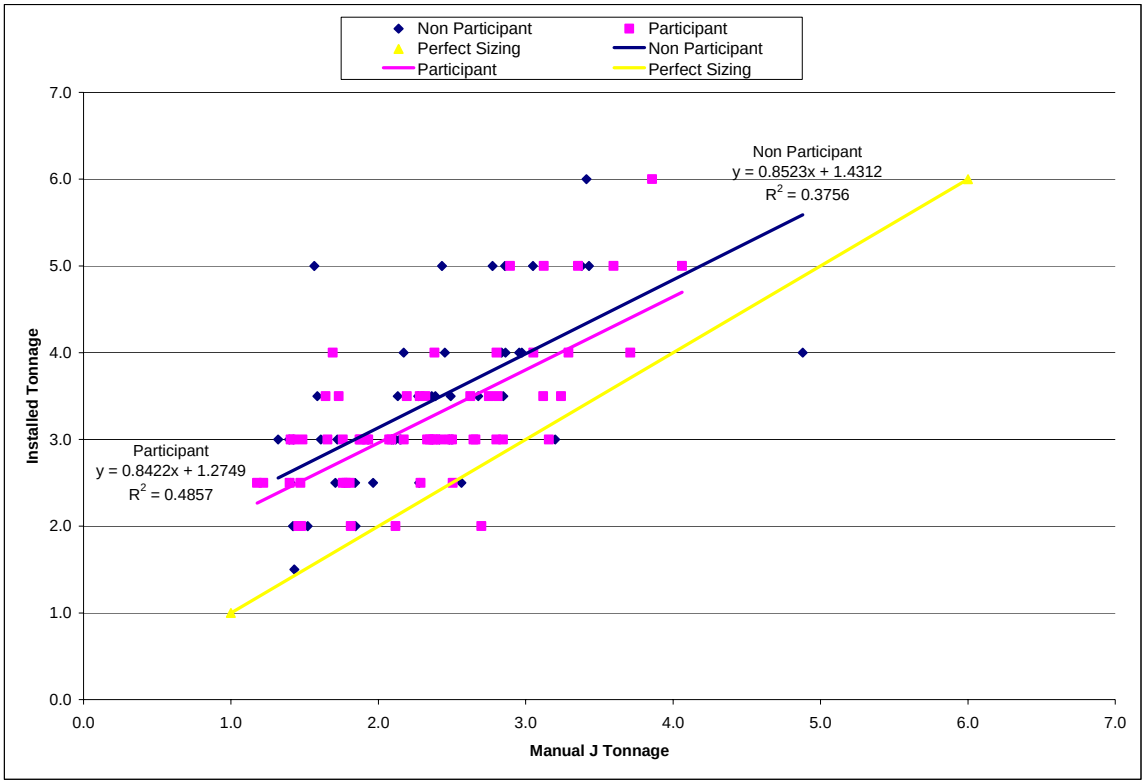


Figure 21: Manual J Sizing

Detailed Survey Results

How homeowners select contractors to perform the replacement

Both participants and non-participants utilized similar methods in selecting a mechanical contractor to install their equipment. The most common methods were hiring a contractor that had previously performed work for the homeowner or choosing one based on recommendations from a friend or colleague. The third most common source used to identify a contractor is reflected as "Other". Many participants choose a contractor as a result of direct solicitation from the contractor. Other methods included Home Shows, the Better Contractors Bureau, and District recommendations (not through the website). As for non-participants, multiple sources noted that a friend or family member installed the unit for them. Other responses included that the landlord or previous homeowner selected the contractor, a home warranty or insurance company provided a referral, and door-to-door solicitations. Note that respondents were asked to specify as many methods as were applicable and therefore the percentage of responses may not add up to 100%. Figure 22 shows the results.

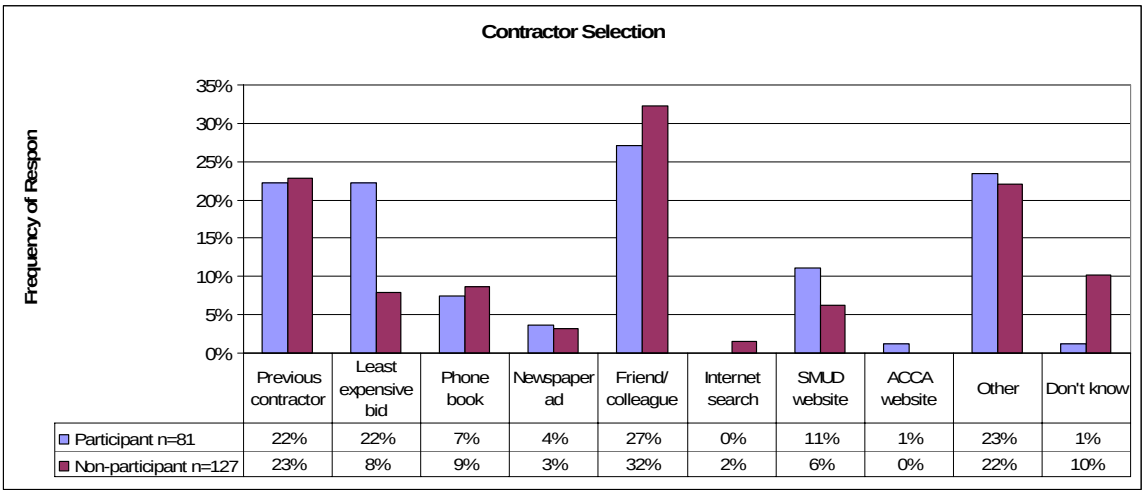


Figure 22: How did you go about selecting a contractor?

The energy efficiency options that contractors offer to prospective customers

Contractors presented participants with more estimates and options in their bid offers than they did non-participants. When options were presented to non-participants, the most common was that for a high efficiency A/C. Many of the "Other" responses for participants were represented by an option for an Energy Star unit which would place most systems at either the Tier1 or Tier2 rebate level. Figure 23 and Figure 24 show the results.

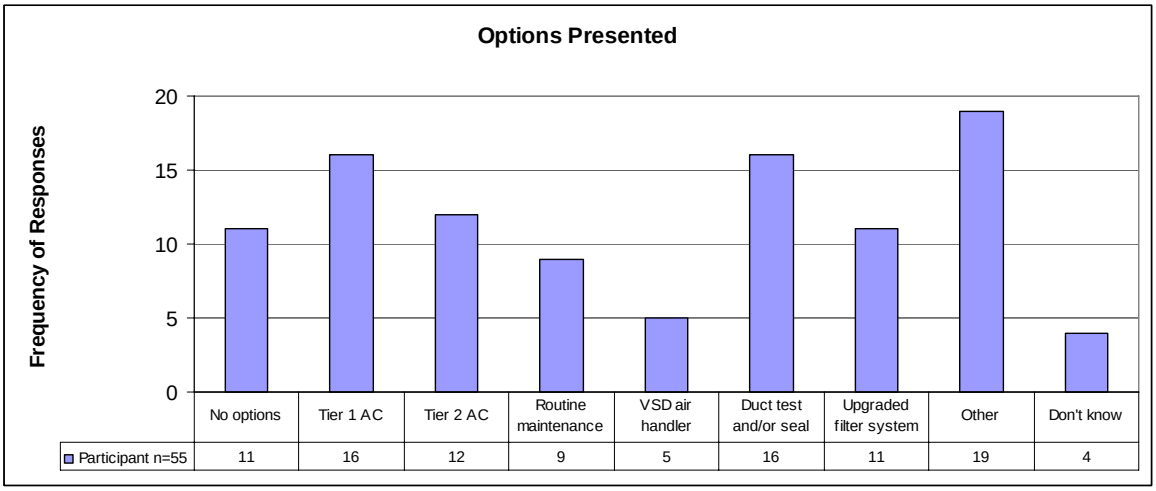


Figure 23: (Participant) Did the winning contractor present a single offer or several estimates?

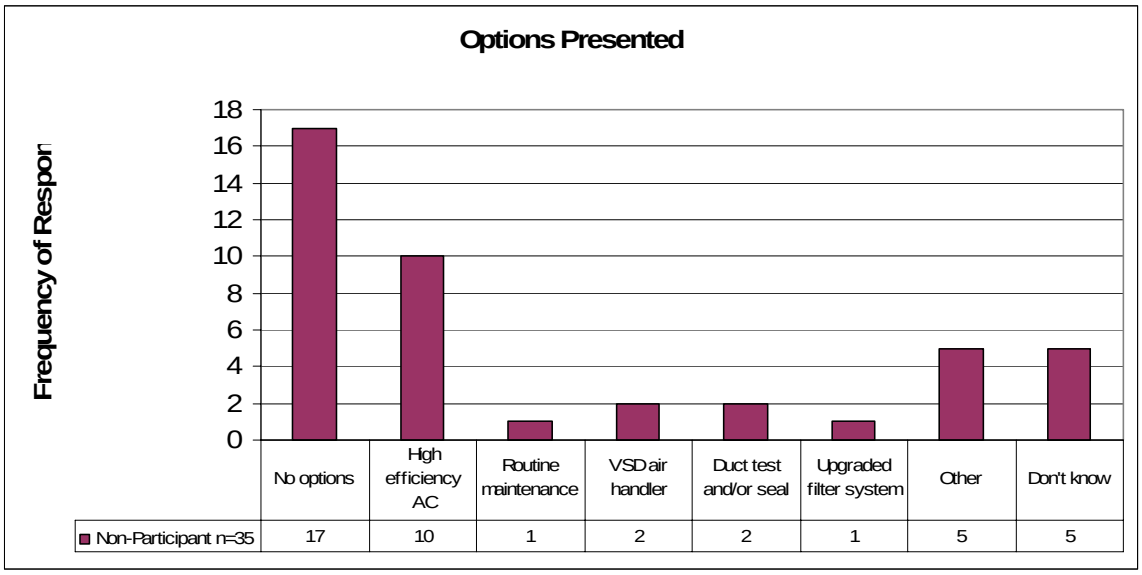


Figure 24: (Non-Participant) Did the winning contractor present a single offer or several estimates?

The Evaluators' recruitment team conducted complete surveys with 49 participant contractors. There were only four non-participant contractors that the team was able to contact and survey. The contractors were asked if they typically present a single offer or several estimates for the work performed, and what options were offered. The most common option offered was duct testing and/or sealing. Almost 78% of participating contractors offered a Program Tier 1 option. Other popular options offered were VSD air handlers and a maintenance contract. The results are shown in Table 37 and Table 38.

	# of Respondents (n=47)
No options presented	11
Tier 1 AC	37
Tier 2 AC	31
Routine maintenance	32
VSD air handler	35
Duct seal and/or test	41
Upgraded filter system	30
Other	14

Table 37: (Participant) Do you present a single offer or several estimates?

	# of Respondents (n=4)
No options presented	2
14 SEER unit	2
15 SEER unit	1
Routine maintenance	2
VSD air handler	2
Duct seal and/or test	3

Table 38: (Non-Participant) Do you present a single offer or several estimates?

The majority of contractors stated they offer a 14 SEER or higher unit option as standard practice as shown in Table 39.

	# of Participant Contractor Respondents (n=47)	# of Non-Participant Contractor Respondents (n=4)
Yes, always	45	3
Yes, only when customer asks	2	1

Table 39: (Contractor) Do you typically present your customer with a high efficiency purchase option?

The degree to which homeowners consider energy efficiency in their selections

Customers were asked during the telephone survey if they thought the District rebate covered the cost of upgrading to a high efficiency unit. Most customers were unsure about the costs of going from a standard to high efficiency unit and therefore were not able to knowledgeably respond to the question. The same was true of non-participants. Most participant contractors stated that the incentives do not cover the incremental cost of going from a standard unit to one eligible for any of the Program's Tier classifications. The results are shown in Table 40, Table 41, and Table 42.

	# of Respondents (n=53)
Yes	17
No	10
Other	2
Don't know	24

Table 40: (Participant) Did the SMUD rebate cover the incremental cost of going from a standard efficiency unit to a high efficiency?

	Yes	No
Tier1 Split AC	6	34
Tier2 Split AC	1	33
Tier1 Package AC	6	25
Tier2 Package AC	4	26
Tier1 Split HP	5	24
Tier2 Split HP	1	26
Tier1 Package HP	1	23
Tier2 Package HP	0	20

Table 41: (Participant Contractor) Did the SMUD rebate cover the incremental cost of going from a standard efficiency unit to a high efficiency?

	# of Repondents (n=47)
Yes	11
No	11
Don't know	25

Table 42: (Non-Participant) Would the SMUD rebate have covered the incremental cost of a high efficiency unit?

Over one-quarter of respondents stated they would have installed the same efficiency unit without District financing or rebates. About 40% would have installed something cheaper and less efficient while the remaining said the rebate hindered them from installing a higher efficiency unit. Table 43 presents the results.

	# of Respondents (n=22)
Higher cost higher efficiency	7
Less expensive less efficient	9
The same	6

Table 43: (Participant) Assuming neither SMUD financing nor rebates had been available, what would you have installed?

The most common reason for purchasing a new A/C unit for both participants and non-participants was that the existing unit was not functioning at all or not functioning properly. The next most common reason was to replace an inefficient system with a more efficient one. Twenty-nine percent of participants responded that the longevity of their unit was a concern. Figure 25 shows the results.

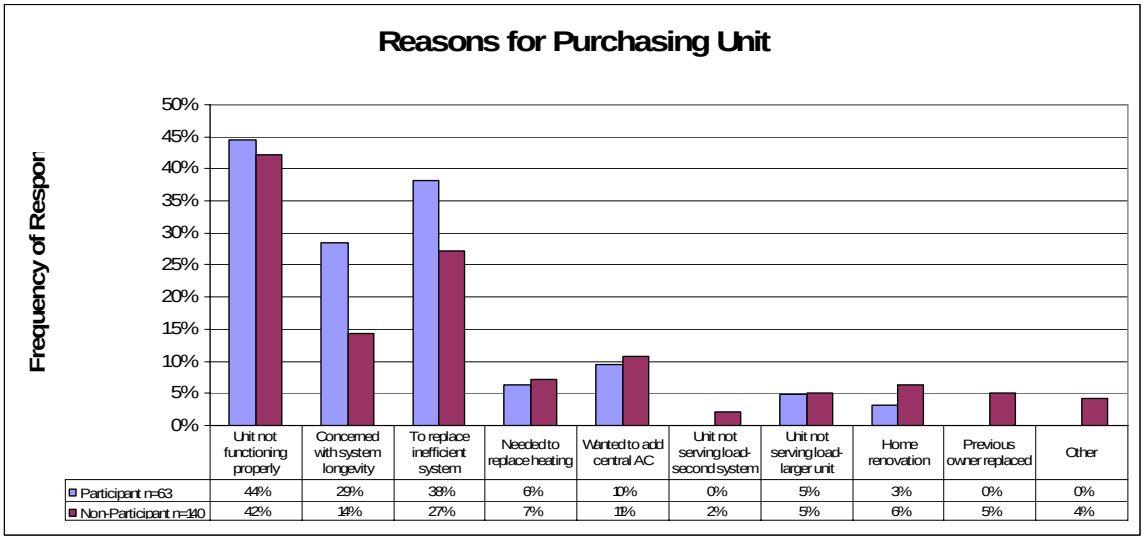
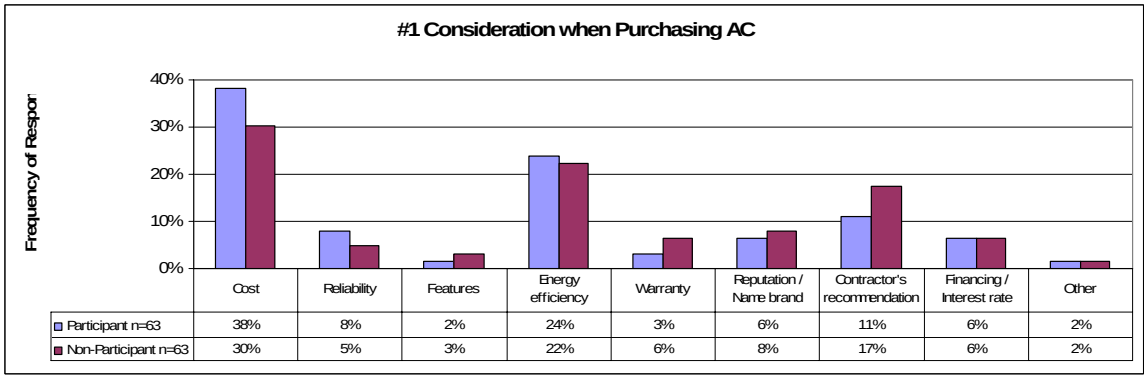
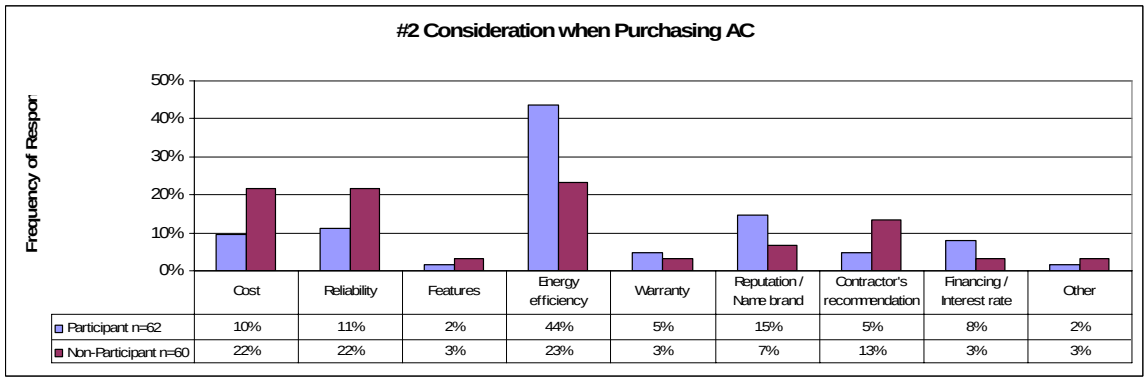


Figure 25: What was the main reason you decided to purchase a new AC?

Customers were asked what the top three considerations were when selecting an A/C unit. Cost was the most important factor A/C for both participants and non-participants. Other significant factors included energy efficiency and the contractor's recommendation. System features and availability of a warranty were reported to be taken into consideration the least often. Figure 26 presents the results.





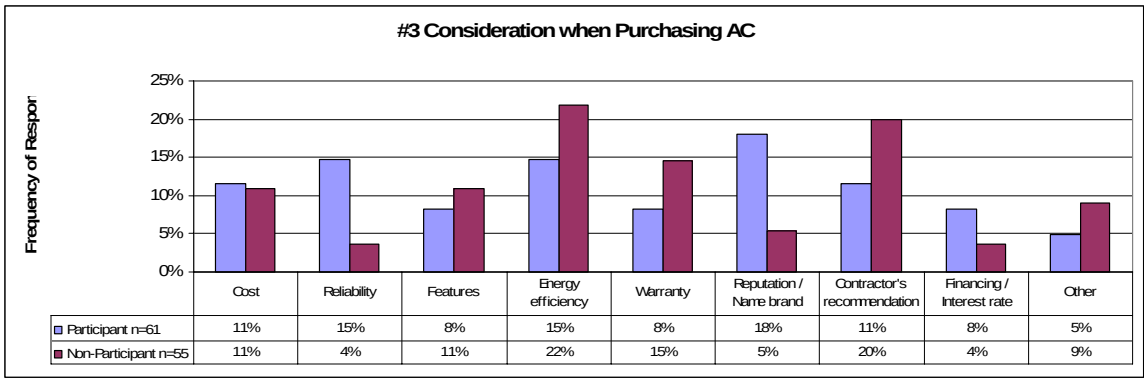
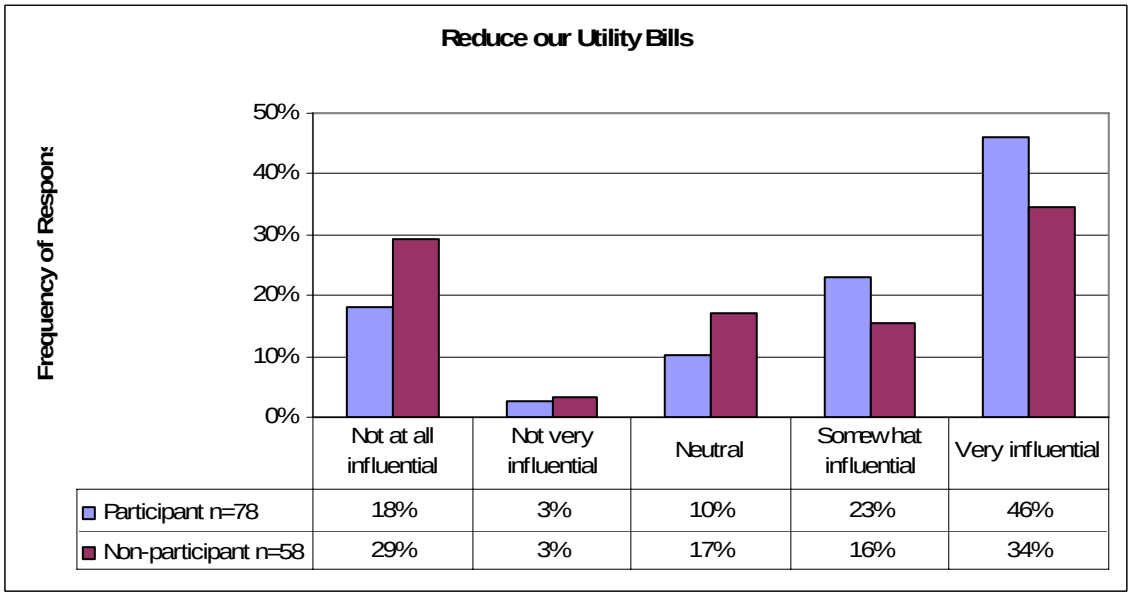
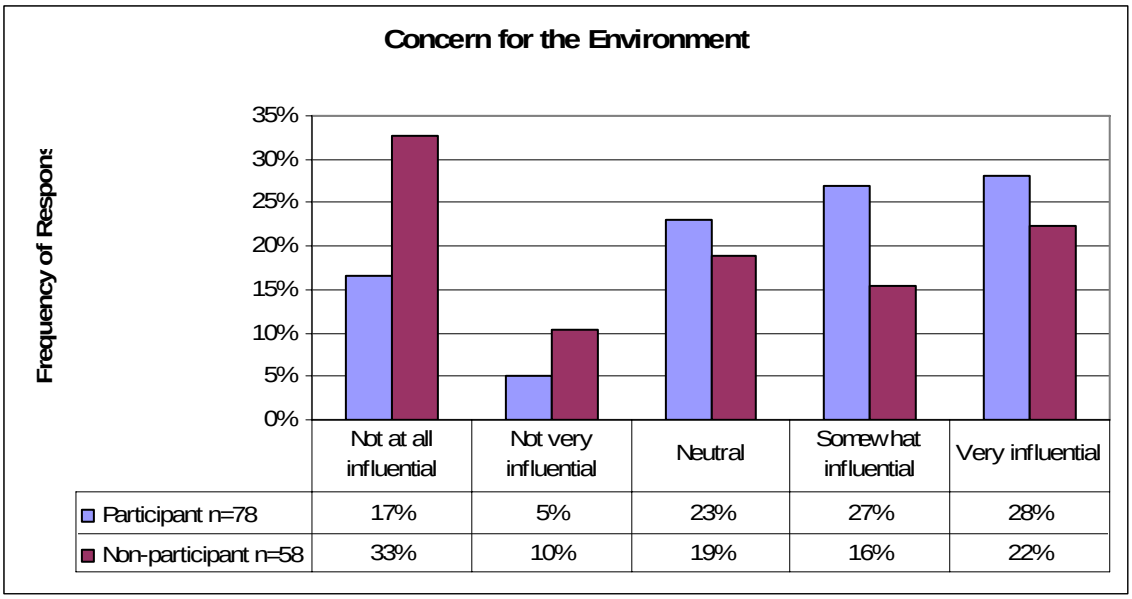


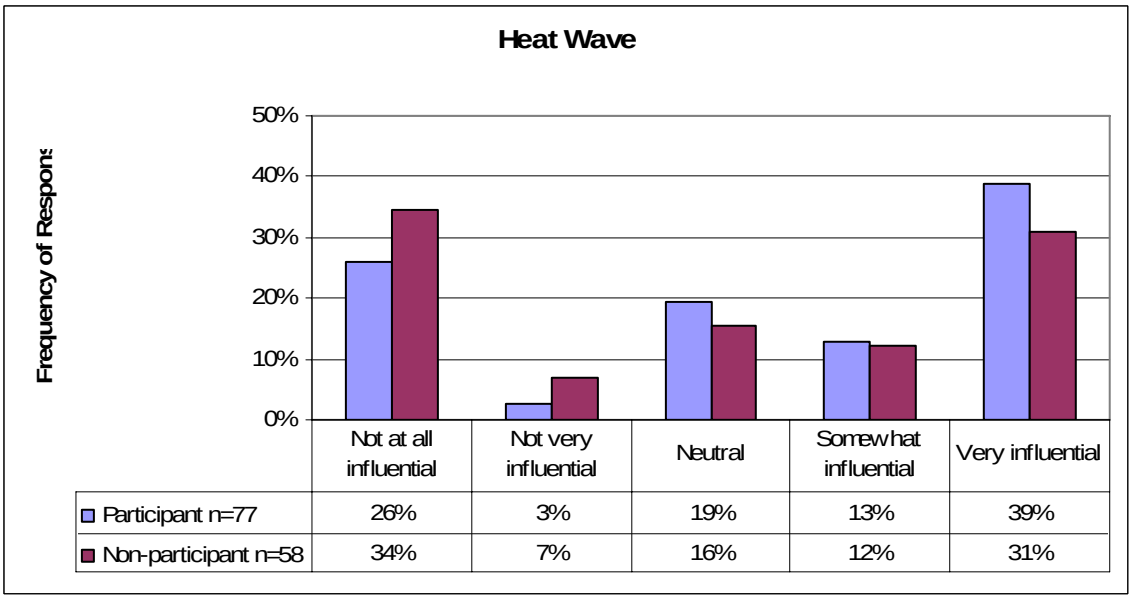
Figure 26: What are the top three considerations you had when selecting an A/C unit?

The most influential factor in the purchase decision for both participants and non-participants was a reduction in utility bills. Around 71% of participants said that rebates were somewhat or very influential in their decision. As expected, most non-participants did not feel rebate availability was influential; however, due to the availability of manufacturer and gas utility rebates a small percentage did take it into account during their purchase decision. The results are presented in Figure 27.

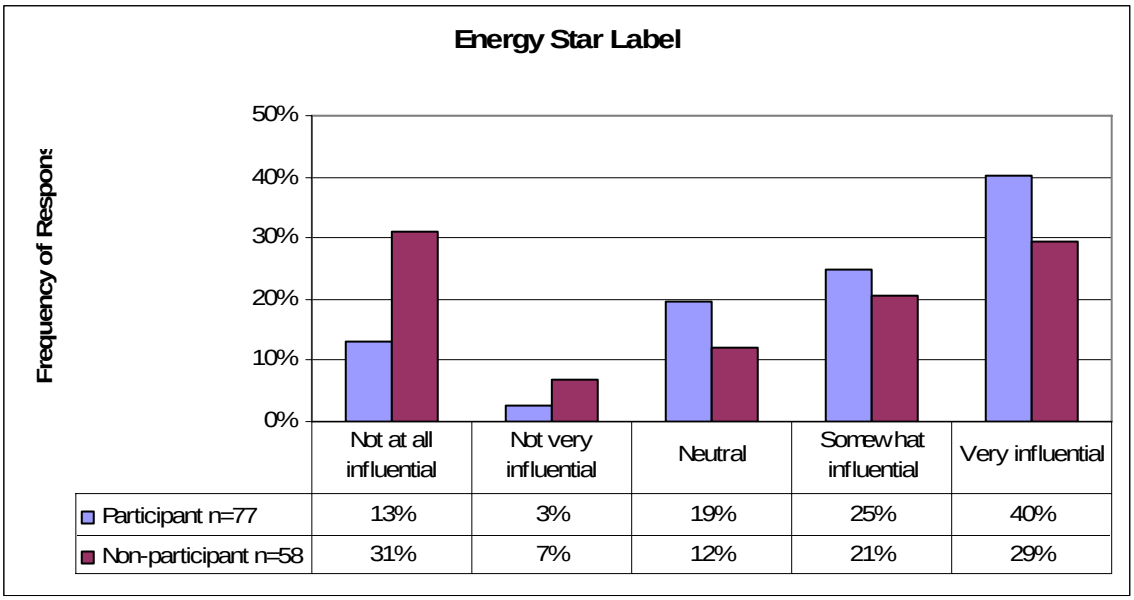




	Not at all influential	Not very influential	Neutral	Somewhat influential	Very influential
Participant n=78	17%	5%	23%	27%	28%
Non-participant n=58	33%	10%	19%	16%	22%



	Not at all influential	Not very influential	Neutral	Somewhat influential	Very influential
Participant n=77	26%	3%	19%	13%	39%
Non-participant n=58	34%	7%	16%	12%	31%



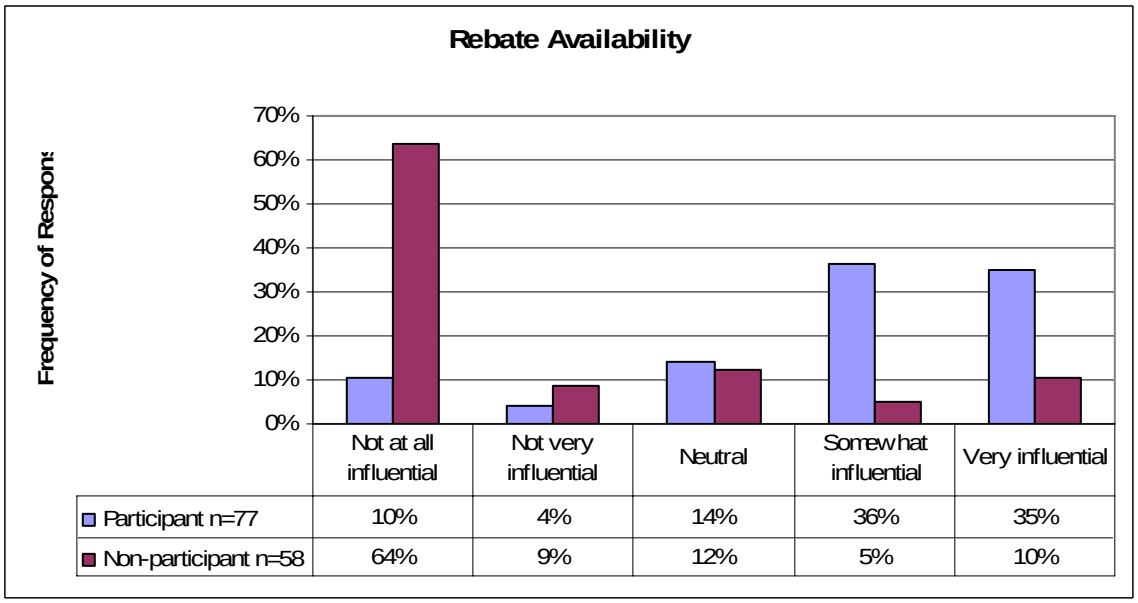


Figure 27: On a scale of 1-5 how much did these factors influence your purchase decision?

Both participant and non-participant contractors stated that the equipment price was the most important feature to customers. They also deem warranty and efficiency of the equipment important to customers. Table 44 and Table 45 present the results. Note that for Table 45 the number of non-participant contractor respondents is four.

	Purchase price of new equipment	Efficiency of new equipment	Brand/make of new equipment	Warranty of new equipment	Financing	Federal tax credits
Very unimportant	0%	0%	2%	0%	2%	4%
Somewhat unimportant	0%	4%	21%	9%	11%	31%
Neutral	9%	32%	23%	20%	36%	29%
Somewhat important	26%	47%	40%	38%	27%	18%
Very important	66%	17%	13%	33%	22%	7%
Don't know	0%	0%	0%	0%	2%	11%

Table 44: (Participant Contractor) Based on your experience rate the importance of the following features from the customers' perspective.

	Purchase price of new equipment	Efficiency of new equipment	Brand/make of new equipment	Warranty of new equipment	Financing	Federal tax credits	Utility Rebate
Very unimportant	0%	0%	0%	0%	25%	0%	0%
Somewhat unimportant	0%	50%	50%	25%	25%	0%	25%
Neutral	0%	25%	0%	25%	25%	0%	25%
Somewhat important	25%	25%	0%	0%	0%	25%	50%
Very important	75%	0%	50%	50%	0%	0%	0%
Don't know	0%	0%	0%	0%	25%	75%	0%

Table 45: (Non-Participant Contractor) Based on your experience rate the importance of the following features from the customers' perspective.

About two thirds of participant contractors said that customers do ask for high efficiency equipment bids when not offered one. Ten contractors did not provide a response to this question because they always present the customer with a high efficiency option. Table 46 presents the results.

	# of Participant Contractor Respondents (n=37)	# of Non-Participant Contractor Respondents (n=4)
Yes	23	2
No	11	2
Don't know	3	0

Table 46: (Contractor) Do customers ask for bids on high efficiency equipment if they are not presented to them?

Information sources homeowners rely upon in their decisions

Most respondents first heard about the rebate through the A/C contractor before the installation process. This suggests that contractors are using the rebate as a selling point. The next most common method of delivery is bill inserts in the customers' bill. The results are presented in Figure 28.

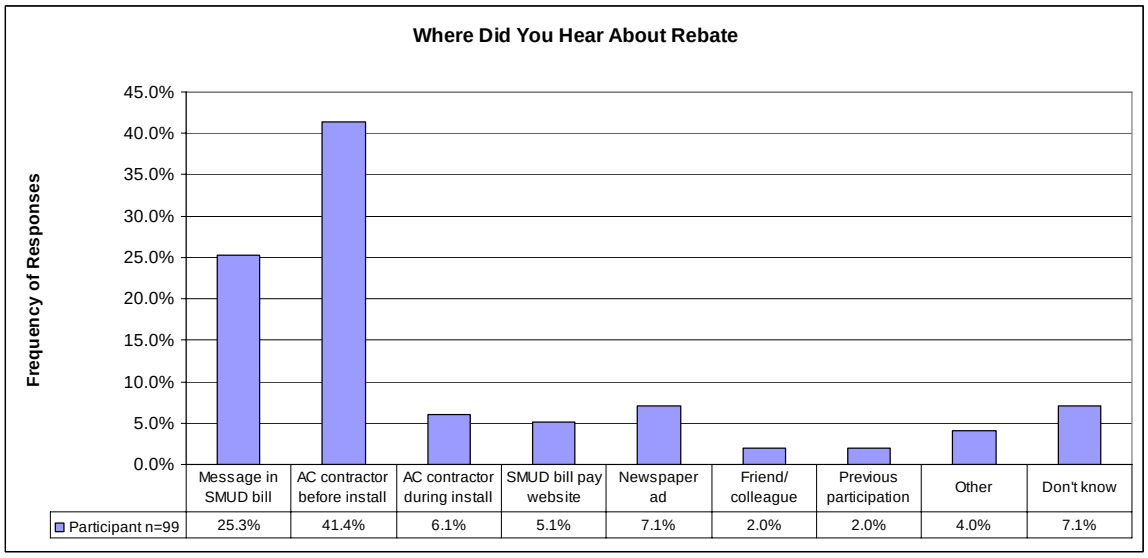


Figure 28: How did you first become aware of SMUD's A/C Rebate Program?

When asked what information sources the customer relied on when making the purchasing decision, the large majority of respondents stated that the contractor's recommendation was relied upon when deciding what unit to purchase. Reputation, efficiency, and manufacture information were also important information sources. Participants also used both the District website and other websites to gather information. Contractors felt that customers take many more sources into account when making purchase decisions than customers stated.

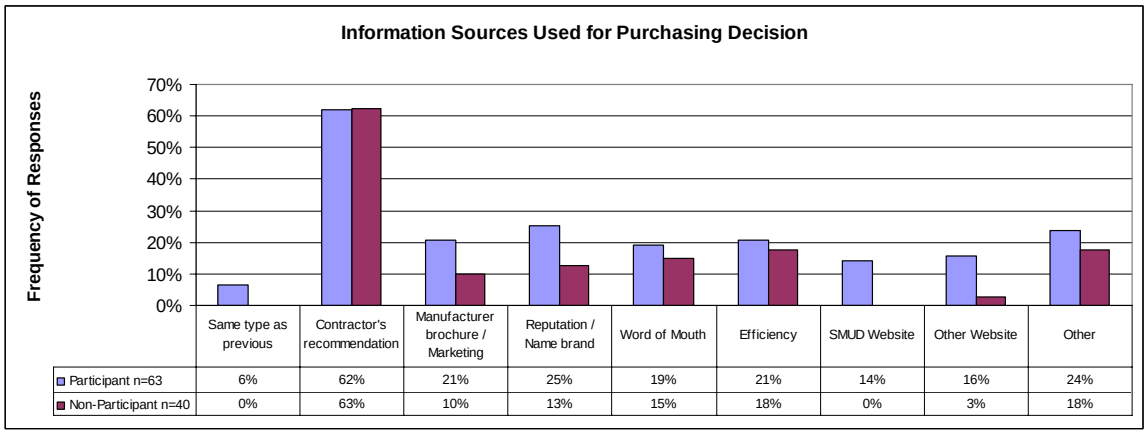


Figure 29: What information sources did you rely on when making the decision to purchase your unit?

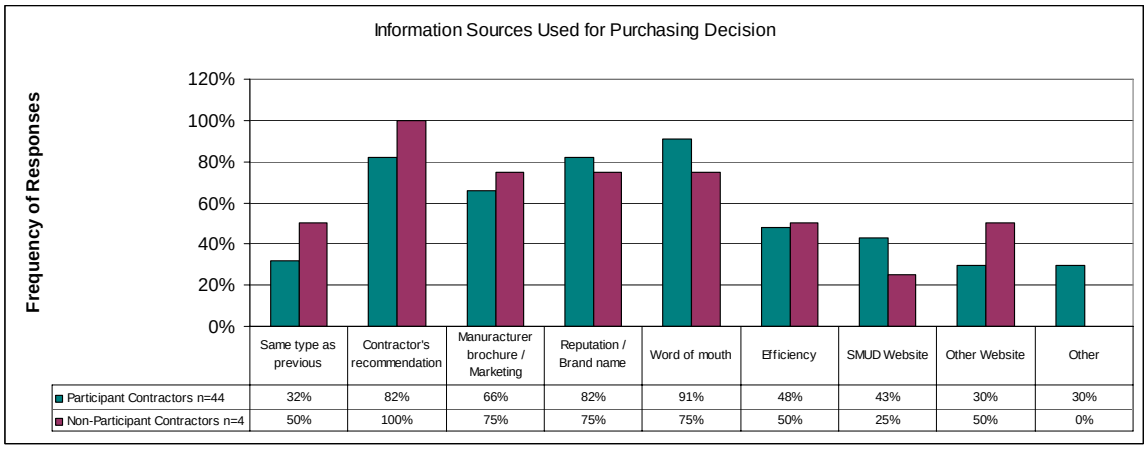


Figure 30: (Contractors) What information sources did the customer rely on when making the decision to purchase the unit?

How homeowners evaluate how much to spend on the replacement system

57% of participant respondents stated that they would purchase the same efficiency unit with or without the rebate from the Program. Thirteen percent would have downgraded to a Tier 1 efficiency unit from a Tier 2 unit. Four percent of respondents would not have purchased any unit if it hadn't been for the rebate.

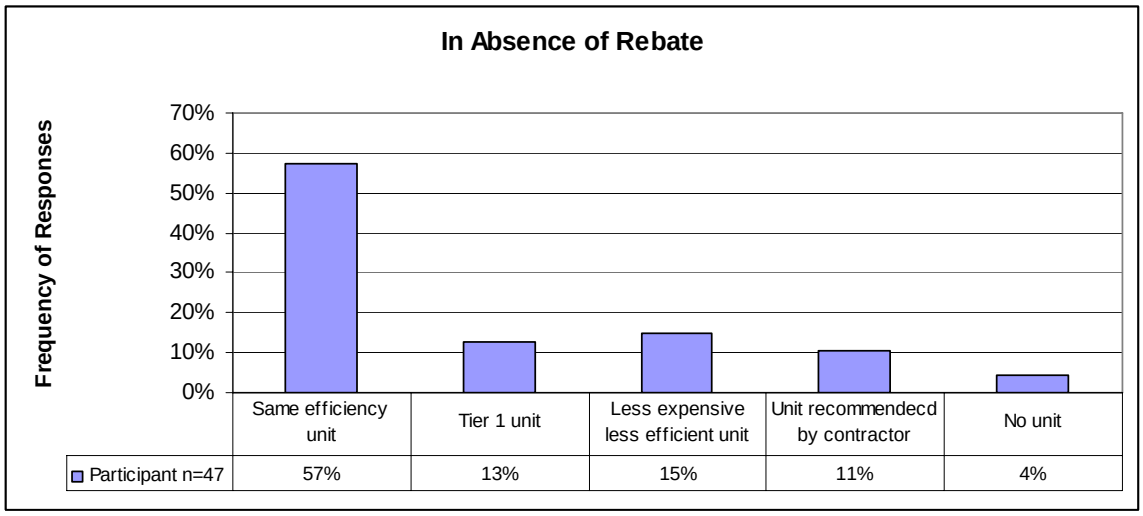


Figure 31: Had the SMUD rebate not been available what would have been done?

The large majority of participants would have purchased their unit at the same time or sooner if the Program rebate had not been available. Only 2 respondents said they would have waited a year or longer to make the purchase. Table 47 presents the results.

	# of Respondents (n=47)
Same time or sooner	42
Several months later	3
1 year later	1
More than 1 year later	1

Table 47: Assuming the rebate had not been available, when would the unit have been purchased?

Approximately half of respondents were planning on receiving a federal tax credit for the installation of a high efficiency A/C unit as shown in Table 48.

	# of Respondents (n=26)
Yes	12
No	10
Other	1
Don't know	3

Table 48: Did you or are you going to receive a federal tax credit?

Half of respondents who received the federal tax credit were told of the credit from their contractor. Three customers could not recall who informed them of the credit. 50% of respondents stated the credit was very or somewhat influential while the other half deemed it to not be influential. Table 49 and Table 50 show the results.

	# of Respondents (n=12)
Contractor	6
SMUD	2
Other	1
Don't know	3

Table 49: How did you learn about the tax credit?

	# of Respondents (n=12)
Very influential	2
Somewhat influential	4
Not very influential	2
Not at all influential	4

Table 50: How influential was the credit in your purchase decision?

Over 63% of respondents who received financing through the Program said they would have still purchased a new unit without the availability of financing. Almost 32% of respondents would have kept their existing unit. Table 51 shows the results.

	# of Respondents (n=22)
Still would have purchased new unit	14
Kept existing unit	7
Other	1

Table 51: Had the SMUD financing not been available what would have been done?

Two-thirds of respondents would have purchased the new unit at the same time or sooner had the District financing not been available. Only 3 participants would have waited a year or longer to replace the existing unit. Table 52 shows the results.

	# of Respondents (n=15)
Save time or sooner	10
Several months later	2
1 year later	3

Table 52: Had the SMUD financing not been available when would the unit have been purchased?

Contractors provided an average incremental cost for upgrading from standard efficiency to Tier 1 and Tier 2 split and packaged A/C and heat pump systems. According to their figures, the rebates cover 38-50% of units qualifying for Tier 1 and 31-40% of those for Tier 2. Table 53 presents the results.

	Average % Covered
Tier1 Split AC	50%
Tier2 Split AC	35%
Tier1 Package AC	47%
Tier2 Package AC	40%
Tier1 Split HP	44%
Tier2 Split HP	35%
Tier1 Package HP	38%
Tier2 Package HP	31%

Table 53: What fraction of the incremental cost does the rebate cover?

When asked how many rebate applications are sent back because of missing information, the majority of contractors stated that very few rebate applications, if any,

are ever sent back to them. Most said that those applications that were, were sent back due to mistakes on the contractor's end. Only two contractors responded they experienced a high return rate or implied there was an issue.

About 74% of contractors said that customers are typically aware of the rebates before contacting the contractor for an estimate. Table 54 presents the results.

	# of Respondents (n=47)
Yes	35
Some	2
No	10

Table 54: Are the customers who take advantage of the SMUD rebate typically aware of the rebate before they contact you?

43% and 40% of participant contractors responded that the average installed efficiency for their customers absent the District's rebate program is 13 SEER and 14 SEER, respectively.

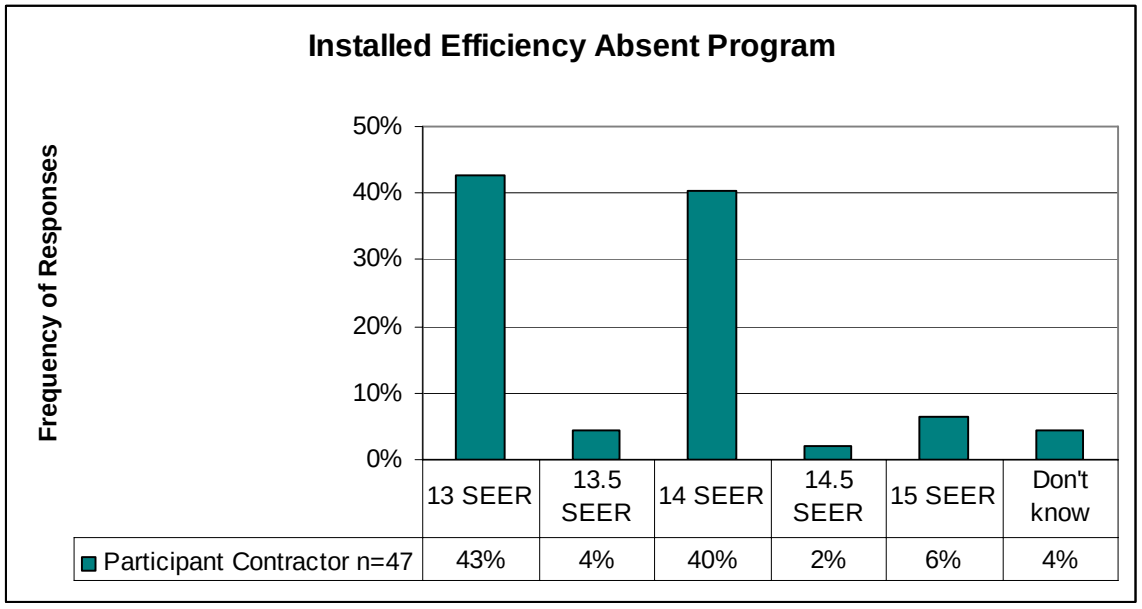


Figure 32: Absent the SMUD rebate what do you think would be the average installed efficiency for your customers?

Compliance Survey Questions

Some questions were added to the contractor surveys from comments received from the CEC. Following are the responses received from those questions. 45 participant contractors responded to most of these questions. Only four non-participant contractors were reachable and willing to conduct the survey with the Evaluators.

Contractors were asked for what percentage of jobs they pull permits. As is expected, almost all participant contractors responded that they pull permits for 100% of their jobs. Only 3 non-participant contractors responded to this question. One stated they pull permits 100% of the time, another said 25%, and the third said less than 40% of the time.

Contractors were asked to detail what is required when replacing HVAC systems under the 2005 Residential Title24 requirements for Sacramento County. The majority of contractors, both participant and non-participant, were aware of the code requirements.

When asked how often TXVs are installed on units, contractors in both groups responded that TXVs are installed almost all of the time. Table 55 shows the results.

	% of Time TXV Installed	Extra Cost ($)
Participant Contractors	99	275
Non-participant	98	<100

Table 55 Contractor TXV Installation and Cost*

*26 participant and 3 non-participant contractors responded that a TXV usually is factory installed and the additional costs are negligible.

When asked how often RCA testing is performed on a system change-out, contractors responded that RCA testing is almost always performed. Participant contractors informed the surveyors that the additional cost is approximately $200. Most contractors use the manufacturer's procedure when conducting an RCA test. Other procedures used included Title 24 or HERS and ACCA. Table 56 shows the results.

	% of Time RCA Checked	Extra Cost ($)
Participant Contractors	97	200
Non-participant	98	DK

Table 56 Contractor RCA Check and Cost*

*24 participant and all 4 non-participant contractors responded that the additional cost is negligible or simply included in their bid.

About half of contractors own a set of duct blaster equipment as presented in Table 57.

Own Duct Blaster?	Yes	No
Participant Contractors	20	21
Non-participant	2	2

Table 57 Duct Blaster Ownership

Non-participant contractors who own their own duct blaster equipment stated they use their equipment on half of their jobs. However, participant contractors set the figure at 92%. Table 58 shows the results.

	% of Jobs using Duct Blaster
Participant Contractors	92
Non-participant	50

Table 58 Duct Blaster Usage

The duct test takes between 1.5 and 2 hours to complete for contractors. The extra cost of performing the test is approximately $265-$315, depending on whether the contractor is a participant or not. Table 59 shows the results.

	Duct Test Time (hours)	Extra Cost ($)
Participant Contractors	1.5	315
Non-participant	2	265

Table 59 Duct Test Time and Cost

When asked how long it takes to seal ducts to meet code requirements, contractors responded that it takes between three to three and a half hours. Participant and non-participant contractors disagreed on the extra cost ducting sealing requires with the average cost ranging from $417 for participants and $610 for non-participants. Table 60 presents the results.

	Duct Seal Time (hours)	Extra Cost ($)
Participant Contractors	3.2	610
Non-participant	3.5	417

Table 60 Duct Seal Time and Cost

Contractors were asked what percentage of the time they install R-410A instead of R-22 as the refrigerant. Participant contractors install R-410A far more often, at a 57% installation rate. Non-participant contractors, however, only install R-410A 33% of the time. The results are presented in Table 61.

	% of Time R-410A installed over R-22	Extra Cost ($)
Participant Contractors	57	600
Non-participant	33	500

Table 61 R-410A versus R-22 Installations and Cost

Contractors indicated that a HERS Rater is involved in change out jobs approximately 90-100% of the time. Table 62 shows the results.

	HERS Rater Included in Changeouts?	Extra Cost ($)
Participant Contractors	90	1100
Non-participant	100	225

Table 62 Percentage of Time HERS Rater Involved in Change Outs*

*For non-participant contractors, 2 said 100% of the time and 1 said it is up to the customer.

Telephone Dispositions

Table 63 presents the multitude of dispositions and outcomes into which calls are categorized when attempting to contact participants and non-participants during the course of this study. Below is a list of all dispositions and descriptions of those that are unique to this project. Many of these outcomes are only applicable to the non-participants.

Outcome	Disposition	Outcome	Disposition
1	Completed Survey- Not Qualified	10	Language Barrier
2	Call Back	11	No Phone Number
3	Left Message	12	Moved
4	Busy Signal	13	No Central AC
5	No Answer	14	Survey Completed-Qualified
6	Refusal	15	Didn't Leave Message
7	Terminated	16	Multi-family/Apartment
8	Wrong Number	17	Not at this address
9	Disconnected	18	Participant

Table 63: Call Dispositions

1 - “Completed Survey-Not Qualified” applied to non-participants who completed the phone survey but did not qualify to participate in the monitoring because their air conditioning unit was not replaced in either 2006 or 2007. This disposition was also

applied to participants who completed the phone survey but refused the on-site monitoring.

13- "No Central AC" applied if the non-participant home did not have a central air-conditioning system.

14- "Survey Completed-Qualified" applied to non-participants who completed the phone survey and had replaced a central air-conditioning system in either 2006 or 2007. This disposition was also used for participants who completed the survey and agreed to participate in the on-site monitoring.

15- "Didn't Leave Message" applied to both participants and non-participants. This disposition was used if the phone recruiters called the home, but in every attempt to reach them, no one answered the phone. In an interest to make the best use of phone recruiters' time, messages were not left on customers' answering machines if there was no answer. The Evaluators' experienced phone recruiters have found customers will rarely return the call unless they have been previously advised that their home has been selected for a study. However, multiple attempts are made at various times of the day before moving onto another sample point. The majority of the phone recruitment occurred from late afternoon until 9PM Monday through Friday.

16- "Multi-family Apartment" applied when apartments were found either by the tracking data or by the customer advising as such.

17- "Not at this address" applied when customers, either participant or non-participant, indicated that although the recruiter had reached them at their correct phone number, the service address listed in the tracking data was not their home and never had been. This issue of poor customer tracking data was brought to the District's attention during a bi-weekly meeting.

18- "Participant" was those residential customers from the District's general population whose account numbers were cross referenced with those who were recipients of the District's rebate and found to be program participants. This information was tracked rather than excluded from the call log in an interest to determine the percentage of total District customers who replaced their A/C unit in either 2006 or 2007. Customers who were coded as 18 were not contacted.

Recruiting Metering Sites

Participant Metering Sites

As stated in the proposal, The Evaluators would obtain savings estimates by performing on-site monitoring at 60 homes that participated in the Program. Once the tracking data of participants was acquired, a random sample of 100 customers was selected to successfully recruit 60. When the 100 customers were exhausted and the sample of 60 was not yet fulfilled, a second sample of 100 customers was drawn for a total of 200 customers. Out of the 200 customers, 99 completed a telephone survey and were asked to participate in the on-site monitoring. 101 customers could not be reached or refused

to participate in the telephone survey. Out of those 99 asked to participate in the monitoring, 60% of them agreed. The remaining 40% who responded to the telephone survey, but choose not to participate in on-site monitoring, did so for reasons such as:

- Concerned monitoring equipment could cause problems
- Elderly woman lives alone and is uncomfortable with the idea
- Need to speak with husband, but couldn't reach him after several attempts
- Doesn't like people in her home
- Medical health reasons
- Moving out of the house and/or spending the summer at our second home

Figure 33 displays the 101 participants who were not recruited in the phone survey and/or monitoring study and why recruiters were unsuccessful at reaching them.

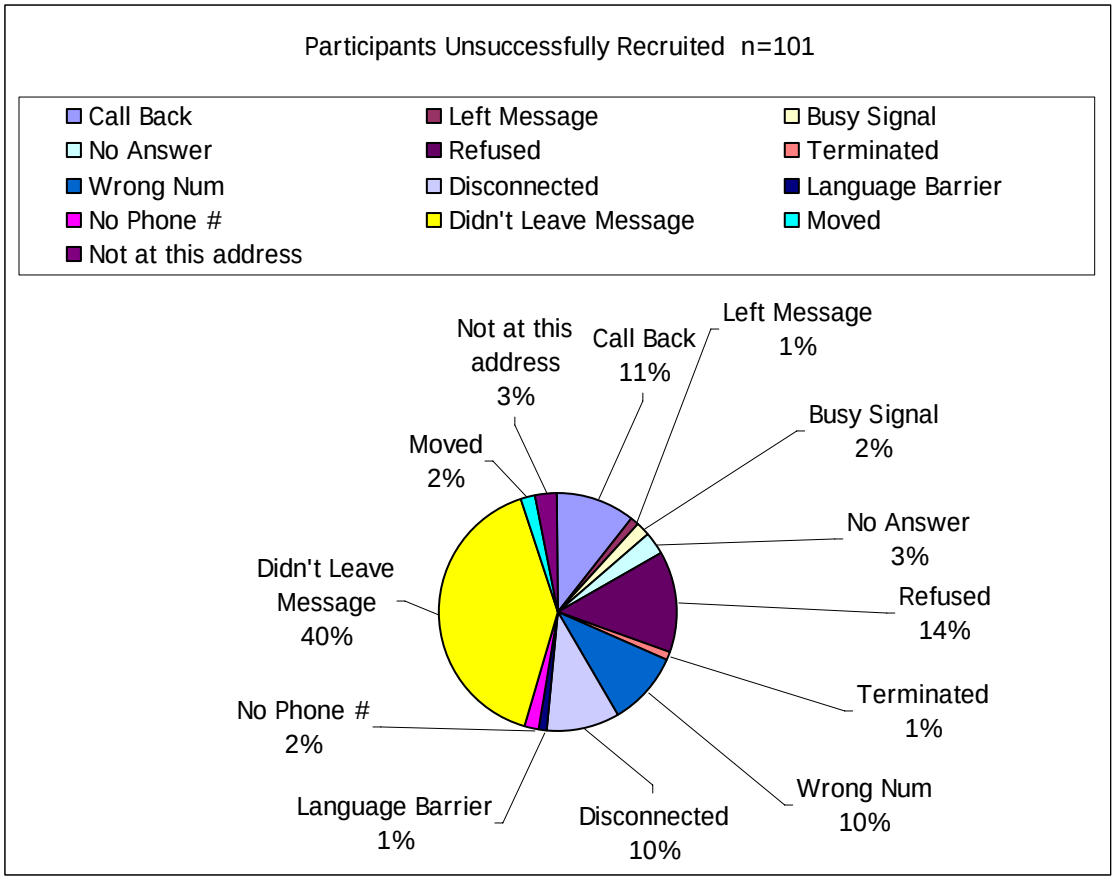


Figure 33: Reasons for Unsuccessful Recruitment

Figure 34 displays the 200 participants and the average number of calls placed by disposition type. A total of 470 calls were placed to recruit the 60 participants in the monitoring study. For every customer recruited, a total of 7.8 calls were made. These averages do not reflect calls placed to the 60 customers for scheduling installation and/or retrieval of metering equipment.

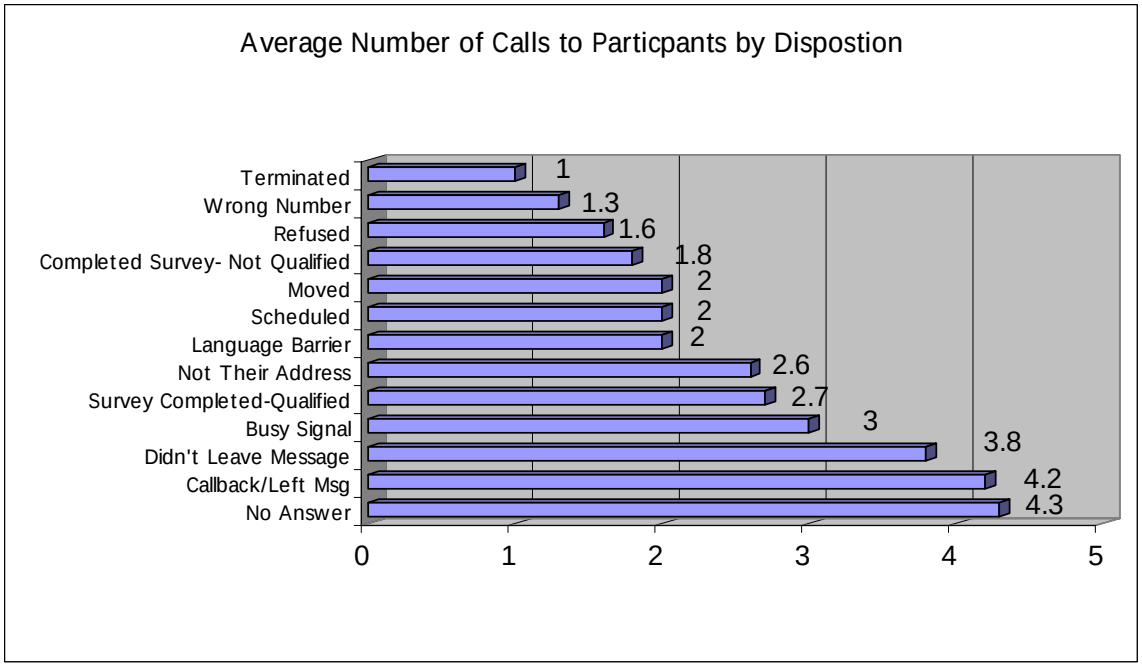


Figure 34: Average Number of Calls

Non-Participant Metering Sites

The Evaluators' proposal outlined several methods to identify and recruit District customers who replaced their central air conditioning unit in either 2006 or 2007, but were not recipients of the District's air conditioning rebate and/or financing. A final decision was made to recruit customers by telephone, rather than through various other proposed methods such as: contractor references, volunteers from the District's bill-pay website, door hangers, targeted mailers, HERS registry, mass mailers, or permits from the building departments. This decision to phone customers was selected in an interest to obtain the most accurate estimate of replacements in the District service territory, including those replacements that were not permitted. Original conjecture outlined 6,000 customers randomly selected from the tracking data of the District's 350,000 residential customers to identify and successfully recruit 60 who had replaced their A/C unit.

As discussed above, previous estimates have indicated 5% of the District's customers replaced their A/C units in 2006 and 2007, which would result in 300 customers identified from the pool of 6,000. If 300 customers were identified, only 1 in 5 would have to agree to participate in the monitoring of their A/C unit. The Evaluators' phone staff began calling the original pool of 6000 while simultaneously recruiting participants in early May of 2007 and exhausted the general population survey pool by the 1st of August 2007 without having identified the desired number of qualified non-participants. Therefore, a second and third pool of customers was later drawn. The second pool (701 customers) and third pool (683 customers) were selected randomly, but excluded homes constructed after 1999, as no customers from the original pool had homes newer than 1999 and had an A/C unit replaced during the desired time period. At the height of recruitment, there was one fulltime employee overseeing the recruitment of 4 part-time employees who worked on average 4-8 PM, 4 days a week.

The three final survey pools included a total of 7,384 customers; however, at least 720 of those customers were never contacted as their homes were either constructed after 1999 or no age of the home was given in the tracking data. Based on the service address, many appeared to be multi-family apartments. The Evaluators' recruitment team did not entirely omit these homes, but began targeting calls to older homes in an interest to identify replacements more quickly. The decision of which homes to target was approved through bi-weekly meetings with the District's project managers. By the first week of September, it was agreed that the Evaluators would only recruit 50 non-participants instead of 60, due to the low number of replacements identified.

The total number of non-participants that the recruitment team attempted to contact is 6664. Table 64 contains the key recruitment dispositions that were tracked from the beginning of the process. These only represent approximately one third of the total attempts. The remaining 4350 attempts were one of the following dispositions: Call Back, Left Message, Busy Signal, No Answer, Refusal, Wrong Number, Disconnected, Language Barrier or No Phone Number.

Survey Recruitment Attempts by Disposition	# of Attempts	%
Completed Survey- Not Qualified	1781	27%
Terminated	9	0%
Moved	72	1%
No Central AC	171	3%
Survey Completed-Qualified	143	2%
Multi-family/Apartment	13	0%
Not at this address	40	1%
Participant	56	1%
Non-Completed Survey- Not Qualified	29	0%
n=6664	2314	35%

Table 64: Total Survey Recruitment Attempts

Table 65 and Table 66 present number of calls and disposition data for a sample of the non-participants. This sample consists of survey pools 2 & 3 representing around 19% of the total population. The reason why this is not presented for the complete sample is because more detailed tracking was kept for these two survey pools. Table 65 demonstrates the total number of calls and the average number of calls placed to recruit non-participants. If this average of 2.2 calls per customer was applied to the 6,664 customers who were phoned, then the Evaluators' phone surveyors placed roughly 14,661 calls to recruit 50 non-participants. In that case, 293 calls were placed for every 1 non-participant recruited.

Survey Pool 2 & 3 (n=1288)	
Total Calls	2834
Average# of calls per recruitment	2.2

Table 65: Number of Calls

Table 66 demonstrates a complete list of dispositions for calls made in survey pools 2 & 3. Approximately 4% of customers replaced their A/C unit in either 2006 or 2007, of which slightly less than 1% were participants in the District's rebate & financing program. Note that had homes built after 1999 been included in these pools, the percentage of replacements would have been lower.

Survey Recruitment Attempts by Disposition (Survey Pools 2 & 3)	# of Attempts	%
Completed Survey- Not Qualified	453	35%
Call Back	40	3%
Left Message	0	0%
Busy Signal	13	1%
No Answer	28	2%
Refusal	59	5%
Terminated	5	0%
Wrong Number	86	7%
Disconnected	78	6%
Language Barrier	13	1%
No Phone Number	17	1%
Moved	17	1%
No Central AC	37	3%
Survey Completed-Qualified	43	3%
Didn't Leave Message	371	29%
Multi-family/Apartment	0	0%
Not at this address	16	1%
Participant	12	1%
n=1288	1288	100.0%

Table 66: Survey Recruitment Attempts – Pools 2 & 3

5. Analysis Results

The study strived to be straightforward and systematic in terms of sampling, data collection, and data analysis with program level gross energy savings realization rates as the focus of the analysis. The results of each study component are presented in order of relevance.

Several other analyses were performed to include results for peak demand savings, net-to-gross rates, and compliance related comparisons. The original sample design was compared to those participants who were included in the study by completing telephone surveys and for some, on-site verifications. Process and market findings collected through telephone surveys with participants, non-participants and contractors are also presented below as they may inform program planning in terms of delivery and processing.

Savings

Ex-Ante

The ex-ante gross and net energy and demand savings per unit are shown in Table 67 and Table 68, respectively. The gross savings are calculated using the following equation.

Total gross unit savings *= equipment unit savings + (duct-system unit savings * repair rate) + (RCA unit savings * repair rate).*

Equipment savings are calculated using a baseline of 10.5 EER. The assumed repair rates for both duct testing and RCA were 80% and 70%, respectively.

Ex-ante Gross (Program Estimate)	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
TIER 1	421	32	292	97
TIER 2	427	53	292	81

Table 67: Ex Ante Gross kWh Savings per Unit

Ex-ante Gross (Program Estimate)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	0.605	0.174	0.280	0.151
TIER 2	0.654	0.247	0.280	0.127

Table 68: Ex Ante Gross kW Savings per Unit

The ex-ante net savings are arrived at by applying a net-to-gross ratio, Title-24 compliance rate and T&D line loss savings. The net-to-gross ratio was assumed to be one. A 96% Title-24 non-compliance rate was ascribed to duct leakage and RCA savings. Line loss savings of 1.06 and 1.0766 were used for energy and peak savings, respectively.

Ex-ante Net (Program Estimate)	Total 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 69: Ex Ante Net kWh Savings per Unit

Ex-ante Net (Program Estimate)	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
Tier 1 Split Systems	454	34	297	123
Tier 1 Pkgd Systems	331	92	297	0
Tier 2 Split Systems	488	68	297	123
Tier 2 Pkgd Systems	331	34	297	0

Table 70: Ex Ante Net kWh Savings per Unit by System Type

Ex-ante Net (Program Estimate)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	0.633	0.188	0.289	0.156
TIER 2	0.686	0.266	0.289	0.131

Table 71: Ex Ante Net kW Savings per Unit

Ex-ante Net (Program Estimate)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
Tier 1 Split Systems	0.695	0.210	0.289	0.195
Tier 1 Pkgd Systems	0.387	0.098	0.289	0.000
Tier 2 Split Systems	0.765	0.280	0.289	0.195
Tier 2 Pkgd Systems	0.527	0.238	0.289	0.000

Table 72: Ex Ante Net kW Savings per Unit by System Type

Ex-Post

To arrive at net savings a baseline model was estimated 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 during the same period of time.

The total unit net energy savings (kWh) resulting from the end-use meter data analysis are presented in Table 73, Table 74 and Table 75. Recall that the efficiency savings resulted from comparisons of participant usage to the SEER 13 / EER 11 baseline. The total savings less the efficiency savings were termed the "compliance" savings which were proportioned into duct sealing savings and RCA savings based on the performance testing, detailed analyses and engineering judgment. Duct sealing savings were estimated to attribute for 80% of compliance savings with RCA savings representing the other 20%.

Ex-post (Measured Savings)	Total Savings kWh	Error Bound	Relative Precision
TIER 1	502	64.7	12.9%
TIER 2	525	67.7	12.9%

Table 73: Ex-post Error Bound & Relative Precision[10]

Ex-post (Measured Savings)	N	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
TIER 1	34	502	59	355	89
TIER 2	16	525	92	346	87

Table 74: Ex-post Energy Savings

Savings by system type and tier are presented below in Table 75. Due to the different sample sizes in each bin, note that total savings will not average to the totals by tier presented above.

[10] The relative precision (rp) is the ratio of the error bound (at the 90% confidence level) over the savings estimate. A ratio greater than or equal to one (rp = 100%) implies that the savings estimate is not statistically significant. A ratio below one (rp < 100%) implies statistically significant savings at the 90% confidence level.

Ex-post (Measured Savings)	N	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
Tier 1 Split Systems	24	514	63	361	90
Tier 1 Pkgd Systems	10	472	48	339	85
Tier 2 Split Systems	13	533	95	351	88
Tier 2 Pkgd Systems	3	490	80	328	82

Table 75: Ex-post Energy Savings by System Type

Similarly, the total unit demand savings (kW) resulted from end use meter data analysis of the peak period defined to be 4PM-7PM on the three hottest consecutive days of the metered period. Participant peak demand profiles were also compared to the EER 11 baseline to develop efficiency savings and compliance savings which were then proportioned into duct leakage and RCA demand savings in a similar manner as was done for kWh savings.

Ex-post (Measured Savings)	N	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	34	0.439	0.258	0.163	0.041
TIER 2	16	0.459	0.414	0.057	0.014

Table 76: Ex-post Demand Savings

Ex-post (Measured Savings)	N	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
Tier 1 Split Systems	24	0.449	0.269	0.163	0.041
Tier 1 Pkgd Systems	10	0.413	0.230	0.164	0.041
Tier 2 Split Systems	13	0.466	0.408	0.072	0.018
Tier 2 Pkgd Systems	3	0.429	0.439	N/A	N/A

Table 77: Ex-post Demand Savings by System Type

The realization rate is 1.17-1.20 for total energy savings (kWh) as presented in Table 78. This means the evaluation found the per unit savings to be approximately 18.5% higher than the utility's estimates. This result is likely due to higher efficiency savings than estimated, significant duct leakage in the non participant sample and the higher percentage of TXVs installed on participant systems.

	Ex-ante kWh Savings	Ex-post kWh Savings	Realization Rate
TIER 1	430	502	1.17
TIER 2	436	525	1.20

Table 78: kWh Realization Rate

However, the realization rate for the peak demand (kW) savings is 0.67-0.69, meaning the evaluated savings are lower than the ex-ante estimates. This result may be attributable to over sizing in both participant and non-participant systems and shows the duct system deficiencies had little impact on peak. The peak demand savings are presented in Table 79.

	Ex-ante kW Savings	Ex-post kW Savings	Realization Rate
TIER 1	0.633	0.439	0.69
TIER 2	0.686	0.459	0.67

Table 79: kW Realization Rate

Ex-Post Details

Table 80 and Table 81 present total program savings achieved by unit size in the metered sample. Most participant units were 3 tons and therefore those results, viewed independently, may be more meaningful. The largest savings were achieved by 4 and 5 ton units for both kWh and kW savings. However, the 2 ton units generate a total savings closest to the overall program savings reported above.

Tons	N	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
2	5	502	23	384	96
2.5	9	496	78	335	84
3	21	535	57	382	96
3.5	7	398	69	264	66
4	5	560	110	360	90
5	3	558	139	335	84

Table 80: Energy Savings by System Size

Efficiency kW savings for both 4 and 5 ton units are larger than total savings. Therefore, no compliance savings are presented for these systems.

Tons	N	Total Savings kW	Efficiency Savings kWh	Duct Leakage Savings kW	RCA Savings kW
2	5	0.439	0.151	0.230	0.058
2.5	9	0.434	0.234	0.202	0.050
3	21	0.467	0.266	0.181	0.045
3.5	7	0.348	0.264	0.067	0.017
4	5	0.489	0.581	N/A	N/A
5	3	0.488	0.665	N/A	N/A

Table 81: Demand Savings by System Size

Presented below is a comparison of the final ex-post savings to those for three different scenarios using distinct baselines. One scenario uses the same non-participant data to calculate total savings; however, for calculating efficiency savings the actual EER of the non-participant sample is used as the baseline. The other two scenarios use subsets of the total non-participant data to develop the baseline model. These two subsets consist of non-permitted non-participants and permitted non-participants. Table 82 and Table 83 show total savings and efficiency savings for all four scenarios.

Ex-post (Measured Savings)	Total Savings kWh Tier 1	Total Savings kWh Tier 2	Efficiency Savings kWh Tier 1	Efficiency Savings kWh Tier 2
11 EER Base (Final Savings)	502	525	59	92
Actual EER Base	502	525	97	135
Non-Permitted Base	674	705	109	149
Permitted Base	170	178	65	99

Table 82: Ex-Post Energy Savings by Scenario

Ex-post (Measured Savings)	Total Savings kW Tier 1	Total Savings kW Tier 2	Efficiency Savings kW Tier 1	Efficiency Savings kW Tier 2
11 EER Base (Final Savings)	0.439	0.459	0.258	0.414
Actual EER Base	0.439	0.459	0.407	0.569
Non-Permitted Base	0.648	0.678	0.465	0.629
Permitted Base	0.018	0.019	0.263	0.417

Table 83: Ex-Post Demand Savings by Scenario

Following are the detailed savings results calculated using the non-participant sample average unit efficiency as the EER baseline. The average non-participant EER was 10.35. This is very close to the EER assumed by the Program which was 10.5. The total savings for this scenario are the same as the 11 EER ex-post savings presented above

as the only changes made between these two scenarios was the efficiency savings calculation. As the tables show, the efficiency savings increased significantly for this scenario due to the 0.65 drop in EER in the baseline.

Ex-post (Measured Savings Actual Base)	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
TIER 1	502	97	324	81
TIER 2	525	135	313	78

Table 84: Ex-Post Energy Savings w/ Actual EER Baseline

As stated previously, compliance savings are estimated as the difference between total savings and efficiency savings. In this scenario, the calculation of the Tier 2 efficiency kW savings using the actual non-participant EER of 10.35 as the EER baseline results in a larger figure than the total kW savings. No compliance savings are presented for Tier 2. The Tier 1 total and efficiency demand savings are very similar. With such small compliance savings it is difficult to accurately split those into duct leakage and RCA and these results should be viewed with that in mind.

Ex-post (Measured Savings Actual Base)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	0.439	0.407	0.025	0.006
TIER 2	0.459	0.569	N/A	N/A

Table 85: Ex-Post Demand Savings w/ Actual EER Baseline

Table 86 and Table 87 show detailed savings results calculated using only the non-permitted non-participant metered sample to generate the baseline model. The savings for this scenario are much larger than the final ex-post savings due to the lower performing baseline. Recall that 74% of the metered non-participant sample was non-permitted and therefore the majority of the non-participants were used to develop this baseline. The average non-permitted EER was 10.15. This EER was used to calculate efficiency savings resulting in savings much larger than any of the other scenarios.

Ex-post (Measured Savings Non-Permitted Base)	Total Savings kWh	Efficiency Savings kWh	Duct Leakage Savings kWh	RCA Savings kWh
TIER 1	674	109	452	113
TIER 2	705	149	445	111

Table 86: Ex-Post Energy Savings w/ Non-Permitted Baseline

As was the case in the previous scenario, the Tier 2 total and efficiency demand savings are very similar. With such small compliance savings it is difficult to accurately split those into duct leakage and RCA and these results should be viewed with that in mind.

Ex-post (Measured Savings Non-Permitted Base)	Total Savings kW	Efficiency Savings kW	Duct Leakage Savings kW	RCA Savings kW
TIER 1	0.648	0.465	0.146	0.037
TIER 2	0.678	0.629	0.039	0.010

Table 87: Ex-Post Demand Savings w/ Non-Permitted Baseline

Table 88 and Table 89 show savings results calculated using only the permitted non-participant metered sample to generate the baseline model. The savings for this scenario are much smaller than the final ex-post savings due to the fact that the permitted non-participants have systems relatively similar to participants. Only 26% of the metered non-participant sample was permitted, therefore the relative precision of these savings numbers may be lower.

The average permitted EER was 10.89. This EER was used to calculate the efficiency savings. The efficiency kWh savings are relatively close to the total kWh savings in comparison to the other scenarios. Demand savings for this scenario are very low. Efficiency kW savings are larger that total kW savings for both Tier 1 and Tier 2. Due to the granularity of this small baseline sample size savings cannot be further divided into compliance savings categories. Systems in this sample have higher leakage to outside than in the non-permitted sample and a larger sample may show leakage nearer to non-permitted. However, savings still may be within the error bound of the savings estimate.

Ex-post (Measured Savings Permitted Base)	Total Savings kWh	Efficiency Savings kWh
TIER 1	170	65
TIER 2	178	99

Table 88: Ex-Post Energy Savings w/ Permitted Baseline

Ex-post (Measured Savings Permitted Base)	Total Savings kW	Efficiency Savings kW
TIER 1	0.018	0.263
TIER 2	0.019	0.417

Table 89: Ex-Post Demand Savings w/ Permitted Baseline

Freeridership and Spillover

The savings methodology is based on measuring participant and baseline (non-participant) energy consumption and peak demand kW. The non-participant HVAC replacements were assumed to be what a participant would have done absent the Program, which is the goal of a net savings assessment. Traditional net savings factors are developed but are not applied to unit savings comparisons. The factors developed from participant surveys may not be applicable to the measured net savings and are not applied in the analysis results. Freeridership was developed as equipment freeridership and compliance freeridership to provide the District with these estimates. It is recommended that only the equipment freeridership be applied to equipment efficiency savings by the District and duct sealing compliance freeridership should be considered but not applied. The duct sealing compliance freeridership has a great deal of uncertainty given that many customers learned about the code requirements from program participating contractors yet said they would have had ducts tested without the District rebates. Application is further complicated by the fact that repair rates are not tracked and some identified "duct sealing freeriders" may not have had any duct repairs at all.

Equipment Freeridership

Analysis of responses to the equipment freeridership questions are presented in the following section. The resulting freeridership rate was not applied to the ex-post measured savings since the approach was designed to measure net savings. The average freeridership was 28.7% based on the methodology outlined in the Freeridership section of the Methodologies Chapter. This score was determined from reviewing answers to telephone and on-site survey questions asked of 60 participants. Table 90 presents the distribution of freeridership scores for participants.

Freeridership Score	Frequency
0	7
1 to 25	23
26 to 50	20
51 to 75	10

Table 90: Distribution of Equipment Freeridership

A flow diagram of the freeridership methodology is presented Figure 35. Contained within the flow diagram are the initial and final average freeridership scores and the number of participants who responded according to the different paths.

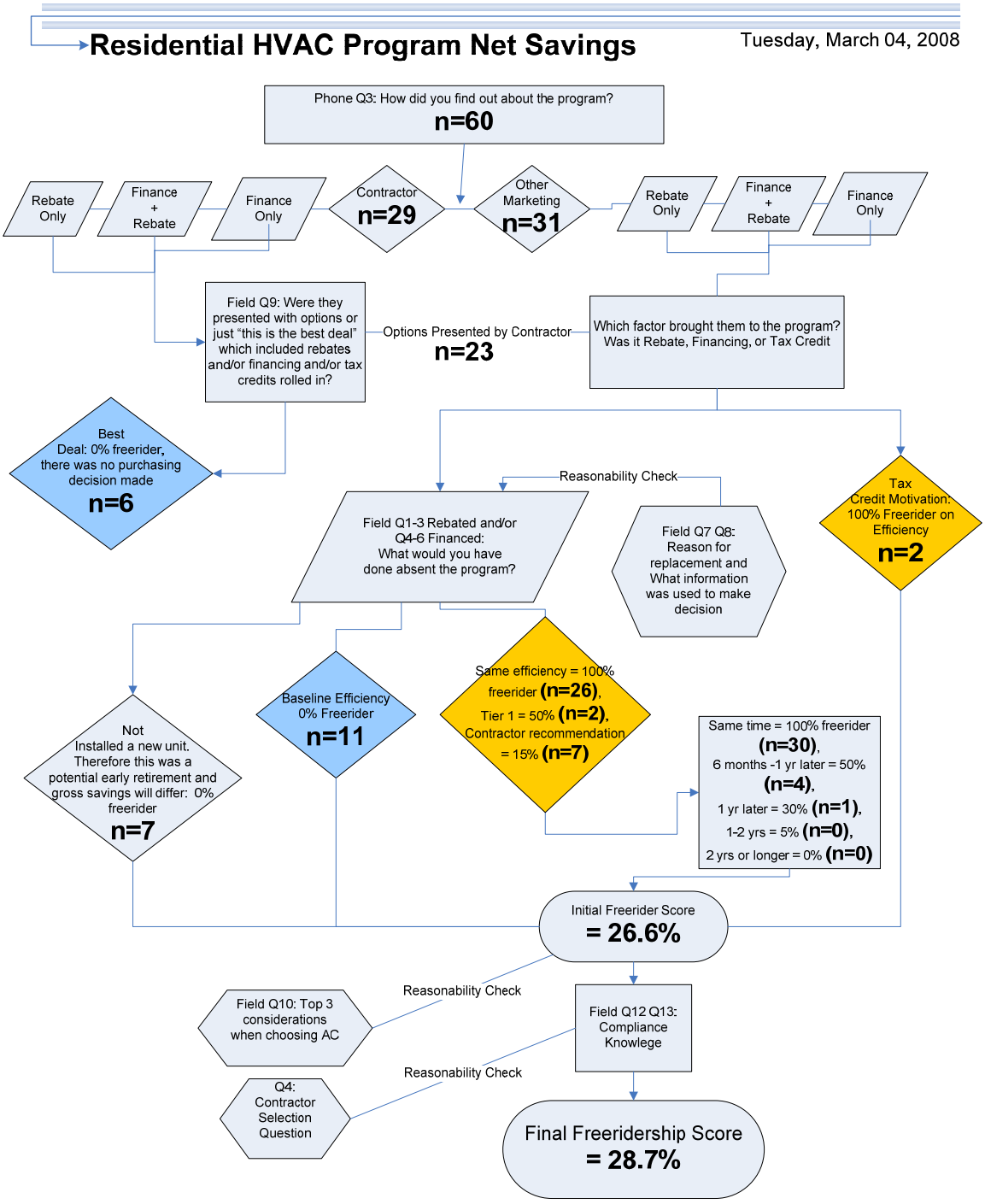


Figure 35: Equipment Freeridership Flow Diagram with Results

As an example, take a participant that indicated he would have replaced his air conditioner with the same high efficiency unit at the same time with or without the rebate. He first heard about the program through his contractor before the installation process began. These three responses give an initial freeridership score of 66%. However, he also stated that the rebate was influential in his purchase decision. This inconsistency cuts the freeridership rate in half to 33%. The contractor was the source from which he first heard about the rebate program and the contractor only provided him with one bid, not multiple bids. This brought the freeridership score down to 0% because he essentially did not make a purchase decision. Lastly, he also said that energy efficiency was a top consideration when purchasing a unit. This increased his freeridership score slightly for a final score of 10%.

Table 91 shows the average equipment freeridership score for each response given to phone question Q4, which asks how participants went about selecting a contractor to install their equipment. Some respondents gave multiple answers; therefore the total number in the sample does not add up to 60. Customers that found their contractor through the phone book had the highest freeridership score of 47%. The lowest freeridership score was from those that found their contractor through the ACCA website. However, the numbers of participants in these cases were only 3 and 1, respectively.

Contractor Selection Method	N	Average Freeridership Score
Already Knew Reputable Contractor	13	34
Selected Least Expensive Bid from Multiple	14	26
Phone Book	3	47
Newspaper Ad	3	18
Friend/Colleague	16	30
SMUD Website	7	31
ACCA Website	1	10

Table 91: Equipment Freeridership Score by Contractor Selection Method

Duct Sealing Compliance Freeridership

Analysis of responses to the compliance freeridership questions are presented in the following section. The resulting freeridership rate was not applied to the ex-post measured savings since the approach was designed to measure net savings. The average freeridership was 38.0% based on the methodology outlined in the Freeridership section of the Methodologies Chapter. To determine the duct sealing compliance freeridership score used the equipment freeridership score was altered based on responses to telephone and on-site survey questions regarding compliance. The average compliance score is somewhat greater than the average equipment score signifying that a larger percentage of participants would have still submitted a permit and chosen the duct sealing compliance option than would have purchased high

efficiency equipment without the rebate program. Table 92 presents the distribution of freeridership scores for participants.

Freeridership Score	Frequency
0	18
1 to 25	14
26 to 50	3
51 to 75	18
100	7

Table 92: Distribution of Compliance Freeridership

Table 93 shows the average compliance freeridership score for each response given to phone question Q4, which asks how participants went about selecting a contractor to install their equipment. Some respondents gave multiple answers; therefore the total number in the sample does not add up to 60. There is not much diversity of scores across contractor selection methods except for the one participant with a zero freeridership score who selected his contractor through the ACCA Website. Customers that requested bids from multiple contractors and simply selected the least expensive bid had the highest freeridership score of 56%.

Contractor Selection Method	N	Average Freeridership Score
Already Knew Reputable Contractor	13	27
Selected Least Expensive Bid from Multiple	14	56
Phone Book	3	33
Newspaper Ad	3	41
Friend/Colleague	16	40
SMUD Website	7	36
ACCA Website	1	0

Table 93: Compliance Freeridership Score by Contractor Selection Method

RCA Compliance Freeridership

No RCA compliance freeridership rate was defined.

Spillover

No site level spillover was identified through the telephone surveys and on-sites.

Process and Market Findings

The Evaluators designed decision-maker surveys to be conducted with customers who changed their air conditioners in 2006 and 2007. The questions were intended to learn

more about program awareness and attitudes, specific building characteristics, and design and construction practices. The following sections report these results and correlate directly with the flow of the decision-maker survey. This section addresses the following areas of interest:

- Home information,
- Descriptive statistics on air-conditioner types, locations, and use,
- Statistics on A/C unit replacement,
- Thermostat and summer month information

Survey Respondents

The target number of total interviews was approximately 1300. The final dataset, however, contained survey responses from 99 participants, 143 general population customers who replaced their central air conditioners in 2006 and the first three quarters of 2007 and 1781 general population customers who did not. The goal of the sample was to infer information about Program participants, A/C replacements and other information. The information was gathered by interviewing home owners and renters.

If the decision maker was not available on the first attempt, recruiting staff continued efforts to contact the customer. Each participant or non-participant was called at least 7 times in such cases. The survey began with a pool of 6000 customers chosen to represent the entire population of over 200,000 based on home age, square footage, and location.

Survey Results for Market Size

Previous estimates have indicated that annually 5 percent of the District's customers replaced their A/C units in 2006 and 2007, which would result in 300 customers identified from the pool of 6,000. If 300 customers were identified, only 1 in 5 would have to agree to participate in the monitoring of their A/C unit. However, after exhausting this first pool the desired 60 non-participant candidates had not yet been recruited. Two additional pools of non-participants were included to arrive at a total pool of 7384. From data gleaned from surveys with the general population it was determined that the 2006-07 market size on August 22, 2007 was estimated to be around 3 percent of the District population and 9 percent of the single family air conditioning market.

	Quantity	% of Sample	% of A/C Market
No Central A/C	171	3%	7%
Central A/C Not Replaced in 06/07	1781	27%	77%
Participant Size	56	1%	2%
Non-Participant Size	143	2%	6%
Total A/C Replacements	199	3%	9%

Table 94: Percent of Market with A/C replacements as of 8/22/2007

Population	2006-2007 Estimated Quantity
Central A/C	273,152
Participant Size	8,550
Non-Participant Size	15,268
Total A/C Replacements	23,819

Table 95: Estimated Populations

Permit & Duct Testing Data

The addresses from the final list of full participants and non participants were compared with available building department records to find permit numbers and permit issue dates. Next, data was collected from the HERS registries, CalCerts CHEERS, and CBPCA, and that data was used to identify which HVAC replacements included duct testing procedures.

Out of 104 full participants, permits were identified for 93. Out of 147 non-participants, permits were identified for 49. Duct test results were found for 48 of the full participants and for 26 non-participants.

	Participants n=99	Non-Participants n=143
Permits	89	49
% of Sites w/ Permit Data	90%	34%
Duct Test Results	47	23
% of Sites w/ Duct Test Data	47%	16%

Table 96: Permit Data & Duct Test Results

To provide a comparison across program years the Evaluators looked at the percentage of non-participants that were permitted in 2006 and 2007, respectively. Table 97 shows that a larger percentage of the population received permits for their replacements in 2007 than in 2006. Approximately 46% of the general population pulled a permit in 2007 and only around 27% did so in 2006. As was expected, due to the timing of this evaluation being conducted mid-2007, there was a larger number of non-participants found in the Mass Market Survey who replaced their air conditioners in 2006 than in 2007.

	2006	2007
Total	106	37
Permitted	27	17
% Permitted	25%	46%

Table 97: Permit Breakdown by Replacement Year

Comparisons and District Objectives

A critical component of this research is to better understand the decision-making process that homeowners utilize when selecting replacement HVAC systems. Particular factors that were addressed during the homeowner and contractor surveys are the following:

- How homeowners select contractors to perform the replacement,
- The energy efficiency options that contractors offer to prospective customers,
- The degree to which homeowners consider energy efficiency in their selections,
- Information sources homeowners rely upon in their decisions,
- How homeowners evaluate how much to spend on the replacement system, and
- The effect of rebates and financing on the purchasing decision.

A copy of the survey showing all questions asked can be found in the Appendix.

The key findings from this report are summarized below:

- The majority of participants and non-participants selected a contractor based on previous work at the home or a recommendation from a friend.
- The contractors presented participants with more estimates and options than they did non-participants. The most common option presented to non-participants was that for a high efficiency A/C.
- The most popular option offered by contractors is the duct seal and testing.
- The majority of participants and non-participants did not know if a rebate of $400-500 would cover the cost of upgrading to a high efficiency unit.
- The majority of both the participant and non-participant contractors offer an option for a high efficiency unit.
- The majority of participants stated they would have installed a less expensive unit without the financial help of a rebate.
- The majority of participants and non-participants stated they replaced their existing cooling system because it was broken.
- The number one consideration when purchasing a unit was cost.
- Both participant and non-participant contractors stated that the equipment price was the most important feature to customers.
- Most respondents first heard about the rebate through the A/C contractor before the installation process. This suggests that contractors are using the rebate as a selling point.
- The large majority of respondents stated that the contractor's recommendation was relied upon when deciding what unit to purchase.
- The large majority of participants would have purchased the unit at the same time or sooner if the Program rebate had not been available.
- Over 63% of respondents who received financing through the District said they would have still purchased a new unit without the availability of financing.
- Most participant respondents stated that they would purchase the same efficiency unit with or without the rebate from the District.
- Most contractors, about 74%, said that customers are aware of the rebates before contacting the contractor for an estimate. This is contrary to what the customers stated.

Costs

The total installed cost for each participant was available in the Program tracking data. The proportion of labor cost and equipment cost was determined by looking at high efficiency system costs in the 2005 DEER database. Based on contractor interviews it was possible to determine additional costs for systems with TXV and R-410a refrigerant which add equipment costs. Additional costs are incurred for duct testing, sealing, and HERS registry fees. The focus of the analysis is on equipment incremental cost. It is noted that participants may be paying $1100-$1500 per installation for duct testing, sealing, HERS verification, and TXV. These compliance costs were not included in the analysis but should be noted when comparing actual costs for participants to incentive levels. Table 98 presents equipments costs per ton for the four system types and range of efficiencies. Table 99 presents the incremental costs from a standard efficiency unit per ton for the efficiency Tiers offered by the Program.

	Average Cost Per Ton of Equipment			
SEER	**Pkg AC**	**Pkg HP**	**Split AC**	**Split HP**
13	$ 1,172	$ 1,350	$ 1,124	$ 1,443
14	$ 1,837	$ 1,971	$ 1,323	$ 1,697
15	N/A	N/A	$ 1,657	$ 2,025
16	N/A	N/A	$ 2,169	$ 2,140

Table 98: Cost per Ton for Various System Types and Efficiencies

	Incremental Cost Per Ton of Equipment			
TIER	**Pkg AC**	**Pkg HP**	**Split AC**	**Split HP**
1	$ 666	$ 621	$ 199	$ 254
2	N/A	N/A	$ 533	$ 582

Table 99: Incremental Cost per Ton by TIER

6. Conclusions & Recommendations

Conclusions

The Residential HVAC incentive program realized much of the estimated program savings. The key component was that participant systems have higher efficiencies and have significantly less distribution system (duct) leakage. Other important conclusions were drawn from the data and analyses including:

- Participants save energy due to high efficiency equipment, higher presence of TXV, and significantly less duct leakage compared to non-participants
- High Efficiency equipment saves significant demand
- Participants are complying using TXV credit as many participants have high charge (low subcooling compared to target)
- Both participants and non-participant systems are oversized compared to Manual J
- About one third of non-participant systems are permitted and half of those test ducts
- The Program has about a one third market share and replacement market is closer to 3.5 to 4 percent annually
- District customers acquire multiple bids for change-outs more so than non-participants

Recommendations

Recommendations for the program implementation process were gleaned from the results and respondents comments by the Evaluators. These recommendations reflect in some cases opinions and interpretations, but all are valuable considerations to be made in program development.

- The program requires and confirms duct testing compliance and should explore expansion of requirements, verifications, and incentives to address sizing, refrigerant charge, and system airflow.
- Train contractors to ensure systems are sized properly and have factory specified charge and airflow. Show the benefits of using SMUD program to ensure all jobs are compliant and use the selling point of all the additional savings the customers receive beyond the equipment.
- Require documentation of Manual J sizing.
    - Require or offer design assistance for right sizing
    - Offer additional incentive for documentation of Manual J that is verified by third party such as a HERS rater
- Require documentation of “pre” conditions and contractor scope of work, to determine duct seal and RCA repair rates. Document when TXV was added by contractors and when TXV was factory installed.
- Use a checklist required for each rebate to include the above elements with itemized costs for testing, repairs, HERS inspection costs, equipment cost, and other material costs.
- Ensure that both SMUD and the appropriate building department both have copies of the permit and forms CF-4R and CF-6R.

- Compile all program collected data in one database including: itemized costs, scope of work, permit information, Manual J documentation, removed equipment information, installed equipment information, HERS verification data, duct and RCA repairs. These data could be used in future evaluation to develop savings per installed tonnage based on actual repairs made and their costs.
- Supply customers with a dictionary of HVAC terms and acronyms and a description of the permitting process explained in both technical and laymen terms including:
    - Description of unit types: Spilt, Packaged, Heat Pumps
    - What to expect with regards to building compliance including cost of permits and building department verification requirements.
    - Title-24 trade offs
    - Why duct testing and sealing and refrigerant charge and air flow are just as important as the unit they choose.
    - Benefits of early HVAC retirement.
    - What to expect and what not to expect if they are to rely on their home warrantee to cover the replacement.
    - Why obtaining bids from at least three contractors is advisable.

Contractors, as do residential customers, feel that the District can aid in the HVAC replacement process. Some of the questions and suggestions that could be addressed include the following:

- Why rebate amounts may increase or decrease over the years and what the incentive covers.
- Why customers should expect to pay $100 for a financing application fee and what that fee covers.
- Post the financing application on the Disitrict's website and allow contractors to submit the application electronically.
- Post city and county permit forms as a PDF on the website to be easily downloaded or provide URL links to permit departments.
- Work with city and county officials to provide applications electronically if they are not doing so already and make permit fees comparable.
- Help with incursion of additional scope of inspection, "whole house" not HVAC only, and difficulty making appointments with Building Inspectors.

<u>Possible Missed Opportunities</u>

Although the District may intend to reach every customer replacing an A/C unit, there does appear to be possible missed opportunities that would require a slightly different marketing approach. Those that are markets include the following:

- Home Warranty Replacements
- Rental Property Replacements
- Early Retirement Replacements

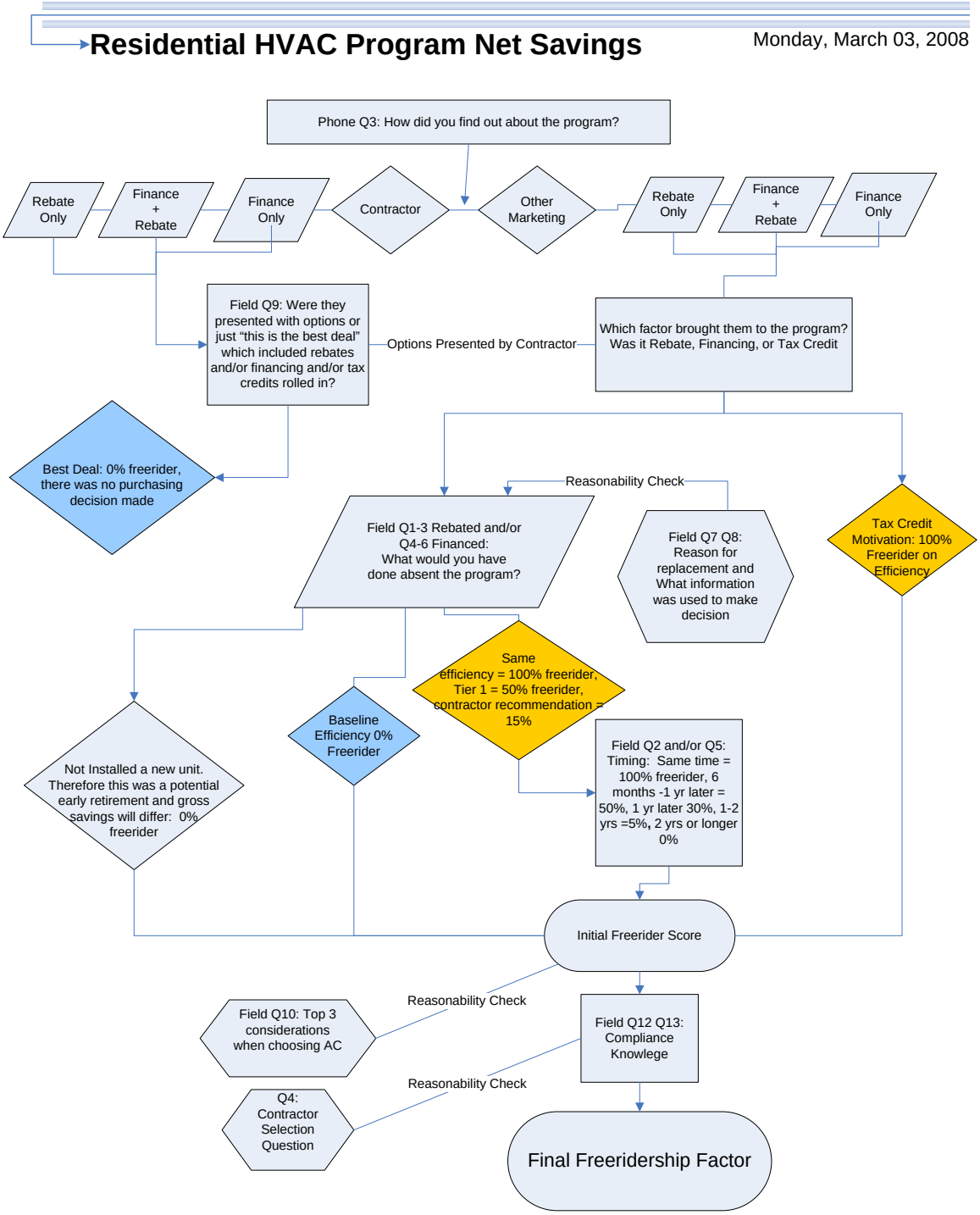
<u>Home Warranty Replacements</u> - Survey findings revealed some contractors are resistant or refuse to work with customers replacing their HVAC unit with a home warranty. For the few that are willing to work with such customers, they find insurers limit their selection to baseline efficiency. Contractors stated "they want the bare minimum and they don't care what's right for the job" and "these types of jobs are not always

permitted and they (insurers) are the number one culprit, willing to look the other way." Insurers and homeowners often dispute who is responsible to pay for such fees as permits and duct tests. As a result, contractors don't always get paid, permits may not be submitted and high performance systems aren't often installed. The issue of insurer efficiency requirements in the District's service territory may require collaboration with government oversight such as the California Energy Commission (CEC).

Rental Property Replacement - Rental property replacements accounted for 18%, or 9 homes, of the non-participant sample and 2%, or 1 home, of the participant sample. Although the participant sample contained one renter, this customer was also a relative of the homeowner, and therefore not truly representative of a rental property. The inclination of property owners may be to install the cheapest equipment available. To close this gap the District should consider devising a strategy specifically tailored to encourage property managers or property owners to increase efficiency. The District should consider providing them with larger incentives, but placing a limit on the total amount of incentives they can receive annually. The District should also create provisions for renters to advocate for their interests to obtain an efficient system. A non-participant customer expressed frustration that they couldn't participate because the landlord wouldn't agree to pay for the more efficient system.

Early Retirement Replacements – the District should consider placing a greater emphasis on promoting early HVAC retirement while working with manufacturers or District-approved contractors to encourage customers to replace their inefficient system before it fails. Ninety-nine customers who participated in the telephone survey were asked why they replaced their air conditioning unit. Of those asked, 90% were a result of unit failure. Eight percent stated the unit was still functioning but they were concerned how long it would last and only 2% replaced the unit to obtain a more efficient system. Out of the participant sample (60) who agreed to monitoring, 92% replaced their unit as a result of unit failure.

7. Appendix A: Freeridership Flow Diagram



8. Appendix B: Survey Instruments

Non-Participant Phone Instrument

RLWID: _____ Customer Name: _____

Introduction

Hello, may I speak with <CUSTOMER>
Hello, my name is **<<interviewer>>,** I am calling on behalf of SMUD, your electric service. We are contacting you today with regards to a SMUD A/C market research study. Our firm RLW Analytics has been hired on behalf of SMUD to ask you a few questions about your home's cooling system.

If the customers has questions about the study, they are welcome to contact the SMUD project manager Wim Bos (916) (Title Senior Demand Supply Specialist) at 916-732-6579 (after May 11th)

Occupant Questions: We would like to ask just a few basic questions about your home.
Our information shows that your home is located at <<ADDRESS, CITY>> is that correct?

Yes
Yes, but we have moved, THANK & TERMINATE
Yes, but home is now a rental
No (Terminate Call)
Refusal
Call Back
50. Other: _____

Do you Own or Rent?

1. Own
2. Rent / Lease
98. DK/Refused

Do you have central air conditioning? If no, what kind of A/C if any? (IF NO TERMINATE)

Yes
No, AC
No, Window/Wall
No, Portable Unit
No, Swamp Cooler
50. No, Explain: _____(i.e. Indirect-Direct Evaporative Cooler)
98. DK/Refusal

Where is the air conditioner located in your home? Is it? (Air conditioning condensing unit)?

1. Outback, in the back or side of house

2. On the Roof
3. A Window/Wall unit, REVIEW Q3
4. DK/Refused
50. Description: _____

Do you have more than one A/C system in your home?

1. Yes, ask for details: _____ (whole house fan?)
2. No

Do you have a gas furnace?

0 Yes
1 No (Use this if they say electric)
98. DK

When was the last time you replaced the A/C unit? What month and year?

1. **Verbatim**_____
   a. **(Mo. Instld._____)**
2. 2007**
3. 2006**
4. 2004-2005
5. 2001-2003
6. 1999-2000
7. 1992-1998
8. 1984-1991
9. 1978-1983
10. Pre 1978
11. Don't Know **(SKIP Q8, Q9)**
12. Has not been replaced as long as I've lived here. Not Since Year: _____ **(SKIP Q8, Q9)**
13. Original Unit has not been replaced **(SKIP Q8, Q9)**

Accept anyone installed in 2006-2007

IF Q7 = 2 or 3 THEN RECRUIT FOR ON-SITE INSPECTION

Approximately how old was the A/C unit you replaced?

1. Verbatim: _____
2. Less than 10 Years
3. 10-15 Years
4. 16-20 Years
5. 21-30 Years
6. As old as the house, Year house was built: _____
98. DK/Refused

What was the main reason you decided to purchase a new central air-conditioner? (circle all that apply, read only as necessary)

8. Unit was not functioning properly or was broken
9. Unit was still working OK, but I was concerned with how long it would last

10. To replace inefficient system with more efficient system
11. Needed to replace heating system, did cooling at same time
12. Wanted to add central A/C (no central A/C previously)
13. Unit was not serving the load
    a. needed a second system
    b. replaced existing unit with a larger system
14. Home Renovation / Making Structural Changes
15. Previous Owner Replaced Unit
98. DK/Refused

How did you go about selecting a contractor to install your equipment? (Circle all that apply)

9. Already knew a reputable contractor who installed or performed maintenance on a previous unit
10. Requested multiple bids selected least expensive offer
11. Phone Book
12. Newspaper AD
13. Friend/colleague Recommendation
14. Internet Search
15. Referred to the SMUD Web site for list of participating contractors
16. ACCA (A/C Contractors of America) Website

50. Other: _____

98. DK/Refused

How often do you use your air-conditioner during the cooling season months (May-September)? Would you say it is used.....?

1. Daily
2. A few days a week
3. A few days a month
4. Only on extremely hot days
5. Never
98. DK/Refused

How many thermostats do you have in your home? 1 2 3

Is/(Are) your thermostat(s) programmable or manual? Programmable (Digital) / Manual

Throughout the summer months do you cool your house to a certain temperature all the time or do you adjust the temperatures when you're home and/or when you're away?

One temperature:_____

Adjust temperature when home and away

a. What is the Occupied Temperature Setting: _____

b. What is the Unoccupied Temperature Setting: _____, off

Something Else, Please Describe:

_____

_____

Our records show your home was built <<Year Built>>. If Blank, In what year was your home built?

1. Verbatim: _____
2. 2004-2005
3. 2001-2003
4. 1999-2000
5. 1992-1998
6. 1984-1991
7. 1978-83
8. Pre 1978

Approximately how many people live in your home year around?

Verbatim_____

Are there any summer or temporary residents who stay longer than a week?

If Yes, Qty: _____

No

Do they qualify for an on-site? YES/NO

If they don't qualify for an on-site:

We would like to thank you for taking the time to provide us input about your home. This concludes all the questions I have do you have any questions before we finish?

If they do qualify for an on-site:

Since your A/C unit was installed in the (2006-07) year you qualify for a SMUD sponsored Air Conditioner Quality Assurance & Performance Testing. SMUD is sponsoring this test on a small sample of homes to better understand the energy performance of recent A/C installations. This test will measure A/C refrigerant charge and air flow, whole house leakage, and leakage through the duct system. We will also complete a heat load calculation and conduct monitoring on the system until October to capture information on energy usage.

This test will be performed by two field engineers at no cost to you. We will provide you with a summary of our test results at the end of the monitoring period (in October). We are providing a cash incentive of $50 to compensate you for your time. The monetary incentive of $40 will be provided at our initial visit and an additional $10 will be given to you when the monitoring equipment is removed in (October 2007). Lastly, we think you will appreciate knowing that these diagnostic tests that cost you nothing are valued at $600-$800. In order for us to do this we need to determine when would be a good day and time to come to your home. Our engineers will be on your property for about 2 hours and a good portion of that time will be spent outside by the condensing unit. They will also need to spend time in the attic or wherever your furnace is located. When we return in October we'll be at your home for no longer than 30 minutes.

If they ask about the monitoring equipment:

The monitoring equipment is a small non-intrusive digital thermometer (the dimensions of the meter is 2" L 2" H ¼ "W) smaller than a pack of playing cards. It will be placed on or near the thermostat to record indoor temperature. Located outside, on the condensing unit will be another meter to monitor the A/C operation.

Would you be willing to participate in the study

1. Yes
2. No, Moving before October 2007
3. No Ask why:_____
4. Don't Know Call back and speak with : _____ at:_____

Survey Date _____ Survey Time _____

If Q1 = 2, THERE ARE TENANTS ON-SITE, ask for tenant Name & Phone No. for On-site Contact

If Q3 = 2 THEY ARE A RENTER, Ask for Owner Info

(DO NOT RECRUIT if yes or possibly yes, Use judgment)

Contacts:

On-site or Owner Contact Person:_____ Company (optional):

Daytime Phone No. or Email:

Is there anything we should know about getting to your home that might make it difficult? Or are you planning to be away from your home for the entire summer?

Participant Phone Instrument

RLWID: _____ Customer Name: _____

Introduction

Hello, may I speak with <CUSTOMER>
Hello, my name is **<<interviewer>>,** I am calling on behalf of SMUD, your electric service. We are contacting you today with regards to the rebate you received through SMUD's residential A/C program. Our firm RLW Analytics has been hired on behalf of SMUD; you may recall receiving a letter notifying you that we would be calling. We would like to ask you a few questions about your purchase decision and to schedule an on-site inspection of your A/C unit. The on-site inspection allows us to verify the performance of your system and to install some short term metering equipment.

If the customer has questions about the study, they are welcome to contact the SMUD project manager Wim Bos (916) (Title Senior Demand Supply Specialist) at 916-732-6579

Occupant Questions: We would like to ask just a few basic questions about your home.

Our information show that you recently purchased and received a rebate for a new energy efficient <<MAIL MERGE>> air conditioner at <<ADDRESS, CITY>> is that correct?

1. Yes
2. Yes, but we have moved, THANK & TERMINATE
3. Yes, but home is now a rental,
4. No (Terminate Call)
5. Refusal
6. Call Back

50. Other: _____

Do you have more than one A/C system in your home?

1. Yes, record type of second unit:
2. No

How did you first become aware of SMUD's Air Conditioner Rebate program?

2. Message in SMUD bill
3. Air Conditioning Contractor **Ask was it?**
    a. Before, During or After Installation?
4. SMUD Bill Pay Website
5. In-store Clerk or Advertisement
6. Newspaper Ad
7. Billboard
8. Friend/colleague
9. Previous Participation

50. Other:_____

98. DK/Refused

How did you go about selecting a contractor to install your equipment? (Circle All That Apply)

17. Already knew a reputable contractor who installed or performed maintenance on a previous unit
18. Requested multiple bids selected least expensive offer
19. Phone Book
20. Newspaper AD
21. Friend/colleague Recommendation
22. Internet Search
23. Referred to the SMUD Web site for list of participating contractors
24. ACCA (A/C Contractors of America) Website
50. Other: _____
98. DK/Refused

Did any of the following factors influence your purchase decision? On a scale of 1-5, where 5 represents very influential, 1 is not at all influential, and 3 in neutral, tell me how much each of the following factors influenced your decision.

A. Wanted to reduce our utility bills	1	2	3	4	5
B. Concern for the environment - Global Warming	1	2	3	4	5
C. Last Years Heat Wave	1	2	3	4	5
D. Energy Star Label	1	2	3	4	5
E. Rebate Availability	1	2	3	4	5

Do you Own or Rent?

3. Own
4. Rent /Lease
98. DK/Refused

Approximately how old was the A/C unit you replaced?

14. Verbatim: _____
15. Less than 10 Years
16. 10-15 Years
17. 16-20 Years
18. 21-30 Years
50. As old as the house, Year house was built:_____
98. DK/Refused

How often do you use your air-conditioner during the cooling season months (May-October)? Would you say it is used.....?

6. Daily
7. A few days a week

8. A few days a month
9. Only on extremely hot days
10. Never
99. DK/Refused

How many thermostats do you have in your home? 1 2 3

Is/(Are) your thermostat(s) programmable or manual? Programmable (Digital) / Manual

Throughout the summer months do you cool your house to a certain temperature all the time or do you adjust the temperatures when you're home and/or when you're away?

1. One temperature:_____
2. Adjust temperature when home and away
   a. What is the Occupied Temperature Setting: _____
   b. What is the Unoccupied Temperature Setting: _____, off
3. Something Else, Please Describe:
   _____
   _____

Our records show your home was built <<Year Built>>. If Blank, In what year was your home built?

9. Verbatim: _____
10. 2004-2005
11. 2001-2003
12. 1999-2000
13. 1992-1998
14. 1984-1991
15. 1978-83
16. Pre 1978

Approximately how many people live in your home year around?

Verbatim_____

Are there any summer or temporary residents who stay longer than a week?

1. If Yes, Qty: _____
2. No

Recruitment

To properly evaluate SMUD's Air Conditioner Program we would like to install a time-of-use meter to collect operating data on your air-conditioner. SMUD is sponsoring this test on a small sample of homes to better understand the energy performance of recent A/C installations. This test will measure A/C refrigerant charge and air flow. We will also complete a heat load calculation and conduct monitoring on the system until October to capture information on energy usage.

This test will be performed by two field engineers at no cost to you. We will provide you with a summary of our test results at the end of the monitoring period (in October). Lastly, we think you will appreciate knowing that these diagnostic tests that cost you nothing are valued at $200-$400. In order for us to do this we need to determine when would be a good day and time to come to your home. Our engineers will be on your property for about 2 hours and a good portion

of that time will be spent outside by the condensing unit. They will also need to spend time in the attic or wherever your furnace is located. When we return in October we'll be at your home for no longer than 30 minutes.

If they ask about the monitoring equipment:
The monitoring equipment is a small non-intrusive digital thermometer (the dimensions of the meter is 2" L 2" H ¼ "W) smaller than a pack of playing cards. It will be placed on or near the thermostat to record indoor temperature. Located outside, on the condensing unit will be another meter to monitor the A/C operation.
Would you be willing to participate in the study?

5. Yes
6. No, Moving before October 2007
7. No Ask why:_____
8. Don't Know Call back and speak with : _____ at:_____

Survey Date _____ Survey Time _____

Contacts:

On-site Contact Person:_____
Daytime Phone No. or Email:

Owner Contact Person:_____ Company (optional): .
Daytime Phone No. or Email:

Is there anything we should know about getting to your home that might make it difficult?

_____
_____
_____

Are you planning on being away from your home for an extended period of time or are you planning on moving (i.e. vacation) during the summer? We ask this question because of the nature of our visit. We do not want to monitor your A/C system if you are not going to be home during the summer months. Definitely (If yes, get dates, schedule installation accordingly) Drop if moving

1. Possibly or Don't Know
2. Definitely Not

If So, when: _____
(Proceed to propose a date for the survey, and gather all of the information needed to get the surveyor on-site.)

On-site Participant Survey

RLWID: ____
Name: _____ **ASK FOR EMAIL:_____:**
ASK FOR CELL PH **ASK FOR WORK PH**
No:_____ **No:_____:**

_____This portion administered On-site_____

Ask for Cell Phone, Work Number or EMAIL in case they move and ask them if it is okay to send them an email as a reminder to install/ remove equipment.

Free Ridership Questions Non Financers

Unit Rebated? <<YES OR NO>> (If No, skip Q1-Q3)
Unit Financed? <<YES OR NO>> (If No, skip Q4-Q6)

IMPACT OF PROGRAM/REBATE

Had the SMUD rebate not been available, which of the following would you have most likely done?

6. Still would have purchased the same high efficiency higher cost unit
7. Would have purchased a unit, but a less expensive less efficient unit
8. Would have purchased a unit, recommended by the A/C contractor
9. Would not have purchased a unit
10. Would have purchased a TIER 1 system (If bought Tier 2 system)
50. Other:_____
99. DK/Refused

Assuming the rebate had not been available; at what time would you have purchased a new unit?

6. Same time or sooner (1-6 Mo)
7. Several months later (6 Mo- 1Yr)
8. One year later
9. More than a year later (1-2 years)
10. Greater than 2 yrs
99. DK/Refused

If Unit is Tier 2 ask, Q3

Did you or are you going to receive a federal tax credit in addition to the SMUD rebate?

5. Yes
    a. How did you learn about the credit?
        i. Contractor
        ii. SMUD
        iii. Other

b. How influential was the credit in your decision to install 15 SEER or better?
   i. Very influential
   ii. Somewhat influential
   iii. Not very influential
   iv. Not at all influential
c. Would you have installed 15 SEER or higher if only the SMUD rebate was available and no tax credit was available?

6. No
7. Other:_____
8. DK/Refused

Free Ridership Questions Financers

Had the SMUD financing not been available to you, and only the SMUD rebates were available, which of the following would you have most likely done?

4. Still would have purchased a new unit
5. Would have kept the existing A/C in place **(skip to Q5)**
50. Other:_____
99. DK/Refused

Assuming the SMUD financing had not been available; at what time would you have purchased a new unit?

5. Same time or sooner
6. Several months later
7. One year later
8. More than a year later
99. DK/Refused

Assuming neither SMUD financing or SMUD rebates had been available, which of the following best describes the efficiency decisions you would have made?

5. I would have purchased a higher cost higher efficiency unit
6. I would have purchased a less expensive less efficient unit
7. The same
50. Other:_____
99. DK/Refused

PURCHASE DECISION

What was the main reason you recently decided to purchase a new central air-conditioner? (circle all that apply, read only as necessary)

16. Unit was not functioning properly or was broken
17. Unit was still working OK, but I was concerned with how long it would last
18. To replace inefficient system with more efficient system
19. Needed to replace heating system, cooling system replaced at that time
20. Wanted to add central A/C (no central A/C previously)
21. Unit was not serving the load needed a second system
    a. needed a second system
    b. replaced existing unit with a larger system

22. Home Renovation / Making Structural Changes
23. Previous owner replace unit.
98. DK/Refused

What information sources did you rely on when making the decision to purchase your unit? READ ALL (Circle all those that apply)

9. Installed the same type of unit or manufacturer as we previously owned
10. Contractors Recommendations
11. Manufacturer Brochures/Marketing Material
12. Reputation/Brand Name/Best Seller
13. Word of Mouth
14. SEER/EER rating (Efficiency Level)
15. SMUD Website
16. Online Websites ACEEE, ACCA, Department of Energy, Energy Star.gov
50. Other:_____
98. DK/Refused

CONTRACTOR SELECTION

Did the winning contractor present a single offer or did they present several estimates? (Circle all that apply)

1. No options were presented, they only presented one estimate
2. An offer with: TIER 1 air-conditioning
3. An offer with: TIER 2 air-conditioning
4. An offer with: Routine Maintenance
5. An offer with: Unit that had variable speed air handler
6. An offer with: Duct Sealing and/or Testing
7. An offer with: Upgraded filter system
8. Other:_____
9. Don't Know/Don't Recall

What are the top three considerations you had when selecting an A/C unit? (Indicate order in which the customer responded) (READ ALL)

#1_____#2_____#3____

9. Cost
10. Reliability
11. Features
12. Energy Efficiency
13. Warranty
14. Reputation/Name Brand
15. Contractors Recommendation
16. Financing / Interest Rate
50. Other:
_____
98. DK/Refused

Did you find the SMUD rebate covered the incremental cost of going from a standard efficiency unit to the high efficiency unit you installed? ($400-$500 incentive)

1. Yes
2. No
3. Don't Know
4. Other:_____
5. DK/Refused

COMPLIANCE KNOWLEDGE

Are you aware as to whether or not you or the contractor filed for a building permit for this replacement?

4. Not Aware
5. Submitted by Homeowner
6. Submitted by Contractor
98. DK/Refused

Were you aware of the Title 24 requirement to have either a high efficiency furnace installed or duct testing and sealing at the time of A/C change out? Which option would you have taken if you had not participated in the program?

4. High Efficiency Furnace (AFUE 90 or greater)
5. Duct Testing and Sealing
6. No I was not aware of the requirement
99. DK/Refused

Contractor and Costs

Who was the contractor and company that completed the A/C replacement?

_____

How would you rate your satisfaction with the contractor that completed the installation of your new central air-conditioner?

1. Very unsatisfied, why?
2. Not Satisfied, why?
3. Neither satisfied nor unsatisfied
4. Satisfied
5. Very Satisfied
98. DK/Refused

Why:_____
_____

Do you have the invoice for the work completed during the replacement?

1. Yes
2. No

98. DK

Line Item	Equipment Cost	Labor Cost
Condensing Unit	$	$
Cooling Coil	$	$
Furnace	$	$
Add Duct Runs	$	$
Duct Leakage Test	$	$
Duct Sealing/Repair	$	$
HERS Inspection	$	$
Filtration System	$	$
Other Repairs	$	$

ATTITUDES TOWARD ENERGY EFFICIENCY

For the next group of questions we would like to ask a few statements please indicate and if the statement is **True Most of the time/ True Some of the time but Not Most of the time or/ if the Statement is false**

A. During the summer I set back the Thermostat at night and during the day	TM	TS	F
B. I close my south and west facing windows and lower the blinds during the summer	TM	TS	F
C. I change the A/C filters at least once a year	TM	TS	F
D. I try and use natural ventilation, or fans rather than running AC	TM	TS	F

Non-Participant On-site Survey

RLWID: ____
Fname Lname
tel_number telnum2
shouse street sunit

scity sstate Szip
ASK FOR CELL PH No:_____
ASK FOR EMAIL:_____:
ASKFORWORK PH No:_____:

_____This portion administered On-site_____

Ask for Cell Phone, Work Number or EMAIL in case they move and ask them if it is okay to send them an email as a reminder to install/ remove equipment.

_

PURCHASE DECISION

What information sources did you rely on when making the decision to purchase your unit? READ ALL (Circle all those that apply)

17. Installed the same type of unit or manufacturer as we previously owned
18. Contractors Recommendations
19. Manufacturer Brochures/Marketing Material
20. Reputation/Brand Name/Best Seller
21. Word of Mouth
22. SEER/EER rating (Efficiency Level)
23. SMUD Website
24. Online Websites ACEEE, ACCA, Department of Energy, Energy Star.gov
50. Other:_____

What are the top three considerations you had when selecting an A/C unit? (Indicate order in which the customer responded) (READ ALL)

#1_____ #2_____ #3_____

17. Cost
18. Reliability
19. Features
20. Energy Efficiency
21. Warranty
22. Reputation/Name Brand
23. Contractors Recommendation
24. Financing / Interest Rate
50. Other:
_____

Did any of the following factors influence your purchase decision? On a scale of 1-5 tell me how much each of the following factors influenced your decision.

Wanted to reduce our utility bills	1	2	3	4	5

Concern for the environment - Global Warming	1	2	3	4	5
Heat Wave	1	2	3	4	5
Energy Star Label	1	2	3	4	5
Rebate Availability	1	2	3	4	5

CONTRACTOR SELECTION

Did the winning contractor present a single offer or did they present several estimates? (Circle all that apply)

10. No options were presented, they only presented one estimate
11. An offer with: High efficiency air conditioning
12. An offer with: Routine Maintenance
13. An offer with: Unit that had variable speed air handler
14. An offer with: Duct Sealing and/or Testing
15. An offer with: Upgraded filter system
16. Other:_____
17. Don't Know/Don't Recall

COMPLIANCE KNOWLEDGE

Are you aware if you or your contractor filed for a building permit for this replacement?

7. Not Aware
8. Submitted by Homeowner
9. Submitted by Contractor
98. DK/Refused

Are you aware of the Title 24 requirement to have either a high efficiency furnace or duct testing and sealing at the time of A/C change out? Which option did you take?

7. High Efficiency Furnace (AFUE 90 or greater)
8. Duct Testing and Sealing
9. No I was not aware of the requirement
100. DK/Refused

Contractor and costs

Who was the contractor and company that completed the A/C replacement?

_____

How would you rate your satisfaction with the contractor that completed the installation of your new central air-conditioner?

7. Not Satisfied, why?
8. Neither satisfied nor unsatisfied
6. Very unsatisfied, why?

9. Satisfied 10. Very Satisfied

Why:_____
_____

Do you have the invoice for the work completed during the replacement?

3. Yes
4. No

Line Item	Equipment Cost	Labor Cost
Condensing Unit	$	$
Cooling Coil	$	$
Furnace	$	$
Add Duct Runs	$	$
Duct Leakage Test	$	$
Duct Sealing/Repair	$	$
HERS Inspection	$	$
Filtration System	$	$
Other Repairs	$	$

SMUD offers a residential A/C rebate ($400-$500 incentive) for newly installed units. Do you think that amount would have covered the incremental cost of going to a higher efficiency unit?

1. Yes
2. No
3. Don't Know
4. Other:_____
5. DK/Refused

Incentive Payment

Yes, I acknowledge receiving $40 in cash as an incentive for the SMUD sponsored Air Conditioner Quality Assurance & Performance Testing. I understand that I will be contacted in October 2007 by RLW Analytics on behalf of SMUD to remove the metering equipment that has been placed near my thermostat and on my condensing unit. At the time of the removal I shall receive an additional $10 incentive.

Write Name:_____

Signature:_____

Date:_____

Participant Contractor Phone Survey

Hello, my name is <<surveyor>>. SMUD has asked my firm to evaluate their Residential Air Conditioning Program. SMUD's records show that your company participated in this program. Do you have a couple of minutes to answer a few brief questions that will help us better understand how the program is actually working? (*If no, schedule a call back time*)

Firm: _____

Respondent Name:_____ Title:_____

1. SMUD would like you to gauge your satisfaction with various aspects of the Program. On a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied, please state your satisfaction with the following program aspects:

1a. Program application material	1	2	3	4	5
1b. Rebate processing	1	2	3	4	5
1c. SMUD marketing of program	1	2	3	4	5
1d. Incentive amounts (Rebates)	1	2	3	4	5
If a financing contractor (F),					
1e. Loan application fee	1	2	3	4	5
1f. Interest rate	1	2	3	4	5

1g.
Comments:_____
_____
_____

Market Shares, Permit Pull Rate

2. Approximately how many single family residential central air-conditioning systems did your company install in existing homes in 2006 and what is your estimate for 2007 in Sacramento County?

2006	**2007**
❑ Number _____	Number _____
❑ Less than 10	Less than 10
❑ 10-25	10-25
❑ 26-50	26-50
❑ 51-100	51-100
❑ More than 100	More than 100
❑ None	None
❑ DK/Refused	DK/Refused

3. What percentage of your customers decide to buy a unit that qualifies for the rebate?
   2006 _____%__ 2007 _____%__

4. Out of the totals what percentage did you pull permits?
   2006 _____%__ 2007 _____%___

5. How often do you think your competition pulls permits?
   2006 _____%__ 2007 _____%__

6. What can be done to make the permitting process easier?

7. What could SMUD do to assist you in pulling permits more often?

8. What proportion of your customers have home warranties which pay for A/C replacements?
   2006 _____%__ 2007 _____%__

   If less than 10 % skip follow up questions a & b.

   8a. Does the insurer typically limit or restrict the system selection based on the efficiency of the units?
   - ❑ YES
   - ❑ NO
   - ❑ Insurer Encourages High Efficiency?
   - ❑ Insurer Requires High Efficiency?
   - ❑ SOMETIMES
   - ❑ DK (don't allow this answer if at all possible)

   If sometimes, get specifics:_____
   _____
   _____

   8b. Does the insurer typically require, encourage, or discourage compliance with local building codes (pulling building permits)?
   - ❑ YES
   - ❑ NO
   - ❑ SOMETIMES
   - ❑ DK (don't allow this answer if at all possible)

   If sometimes, get specifics:_____
   _____
   _____

Costs and Rebate

9. What is the incremental cost of going from standard efficiency split and packaged, air conditioners and heat pumps to the SEER 14 and higher units that SMUD is promoting? Does the SMUD rebate cover the incremental cost?

System	**Tier**	**Inc. Cost**	**Rebate**	**Covered?**	**Comment** (Tonnage, R-410a, etc.)
Split System AC	14 SEER		$400	Y N	
Split System AC	15 SEER		$500	Y N	
Package AC	11 EER		$400	Y N	
Package AC	12 EER		$500	Y N	
Split System HP	14 SEER		$400	Y N	
Split System HP	15 SEER		$500	Y N	
Package HP	11 EER		$400	Y N	
Package HP	12 EER		$500	Y N	

10. What percentage or approximately how many of the rebate applications, if any, where sent back to you by SMUD because of insufficient requirements?
    _____

11. What general questions do you ask the customer before presenting a bid – and what information do you gather before providing a bid to a customer? Size, level of efficiency, budget, etc.

_____

_____

_____

12. Do you present a single offer or several estimates for the work performed? (Circle all that apply)
    a. No options are presented, we only present one estimate
    b. An offer with: SMUD TIER 1 (14 SEER) air-conditioning
    c. An offer with: SMUD TIER 2 (15 SEER) air-conditioning
    d. An offer with: Routine Maintenance
    e. An offer with: Unit that had variable speed air handler
    f. An offer with: Duct Sealing and/or Testing
    g. An offer with: Upgraded filter system
    h. Other:_____
    i. Don't Know/Don't Recall

13. Outside the program, --do you typically present your customers with a "high efficiency" (SEER 14 or greater) purchase option?
    - ❑ YES, always
    - ❑ YES, but only when customer asks for high efficiency
    - ❑ NO
    - ❑ DK

14. Do customers typically ask for bids on high efficiency equipment if it is not presented to them?
    - ❑ YES
    - ❑ NO
    - ❑ DK

15. Are the customers who take advantage of the SMUD rebate typically aware of the rebate and or financing, federal tax credits before they contact you for an estimate?
    - ❑ YES
    - ❑ NO
    - ❑ DK

16. How often would you say your customers learn about the SMUD rebate and financing and federal tax credits from you?
    _____%

17. Do you explicitly make the customer aware of the SMUD rebate and financing and federal tax credits?
    - ❑ YES
    - ❑ NO
    - ❑ DK

18. For those customers, why do you think they opt not to buy the high efficiency rebated unit?

_____
_____
_____

19. Do you sell 14 SEER and higher units to SMUD customers who choose not to go through SMUD's rebate program?
    - ❑ YES
    - ❑ NO

21b. IF YES, how frequently does this happen and why?

_____
_____

20. Absent the SMUD RES A/C rebate program, what do you believe would be the average installed efficiency for the customers you serve in the SMUD service territory?
    - ❑ SEER 13
    - ❑ SEER 13.5
    - ❑ SEER 14
    - ❑ SEER 15

22b. Why?

_____
_____

21. Based on your experience please rate the importance of the following features, from the customers' perspective?

	Very unimportant.....				Very Important
16a. Purchase price of new equipment	1	2	3	4	5
16b. Efficiency of new equipment	1	2	3	4	5
16c. Brand/Make of new equipment	1	2	3	4	5
16d. Warranty on new equipment	1	2	3	4	5
16e. Financing	1	2	3	4	5
16f. Federal Tax Credits	1	2	3	4	5

22. What information sources do customers typically rely on when making the decision to purchase a unit? READ ALL (Circle all those that apply)
    25. Installed the same type of unit or manufacturer as we previously owned
    26. Contractors Recommendations
    27. Manufacturer Brochures/Marketing Material
    28. Reputation/Brand Name/Best Seller
    29. Word of Mouth
    30. SEER/EER rating (Efficiency Level)
    31. SMUD Website
    32. Online Websites ACEEE, ACCA, Department of Energy, Energy Star.gov
    50. Other:_____

23. If we spoke to a number of customers that received new central air-conditioners through the SMUD Program. Would many of them report that they would have purchased the same high efficiency air-conditioner even if the program funding and financing, federal tax credits had not been made available to them?

- ❑ YES
- ❑ NO
- ❑ DK

24. One primary purpose of this survey is to determine what efficiency the customer might have installed had the program not been available to you. Do you have any further information that might assist us make this determination?

_____
_____
_____

Compliance

25. Can you tell us what is required when replacing HVAC systems under the 2005 Residential Title 24 requirements for Sacramento County?

26. What is your general opinion of the 2005 Residential Title 24 requirements regarding HVAC system replacements?
    a. Good
    b. Reasonable, but Too Costly
    c. Reasonable, but Too Time Consuming
    d. Reasonable, but Too difficult
    e. Unreasonable

27. We would like you to estimate the costs and time added due to recent codes and standards (Title -24 2005) changes. Please quantify the direct cost to the customer and time requirements for the following:
    a. How often do you install a TXV's on changeouts. What is the additional cost
    b. How often do you check RCA on a changeout? What is the additional cost
    c. Who's testing procedures do you use to check RCA
    d. Do you own a duct blaster?
    e. What percentage of the non-permited/permited jobs do you use it on
    f. How long does the duct test take? What do you charge?
    g. How long does it take for you to seal the ducts to meet code and what do you charge?
    h. What percentage of the time do you install a R-410A compared to R22 in a changeout and what is the extra cost
    i. How often do you have a HERS rater involved in your changeouts? What is the added cost to the homeowner?

Question	How Often	Customer Cost	Contactor Cost
a. TXV			
b. RCA			
c. RCA procedure?			
d. Duct blaster?			
e. DB tests			
f. Time length of DB test			
g. How long for sealing?			
h. R-410A %			
i. HERS rater			

28. What criteria do you use when selecting a HERS inspector?

_____
_____
_____

29. How would you rate your customer's awareness and knowledge of the Title 24 standards including performance testing requirements for changeouts?
    - ❑ Clearly understood
    - ❑ Somewhat understood
    - ❑ Aware but not understood
    - ❑ Unaware

30. Is there anything else you would like to say about the program that might help SMUD improve program delivery and increase participation?

_____
_____
_____

Non-Participant Contractor Phone Survey

Non-participant Contractors Survey

Hello, my name is <<Surveyor>>, SMUD has asked my firm to evaluate their Residential Air Conditioning Program. As part of the evaluation we are talking to contractors that do not participate in the program. Can I ask you a few very brief questions that will take 15 minutes and help us better understand certain dynamics of the residential A/C market? We are asking these questions to decide where SMUD needs to add rebates. Information from this survey will no be shared with the public. If you do not wish to answer a question please say so. Please do not give incorrect information as this will make the survey unreliable.

Firm: _____

Respondent Name:_____ Title:_____

4. Our information shows you are a residential air-conditioning installation contractor operating in and around Sacramento County, is this correct?
   - ❑ YES
   - ❑ NO
   - ❑ DK
5. Do you do much work outside of Sacramento County?

6. Are you aware of the SMUD Residential HVAC replacement program?
   - ❑ YES
   - ❑ NO
   - ❑ DK

7. We are primarily interested in the residential retrofit market; does your business include residential retrofits of central air-conditioners?
   - ❑ YES
   - ❑ NO, if no, thank and terminate the call.
   - ❑ DK

<u>Market Shares, Permit Pull Rate</u>

8. Approximately how many single family residential central air-conditioning systems did your company install in existing homes in 2006 and what is your estimate for 2007 in Sacramento County?

2006	**2007**
❑ Number _____	Number _____
❑ Less than 10	Less than 10
❑ 10-25	10-25
❑ 26-50	26-50
❑ 51-100	51-100
❑ More than 100	More than 100
❑ None	None
❑ DK/Refused	DK/Refused

9. Out of the totals what percentage did you pull permits?
   2006 _____%__ 2007 _____%___

10. How often do you think your competition pulls permits?
    2006 _____%__ 2007 _____%__

11. What can be done to make the permitting process easier?

12. What could SMUD do to assist you in pulling permits more often?

13. What proportion of your customers have home warranties which pay for A/C replacements?
    2006 _____%__ 2007 _____%__

If less than 10% skip follow up questions a & b.

10a. Does the insurer typically limit or restrict the system selection based on the efficiency of the units?

- ❑ YES
- ❑ NO
- ❑ Insurer Encourages High Efficiency?
- ❑ Insurer Requires High Efficiency?
- ❑ SOMETIMES
- ❑ DK (don't allow this answer if at all possible)

If sometimes, get specifics:_____

_____

_____

10b. Does the insurer typically require, encourage, or discourage compliance with local building codes (pulling building permits)?

- ❑ YES
- ❑ NO
- ❑ SOMETIMES
- ❑ DK (don't allow this answer if at all possible)

If sometimes, get specifics:_____

_____

_____

Costs, Bids to Customers

14. What is the incremental cost of going from standard efficiency split and packaged, air conditioners and heat pumps to the SEER 14 and higher units that SMUD is promoting? Does the rebate SMUD offers cover the incremental cost?

System	Tier	Inc. Cost	Rebate	Covered?	Comment (Tonnage, R-410a, etc.)
Split System AC	14 SEER		$400	Y N	
Split System AC	15 SEER		$500	Y N	
Package AC	11 EER		$400	Y N	
Package AC	12 EER		$500	Y N	
Split System HP	14 SEER		$400	Y N	
Split System HP	15 SEER		$500	Y N	
Package HP	11 EER		$400	Y N	
Package HP	12 EER		$500	Y N	

15. What general questions do you ask the customer before presenting a bid – and what information do you gather before providing a bid to a customer? Size, level of efficiency, budget, etc.

16. Do you typically present your customers with a "high efficiency" (SEER 14 or greater) purchase option?
    - ❑ YES, always
    - ❑ YES, but only when customer asks for high efficiency
    - ❑ NO
    - ❑ DK

17. Do customers typically ask for bids on high efficiency equipment if it is not presented to them?
    - ❑ YES
    - ❑ NO
    - ❑ DK

18. Do you present a single offer or several estimates for the work performed? (circle all that apply)
    a. No options are presented, we only present one estimate
    b. An offer with: 14 SEER air-conditioning
    c. An offer with: 15 SEER air-conditioning
    d. An offer with: Routine Maintenance
    e. An offer with: Unit that had variable speed air handler
    f. An offer with: Duct Sealing and/or Testing
    g. An offer with: Upgraded filter system
    h. Other:_____
    i. Don't Know/Don't Recall

19. In a residential central A/C retrofit situation, what is the average installed SEER level for your customers?
    - ❑ SEER 13
    - ❑ SEER 13.5
    - ❑ SEER 14
    - ❑ SEER 15

20. What proportion of the retrofit units you install are SEER 14 or higher? _____%

21. In your experience, please rate the following in terms of importance to the customer when installing or retrofitting a new AC?

	Very unimportant.....				.....Very Important
15a. Purchase price of new equipment	1	2	3	4	5
15b. Efficiency of new equipment	1	2	3	4	5
15c. Brand/Make of new equipment	1	2	3	4	5
15d. Warranty on new equipment	1	2	3	4	5
15e. Financing	1	2	3	4	5
15f. Federal Tax Credit	1	2	3	4	5
15g. Utility Rebate	1	2	3	4	5

22. Why do you think customers tend not to buy higher efficiency units?

_____

Why do some customers pay for higher efficiency?

_____

23. What information sources do customers typically rely on when making the decision to purchase a unit? READ ALL (Circle all those that apply)
    33. Installed the same type of unit or manufacturer as we previously owned
    34. Contractors Recommendations
    35. Manufacturer Brochures/Marketing Material
    36. Reputation/Brand Name/Best Seller
    37. Word of Mouth
    38. SEER/EER rating (Efficiency Level)
    39. SMUD Website
    40. Online Websites ACEEE, ACCA, Department of Energy, Energy Star.gov
    50. Other:_____

<u>Compliance</u>

24. Can you tell us what is required when replacing HVAC systems under the 2005 Residential Title 24 requirements for Sacramento County?

25. What is your general opinion of the 2005 Residential Title 24 requirements regarding HVAC system replacements?
    a. Good
    b. Reasonable, but Too Costly
    c. Reasonable, but Too Time Consuming
    d. Reasonable, but Too difficult
    e. Un-Reasonable

26. We would like you to estimate the costs and time added due to recent codes and standards changes. Please quantify the direct cost to the customer and time requirements for the following:
    a. How often do you install a TXV's on changeouts. What is the additional cost
    b. How often do you check RCA on a changeout? What is the additional cost
    c. Who's testing procedures do you use to check RCA
    d. Do you own a duct blaster?
    e. What percentage of the non-permited/permited jobs do you use it on

f. How long does the duct test take? What do you charge?
g. How long does it take for you to seal the ducts to meet code and what do you charge?
h. What percentage of the time do you install a R-410A compared to R22 in a changeout and what is the extra cost
i. How often do you have a HERS rater involved in your changeouts? What is the added cost to the homeowner?

Question	How Often	Customer Cost	Contactor Cost
a. TXV			
b. RCA			
c. RCA procedure?			
d. Duct blaster?			
e. DB tests			
f. Time length of DB test			
g. How long for sealing?			
h. R-410A %			
i. HERS rater			

27. What criteria do you use when selecting a HERS rater?

_____
_____
_____

28. How would you rate your customer's awareness and knowledge of the Title 24 standards including performance testing requirements for changeouts?
    - ❑ Clearly understood
    - ❑ Somewhat understood
    - ❑ Aware but not understood
    - ❑ Unaware

29. Why do you not participate in SMUD's air conditioner rebate program?

_____
_____

9. Appendix C: Customer Letters

Participant Letter

<<CUSTOMER FIRST NAME>> <<CUSTOMER LAST NAME>>
<<CUSTOMER ADDRESS>>
<<CUSTOMER CITY>>, CA <<CUSTOMER ZIP>>

Re: SMUD Residential Air Conditioning Rebate Programs

Dear <<CUSTOMER FIRST NAME>>,
You are receiving this letter because our records indicate you had an energy-efficient air-conditioner installed as part of SMUD's Residential HVAC Program– thank you for participating! The improvements you've made can lower your utility bills and help the environment. In order to better serve you and future program participants, we have contracted an independent consultant, RLW Analytics Inc. and the Benningfield Group, to assess this program and install monitoring equipment on randomly selected homes to verify the energy savings.

You have received this letter today because you have been selected as part of this study, and we hope that you will agree to help us improve our programs. RLW will be contacting you in the near future to schedule an appointment for the on-site inspection and conduct the brief telephone survey. The phone survey will address the verification of your HVAC unit installation, and how the program may have impacted your decision to make energy efficiency upgrades.
Our current records show the following information for you:
Primary Phone No: <<CUSTOMER PRIMARY#>> Secondary Phone No:

Alternatively, you may also call RLW Analytics toll-free at 1-800-472-6716 ext. 10 (9AM – 8PM) to conduct the survey at your convenience. The survey can be conducted in English or Spanish, and all responses will be kept strictly confidential.
Please permit our contractors to conduct their measurements and provide them access to install monitoring equipment on your air-conditioner. The monitoring team will carry SMUD contractor badges for verification. The installation procedure will be quick and unobtrusive. The team will return in September to remove the equipment.
Thank you for your participation and your assistance to us in this effort. If you have any questions or concerns, please feel free to contact me at my direct telephone number listed below.

Sincerely,
Wim Bos
Senior Analyst – Sacramento Municipal Utility District

If you…	Who to Contact	Phone Number
Need to update your phone number or contact person or would like to volunteer	RLW Analytics, Inc. Amber Watkins	1-800-472-6716 x 10
Have questions about the study or the contractors	SMUD Mr. Wim Bos	(916) 732-6579

Non-Participant Letter

CUSTOMER NAME
CUSTOMER ADDRESS
CITY NAME, CA ZIP
Re: SMUD Residential Air Conditioning Assessment

Dear CUSTOMER NAME,
You are receiving this letter because it has been recently identified you have replaced your central Air Conditioning (AC) System in either the 2006 or the 2007 calendar year. Since your A/C has recently been replaced you qualify for SMUD's sponsored Air Conditioner Quality Assurance & Performance Testing. SMUD is sponsoring this test on a small sample of homes to better understand the energy performance of recent A/C installations. In order to better serve you we have contracted with an independent consultant, RLW Analytics Inc. and the Benningfield Group, to assess air conditioning replacements in Sacramento County.

What Does the Study Involve? If you choose to participate our consultants will measure A/C refrigerant charge and air flow, whole house leakage, and leakage through the duct system. We will also complete a heat load calculation and conduct monitoring on the system until October to capture information on energy usage. This test will be performed by two experienced field engineers at no cost to you. Our engineers will be on your property for about 2 hours and a good portion of that time will be spent outside by the condensing unit. They will also need to spend time in the attic or wherever your furnace is located. When we return in October we'll be at your home for no longer than 30 minutes. The monitoring team will carry SMUD contractor badges for verification. The installation procedure will be quick and unobtrusive. The team will return in October to remove the equipment.

What Do I Receive for My Participation? We will provide you with a summary of our test results at the end of the monitoring period (in October of 2007). We are providing a cash incentive of $50 to compensate you for your time. The $40 of the monetary incentive will be provided at our initial visit and an additional $10 will be given to you when the monitoring equipment is removed in (October 2007). Lastly, we think you will appreciate knowing that these **free** diagnostic tests are valued at $600-$800.

Thank you for your participation and your assistance in this effort. If you have any questions or concerns, please feel free to contact me at my direct telephone number listed below.
Sincerely,
Wim Bos
Senior Market Analyst, Sacramento Municipal Utility District

If you…	Who to Contact	Phone Number
Need to update your phone number or contact person or would like to **volunteer**	RLW Analytics, Inc. Amber Watkins	1-800-472-6716 x 10
Have **questions** about the study or the contractors	SMUD Wim Bos	(916) 732-6579

10. Appendix D: On-site Data Collection Instruments

Non-Participant On-site Data Collection Instrument

HVAC Unit Site Sheet

Site	
Room(s) Served	
Unit Number	
Unit Description	

A/C Manf		**HVAC Sys Type**	Package Split
A/C Model Number		**Heating Type**	Elec. Resist Gas HP
A/C Serial Number		**Heating Manf.**	
Year Manf		**Heating Model #**	
Refrig Type	R-22 R-410a	**Heating Serial #**	
Metering Device	Non TXV TXV	**Heating Capacity**	
Evap Coil Manf		**Heating Eff.**	
Evap Coil Model #		**Supply Fan Hp/Amps**	
Evap Coil Serial #		**Condenser Fan HP/FLA**	
Cooling Capacity (Cond/Coil)		**Comp Motor RLA**	
Filter Information (MERV rating, cleanliness,size, comments)			

Is unit accessible for maintenance? π Yes π No – describe below
Describe general unit condition: π Good π Average π Poor – describe below
Describe general condition around condenser π Good π Average π Poor – describe below
Install date of HVAC unit: _____
Notes:

TrueFlow Volumetric Air Flow Measurement

Install Flow Grids, Reset Outside Air as Found, Measure with Coils Wet

Trueflow Air Flow Measurement					
For all readings on each a/c unit, Trueflow must be placed in exactly the same location. All air pressure measurements to be in Pascals (PA)					
Grid Size (circle one)	**Spacer 1 size**	**Spacer 2 size**	**Spacer 3 size**	**Comments**	
#14 #20					
#14 #20					
	Normal Static Press (NSOP)	**Trueflow Static Press (TFSOP)**	**Trueflow CFM (TFCFM)**	**Adjusted CFM ***	**Comments**
	new filter in place	*Flow Grid in filter rack*	*State Time Ave setting:*	*TFCFM x correction factor*	
Reading 1 Time recorded					
Reading 2 Time recorded					
Reading 3 Time recorded					
Reading 4 Time recorded					
Reading 5 Time recorded					

*IF AIRFLOW MEASUREMENT AT A REMOTE RETURN APPLY 1.04 CORRECTION FACTOR

Fan Operating Data - Unit in Cooling Mode (wet coils)

	Fan only	**Comments**
Volts1 Ph-Gnd		
Amps1		
Power 1		
PF1		

Test Data

Compressor #:_____

(add sheet if multiple compressors)

	Test data	Test #1	Test #2	Test #3	Logger #	Notes
	Weather Station	North, South, East, West				
	Minutes unit in operation*					
	Condenser Air Exiting Temp (Above condenser fan)					
					#	
SP	Suction (low side) Pressure (psig)*					
ST	Suction Line Temp*					
DP	Discharge (high side) Pressure (psig)*					
LT	Liquid Line Temp* (Between Condenser Entering and Condenser Saturation Temperature)					
AMB	Condenser Air Entering Temp* (Ambient)					
L1	Volts1 Ph-Gnd					
L2	Volts2 Ph-Gnd					
L1	Amps1					
L2	Amps2					
L1	Power 1				#	
L2	Power 2					
L1	PF 1					
	PF2					

*** These Measurements are performed with Honeywell Service Assistant**

Logger Installation

Unit #____

	Logger ID	Install Date	Install Time	Location
Return Air RH/Dry Bulb Temp				
Supply Air RH/ Dry Bulb Temp				
Condenser Air Entering Temp (Ambient)				
A/C Power				L1 L2
Indoor Temp (at or near T-Stat)				

Unit #____

	Logger ID	Install Date	Install Time	Location
Return Air RH/Dry Bulb Temp				
Supply Air RH/ Dry Bulb Temp				
Condenser Air Entering Temp (Ambient)				
A/C Power				L1 L2
Indoor Temp (at or near T-Stat)				

Installation Notes

_____
_____
_____
_____
_____
_____
_____

Photo Checklist

(Where permitted)

Location	Done	Notes
Unit	ρ	
Filter Bank	ρ	
Supply Temp RH	ρ	
Orientations	ρ	
Ducts	ρ	
Thermostat	ρ	

Single Point House infiltration Test:
Infiltration Test Data:

Blower Door Tests	Blower Door Type	Rings / Hole #	House P near -50 Pa (P_{50})	Blower Door Fan Pressure	BD CFM near 50 Pa (Q_{50})	Rings / Hole #	House P near -25 Pa (P_{25})	Blower Door Fan Pressure	BD CFM near 25Pa (Q_{25})	*Flow Exponent
Test 1	BD 3									
Test 2*	BD 3									
Test 3*	BD 3									

- ***To check test, calculate the flow exponent, n.***

Total Duct Leakage Test Data:
System #_____

Duct Leakage Tests	Duct Blaster Fan Pressure @25 PA	Duct Blaster Ring	Duct Blaster CFM near 25 Pa	Measured Air Flow (From TrueFlow Measurement)	Total Leakage Percentage
Test 1					
Test 2*					
Test 3*					

System #_____
Duct Leakage to Outside Test Data:

Duct Leakage Tests	**BD House Pressure near 25 Pa (P_{25}**	**Duct Blaster Fan Pressure near Zero**	**Duct Blaster Ring**	**Duct Blaster CFM near 0 Pa (Q_{25})**	**Measured Air Flow (From TrueFlow Measurement**	**Leakage Percentage**	Blower Door House Pressure near 50 Pa (P_{50})	Duct Blaster Pressure Near Zero	Duct Blaster Ring	Duct Blaster CFM near 0 Pa (Q_{50})	* Flow Exponent
Test 1											
Test 2*											
Test 3*											

To check test, calculate the flow exponent, n.

Use ***the following formula, $n = \ln(Q_{50}/Q_{25})/\ln(P_{50}/P_{25})$.*** *Note Q_{50} and Q_{25} are the flows through the blower door at the testing pressures (which are denoted P_{50} and P_{25}. Depending on the test, you may not get the house to exactly –50 or –25 Pa WRT outside. Use the exact ΔP you measure when checking the flow exponent. For example, if the house gets to –48 Pa for the high ΔP, use this as the P_{50} in the equation.* ***If the flow exponent is not between 0.50 and 0.75, repeat the test****.*

Participant On-site Data Collection Instrument

HVAC Unit Site Sheet

Site	
Room(s) Served	
Unit Number	
Unit Description	

A/C Manf		**HVAC Sys Type**	Package Split
A/C Model Number		**Heating Type**	Elec. Resist Gas HP
A/C Serial Number		**Heating Manf.**	
Year Manf		**Heating Model #**	
Refrig Type	R-22 R-410a	**Heating Serial #**	
Metering Device	Non TXV TXV	**Heating Capacity**	
Evap Coil Manf		**Heating Eff.**	
Evap Coil Model #		**Supply Fan Hp/Amps**	
Evap Coil Serial #		**Condenser Fan HP/FLA**	
Cooling Capacity (Cond/Coil)		**Comp Motor RLA**	
Filter Information (MERV rating, cleanliness,size, ,comments)			

Is unit accessible for maintenance? π Yes π No – describe below
Describe general unit condition: π Good π Average π Poor – describe below
Describe general condition around condenser π Good π Average π Poor – describe below
Install date of HVAC unit: _____
Notes:

TrueFlow Volumetric Air Flow Measurement

Install Flow Grids, Reset Outside Air as Found, Measure with Coils Wet

Trueflow Air Flow Measurement					
For all readings on each a/c unit, Trueflow must be placed in exactly the same location. All air pressure measurements to be in Pascals (PA)					
Grid Size (circle one)	**Spacer 1 size**	**Spacer 2 size**	**Spacer 3 size**	**Comments**	
#14 #20					
#14 #20					
	Normal Static Press (NSOP)	**Trueflow Static Press (TFSOP)**	**Trueflow CFM (TFCFM)**	**Adjusted CFM ***	**Comments**
	new filter in place	*Flow Grid in filter rack*	*State Time Ave setting:*	*TFCFM x correction factor*	
Reading 1 Time recorded					
Reading 2 Time recorded					
Reading 3 Time recorded					
Reading 4 Time recorded					
Reading 5 Time recorded					

*IF AIRFLOW MEASUREMENT AT A REMOTE RETURN APPLY 1.04 CORRECTION FACTOR

Fan Operating Data - Unit in Cooling Mode (wet coils)

	Fan only	**Comments**
Volts1 Ph-Gnd		
Amps1		
Power 1		
PF1		

Test Data

Compressor #:_____

(add sheet if multiple compressors)

	Test data	Test #1	Test #2	Test #3	Logger #	Notes
	Weather Station	North, South, East, West				
	Minutes unit in operation*					
	Condenser Air Exiting Temp (Above condenser fan)					
					#	
SP	Suction (low side) Pressure (psig)*					
ST	Suction Line Temp*					
DP	Discharge (high side) Pressure (psig)*					
LT	Liquid Line Temp* (Between Condenser Entering and Condenser Saturation Temperature)					
AMB	Condenser Air Entering Temp* (Ambient)					
L1	Volts1 Ph-Gnd					
L2	Volts2 Ph-Gnd					
L1	Amps1					
L2	Amps2					
L1	Power 1				#	
L2	Power 2					
L1	PF 1					
	PF2					

*** These Measurements are performed with Honeywell Service Assistant**

Logger Installation

Unit #____

	Logger ID	Install Date	Install Time	Location
Return Air RH/Dry Bulb Temp				
Supply Air RH/ Dry Bulb Temp				
Condenser Air Entering Temp (Ambient)				
A/C Power				L1 L2
Indoor Temp (at or near T-Stat)				

Unit #____

	Logger ID	Install Date	Install Time	Location
Return Air RH/Dry Bulb Temp				
Supply Air RH/ Dry Bulb Temp				
Condenser Air Entering Temp (Ambient)				
A/C Power				L1 L2
Indoor Temp (at or near T-Stat)				

Installation Notes

_____
_____
_____
_____
_____
_____
_____

Photo Checklist

(Where permitted)

Location	Done	Notes
Unit	ρ	
Filter Bank	ρ	
Supply Temp RH	ρ	
Orientations	ρ	
Ducts	ρ	
Thermostat	ρ	