California Statewide Residential Lighting and Appliance Saturation Study

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ABSTRACT

In 1999 the CPUC was seeking to change conservation programs in California from resource acquisition programs into market transformation programs. To assess the success of these efforts and to guide public policy and program planning, this study was undertaken to collect baseline data on the saturation of lighting and major appliances in the residential sector.

RLW Analytics and ASW Engineering conducted this study for San Diego Gas and Electric Company, Sacramento Municipal Utility District and the CPUC. The study had three primary objectives:

Objective 1: Completion of 1,258 on-site surveys of single-family, multi-family and mobile homes throughout the service territories of PG&E, SCE, SDG&E and SMUD.

Objective 2: Development of a user-friendly database of residential lighting and appliance saturation by energy efficiency.

Objective 3: Determination of potential market barriers in the residential market to adopting energy efficient lighting systems.

The intent of this paper is not to focus on the results of the study, not only because they are so extensive, but also because the results have already been documented in a publicly available final report. This paper concentrates on the study methodology that was employed throughout the course of the study, the leading contributors of study bias, current and future uses of the study findings and future study recommendations.

Introduction

In 1999-2001 RLW Analytics of Sonoma, CA was the prime contractor for the California Statewide Lighting and Appliance Saturation Study (CLASS). ASW Engineering performed as a sub-contractor to RLW Analytics, assisting in the data collection component of the study. California's IOUs and SMUD funded the study. The study included 1,258 residential on-site surveys that facilitated data collection for major household appliances and lighting fixtures and lamps. The data collected on-site were input into a master database that included the lighting and appliance data along with the household demographics. Appliance model numbers were linked to efficiency databases to determine appliance efficiency. A database summarization tool that utilized RLW's Model Based Statistical Sampling (MBSS) software and Microsoft Access queries was used to conduct nearly all of the analysis and was also delivered to the utilities for analyzing data at the utility level. The final report delivered to the IOUs reported findings only at the statewide level, utility program managers were trained to use the analysis software for analyzing the data as desired.

The intent of this paper is not to focus on the results of the study, not only because there are so many, but also because the results have already been documented in a publicly available final report. This paper concentrates on the study methodology that was employed throughout the course of the study, the leading contributors of study bias, study limitations, current and future uses of the study findings and future study recommendations.

Study Objectives

In 1999 the CPUC was seeking to change conservation programs in California from resource acquisition programs into market transformation programs. To assess the success of these efforts and to guide public policy and program planning, this study was undertaken to collect baseline data on the saturation of lighting and major appliances in the residential sector.

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Approach

RLW and ASW Engineering combined together to form a team that offered considerable coverage of the state of California. RLW is located in northern California, while ASW is located in southern California. Together, the team was able to cost effectively conduct 1,258 on-site surveys spanning December 1999-March 2000. In the early stages of the study survey instruments were developed by RLW under guidance from the study team. With the integrity of all survey questions intact, the finalized survey was redesigned for a palm-top computer software program (FieldWorker Pro™). Combined with easy to use mini-PC computers, the software was programmed to allow for fast and easy on-site data collection.

While on-site, the surveyors collected nameplate data on the following major appliances in the home:

- Refrigerator-Freezer
- Self-standing Freezers
- Dishwashers
- Clothes Washers
- Clothes Dryers
- Water Heaters
- Heating Equipment
- Cooling Equipment

Each lighting fixture and lamp type was also surveyed within the home, including the front porch fixture and lamp type. In addition to the lighting and appliance survey data, the on-site surveyors also collected data on attic, floor and wall insulation R-values, wall construction (i.e. 2x4, 2x6, masonry) types, window type and number of panes, and demographic information.

As the data was collected the auditors uploaded the site data from the palm-top computers to the RLW office. The data were cleaned for any data inconsistencies and imported into the MS Access master database. Using existing databases of appliance efficiencies (i.e. CEC appliance databases, ARI, AHAM, etc.), MS Access queries were designed and written to link on-site data to the efficiency databases based on manufacturer model number. If linked, the corresponding efficiency was assigned to the matched appliance.

Matching rates varied greatly by appliance type. For example, refrigerators had the highest match rates, while room air-conditioners and clothes dryers had the lowest. One of the key tasks of this project was the search for efficiency databases. At least one database for each appliance was found with the exception of clothes dryers, therefore there were no efficiency results or match rates for clothes

dryers. Table 1 shows the final match rates, numbers of each appliance surveyed, number of model numbers found, and percentages of the values for each appliance surveyed.

Table 1. Model Number Match Rates by Appliance

All Utilities		Total Number In Database (A)	Model Numbers Found (B)	Model Numbers Matched (C)	% Model Numbers Matched (C/B)	% Model Numbers Not Found (B/A)	% of Total Matched (C/A)
Appliance	Refrigerators	1444	1260	865	69%	13%	60%
	Cooling Overall	733	460	300	65%	37%	41%
	Cooling Evap	49	13	0	0%	73%	0%
	Cooling Packaged	117	48	26	54%	59%	22%
	Cooling Split Sys	400	328	268	82%	18%	67%
	Cooling Win Wall	167	71	6	8%	57%	4%
	Furnace	1275	791	339	43%	38%	27%
	Heat Pumps	83	60	30	50%	28%	36%
	Freezers	214	165	51	31%	23%	24%
	Dishwashers	871	849	286	34%	3%	33%
	Washing Machines	965	865	156	18%	10%	16%
	Hot Water Heaters	1074	822	439	53%	23%	41%

It was anticipated in the design stages of the project that the match rates would be better than what are shown in Table 1. RLW encountered several problems when matching model numbers. One of the most troubling problems was that of wildcards (*, /, #, etc.) found in the manufacturer model numbers. The wildcards added to the complexity of the query designs and decreased matching rates. RLW wrote "layered" queries that searched several databases for matching model numbers. Once the automated process was complete, a lengthy manual process of looking up the unmatched appliances was undertaken. There was approximately equal success between the manual and automated process.

Efficiency databases were exhausted using the above protocols for matching appliances. RLW is confident that the great majority of model numbers found on-site were matched if they appeared in any of the efficiency databases. The problem with the low matching rates lies in the efficiency databases themselves. Simply put, much of the equipment found in the state of California is not documented in publicly or privately available efficiency databases. Furthermore, the private data (refrigerator-freezer) that was purchased from AHAM was not in the best condition, and somewhat partial in content. Due to cost considerations, the AHAM room air-conditioner database was not purchased for this project. It is our belief that if the AHAM room air-conditioner data had been available, the match rates for these units would be much better than the present 8%. This is the only database to our knowledge that could increase any of the match rates presented above in Table 1.

Midway through the project, the study team discussed ways to "slice and dice" the lighting and appliance data for analysis purposes. Those discussions formed the basis for the final report and the queries to be delivered with the final analysis database. Once all of the analysis queries were written, each site was given its appropriate weight and the queries were run. Each query was then processed through RLW's Model Based Statistical Sampling (MBSS) software, which projected the results to the population. The analysis for lighting and appliances is summarized in the final report at the statewide level. Each member of the study team received the analysis database and software for conducting their own analyses (e.g. by utility, home type, income level, etc.) on the data.

Methodology

This section provides an overview of the methodology that was employed for the major study tasks. Also, where applicable, discussions are included that describe strengths and weaknesses to the study methods. The components covered in this section include the following:

- ❑ Sample Design
- ❑ Customer Recruiting
- ❑ Data Collection
- ❑ Analysis

Sample Design

For SCE, SDG&E, and PG&E, the sample of 1,000 sites was stratified by utility rate class. The sample size for each rate class was calculated by multiplying the desired sample of 1,000 homes by the proportion of the total residential accounts in that class. In practice several of the classes were so small that the preceding methodology led to less than a single home. Therefore a constraint was added so that the sample would be at least 1 from each rate class to ensure that each rate class would be represented in the sample. Later the results were adjusted proportionately so that the total sample would still be 1,000 for the three utilities. Furthermore, the sampling plan and sample weights allows for each of the utilities to conduct statistically representative analyses for the population of customers at the utility level.

For SMUD, the sample sizes were selected so that the expected relative precision associated with the SMUD sample would be 7%. In other words, the SMUD sample sizes were selected so that the error associated with estimates for the SMUD population alone would be 7% of the estimate.

Recruiting

RLW and ASW recruited customers based on their geographic location. In general, RLW recruited in the northern part of California, and ASW the southern region. A twenty-five-dollar incentive was offered to customers that agreed to participate in the study. The recruiters scheduled appointments between the hours of 9AM and 8PM. The recruiting manager dispatched the information electronically to the field surveyors at the end of each day. Using their palm-top computers, auditors downloaded their daily appointments and also used the handhelds Internet capabilities to get directions to the scheduled sites. Table 2 shows the distribution of the 1,258 sites recruited and surveyed by utility service territory.

Table 2. Number of Sites Recruited by Service Territory

Service Territory	Number of Sites Recruited
PG&E	460
SCE/SCG	420
SDG&E	120
SMUD	258

Generally, the recruiters made up to seven attempts to recruit the customer's participation. If unsuccessful after the seventh call the customer was replaced with a back-up customer. Table 3 summarizes the disposition codes and final outcome for customers that the recruiters attempted to contact during the study. PG&E had the highest refusal rate of the utilities. During recruiting we found a higher refusal rate among customers living in the south bay (San Jose metropolitan area/Silicon Valley) than we did from customers in other parts of the PG&E service area.

RLW and ASW took a slightly different approach to leaving messages; on the third message RLW recruiters would explain the reason for the call and leave a number that they could call to either refuse or accept participation in the study. This approach was not used for SCE or SDG&E customers by the ASW recruiters. The difference in approach explains whey the PG&E and SMUD refusal rates are higher than SCE and SDG&E, and also why the final outcomes for "left message" are higher for SCE and SDG&E.

Table 3. Recruiting Final Outcome by Service Territory

	PG&E		SCE		SDG&E		SMUD		Statewide	
	Count	%	Count	%	Count	%	Count	%	Count	%
Appointment Completed	460	19%	420	15%	120	21%	258	22%	1,258	18%
Appointment Scheduled but Not Completed	41	2%	49	2%	13	2%	21	2%	124	2%
Left Message	203	8%	403	14%	75	13%	73	6%	754	11%
Call Back Later	58	2%	146	5%	18	3%	47	4%	268	4%
Busy	5	0.2%	39	1%	3	0.5%	12	1%	59	0.8%
No Answer	104	4%	204	7%	23	4%	57	5%	389	6%
Refused	1,054	44%	672	24%	116	20%	332	29%	2,174	31%
Wrong or No Number	386	16%	774	27%	184	32%	319	28%	1,663	24%
Communication Barrier	75	3%	81	3%	14	2%	38	3%	208	3%
Vacant Address	6	0.3%	59	2%	6	1%	0	0%	71	1%

SMUD had the highest conversion rate, at 22%. This is most likely explained by the fact that half of their customers were sampled from their low-income rate class, where a twenty-five-dollar incentive is more attractive. SCE had the lowest conversion rate of 15%, a result of a large majority of wrong numbers, refusals and un-returned phone calls.

Recruiting Bias

Judging from the data included in Table 3, it is easy to see that low recruiting conversion rates were realized for this study. Leading one to believe that a certain amount of bias was introduced as a result of low customer acceptance. The participation incentive of $25 potentially further increased recruiting bias by over-selecting low-income customers

On a statewide average, 31% of customers contacted refused to participate in the study for various reasons. Refusals accounted for the highest proportion of non-response. It is thought that offering customers a $25 incentive increases the response rate, however we heard customers tell us that twenty-five dollars was not enough of an incentive for what we were asking them to do. Unfortunately we have no answer or concrete recommendation that might encourage higher participation and less overall refusals. The type of data that was collected through this study is not the kind that can be supported by a mail or telephone survey.

The second highest contributor to non-response was wrong or bad telephone numbers provided by each utility. Going into the study we knew that contact information maintained by the utilities would be poor and potentially a leading contributor to non-response bias. For customers whose contact information was bad we used a couple of techniques used to obtain an accurate contact number. It is important to know that the sample design targeted home addresses, not customers, therefore if the contact information was inaccurate we would then look to obtain contact data specifically for the address, not the customer. We used a combination of Internet tools, directory services and ProCD software to search for contact information that was bad or missing. Obviously it would have been best if the utilities maintained a more comprehensive and accurate database of customer contact information, however, in the absence of these data we believe we used the best sources for searching out contact

information. Though undocumented, we believe these efforts resulted in finding contact numbers for 20-30% of customers that had bad or missing numbers.

Demographics

A list of demographic data was developed by the study team to be collected by the field surveyors. We collected demographic information such as the type of residence, number of residents by age, primary language, annual income for the home, year residence was built, total heated floor space of the home, has the home been remodeled in last 10 years, are there plans to remodel in the future, just to name a few. This section contains selected tables that summarize the demographic characteristics of the sample. These results have not been weighted to reflect the population. We also included some percentages that summarize the population of California from the 1990 Census to show how our sample compares to the state population.

Table 4 shows the percentage of homes by single family or multi-family residences. The CLASS sample and the 1990 California Census population are closely matched. Approximately one-third of both groups are multi-family, and two-thirds are single-family residences.

Table 4. Percentage of Homes by Single Family or Multi-Family Residence

Type of Residence	% of Homes	
	CLASS	1990 Census
Multi-Family Home	36.0%	33.4%
Single Family Home	63.4%	66.6%

Table 5 shows the percentage of homes by number of people occupying the home sampled in CLASS and found in the 1990 US Census in California. The largest percentage of homes in the CLASS sample, or 32.0% of homes, were found to have 2 occupants. The largest percentage of homes in the 1990 US Census in California also had 2 occupants, constituting 31.1% of California homes. The average number of people per home was found to be 2.8 people for both CLASS and the 1990 US Census in California. The CLASS sample appears to be closely matched to the California population as far as the number of people occupying the homes that were surveyed.

Table 5. Percentage of Homes by Number of People

	% of Homes	
Total People	CLASS	1990 Census
1	19.8%	23.4%
2	32.1%	31.1%
3	18.1%	16.6%
4	17.6%	14.6%
5	6.5%	7.3%
6	3.7%	3.4%
7 or more	2.3%	3.5%

Table 6 shows the percentage of homes by whether the occupant rents or owns the home. Over 60% of homes in the CLASS sample were occupied by owners/buyers, and over 55% of homes in the 1990 Census were occupied by owners/buyers. The CLASS sample appears to be closely matched to the California population as far as the percentage of homes occupied by renters and owners.

Table 6. Percentage of Homes by Rent or Own Home

	% of Homes	
Rent or Own	**CLASS**	**1990 Census**
Own/Buying	60.7%	55.6%
Rent	39.3%	44.4%

Table 7 shows the percentage of homes by total household income. Almost 27% of the residents in the CLASS sample had an annual income under $25,000, compared to over 34% of the households in the 1990 US Census in California. It appears that the CLASS sample may be slightly biased toward higher income households. This contradicts the presumption that the cash incentive may have contributed to bias by encouraging higher participation among lower income customers.

Table 7. Percentage of Homes by Household Income

	% of Homes	
Total Household Income	**CLASS**	**1990 Census**
< $25000	26.7%	34.1%
$25001 - $50000	30.1%	32.9%
$50001 - $75000	19.1%	18.4%
$75001 - $100000	13.3%	7.6%
> $100000	10.9%	7.1%

Table 8 shows the percentage of homes by primary language. In the CLASS sample, english was the primary language spoken at over 89% of the homes. Spanish was the second most common language, with over 5% of all respondents speaking Spanish as their primary language. The data from the 1990 US Census in California indicates that a higher percentage of California residents speak Spanish (20%) than were represented in the CLASS sample. This is not a surprising outcome since we had only one bilingual recruiter for the CLASS study, therefore it was more difficult to schedule visits at Spanish speaking households. We would recommend using more or all bilingual recruiters in future studies of this type in order to minimize any bias that language introduces to the sample.

Table 8. Percentage of Homes by Language Spoken

	% of Homes	
Primary Language	**CLASS**	**1990 Census**
Chinese	1.3%	2.1%
English	89.7%	68.5%
French	0.2%	0.5%
Indian	0.2%	0.0%
Japanese	0.3%	0.5%
Korean	0.2%	0.8%
Other	1.7%	5.3%
Russian	0.2%	0.2%
Spanish	5.1%	20.0%
Tagalog	0.8%	1.7%
Vietnamese	0.2%	0.9%

Data Collection

The data collection component of the study was highly resource intensive, taking the better part of four months to complete, utilizing over 21 surveyors. The data collection began during the month of December 1999 and ended at the end of March 2000. During December and early January, very few on-sites were completed due to low customer willingness to participate.

ASW Engineering completed the on-site surveys in the territories of San Diego Gas and Electric, Southern California Edison, Southern California Gas, and the southern most regions of PG&E service territory. RLW Analytics field staff surveyed sites in PG&E and SMUD territory.

Each auditor participated in a one-day training session that focused on the demographic, lighting and appliance, and market barrier data to be collected in the field. Additionally, the auditors were trained to use the palm-top computers, including data entry using FieldWorker Pro, data uploading and downloading and Internet access. Two training sessions were conducted, one in Tustin, CA for the ASW auditors, the other in Sonoma, CA for the RLW auditors.

Like most studies that have limited financial resources and large amounts of field data collection, budgets can easily be consumed by the cost of collecting the data. As a result contractors must look for economies that will reduce ballooning field costs in order to invest the appropriate amount of resources in the analysis of the data. There are few variable costs when it comes to data collection and perhaps the costliest variable component is that of the field staff. Therefore it is imperative to use staff that will not heavily impact the budget because of their high cost, but will not compromise the study due to inexperience.

The key for us was to find affordable surveyors knowledgeable in regard to residential HVAC equipment and the plethora of lighting technologies we expected to encounter. The key variable cost then becomes the hourly rate of the field staff, since they will certainly carry the dominant number of project hours. To accomplish this and to remain competitive among other bidders, RLW and ASW primarily utilized retired utility staff and engineering student interns for the field data collection component. We found that surveyors with these backgrounds had considerable existing knowledge of the data collection requirements and were also easily trainable. That said, the importance of a properly trained surveyor should not be overlooked. While efficiency is important, it is worthless if the surveyed data are invalid or collected improperly.

Few known circumstances arose where surveyors collected incorrect data. In the few cases we were able to identify the surveyors misunderstandings early by sending fully competent staff along side the surveyors during the early stages of the project. In addition to the training sessions, we also held surveyor conference calls, bi-weekly in person meetings and set up email addresses for each of the surveyors to ask questions as they arose. This open line of communication was a key factor in limiting biases introduced through surveyor error and led to a more successful data collection task. That said, the importance of well-trained staff and open lines of communication should not be overlooked or under budgeted.

RLW found another economy in the field data collection component of the study using palm-top (handheld) computers. The survey was fairly long and detailed which would have meant a considerable amount of time in data entry and data entry supervision. Instead, each surveyor was issued an HP Jornada 680 powered by Windows CE. Each unit came with a colored touch screen, 12-hours of battery life, a modem for email, and Field Worker Pro software.

Surveyors were trained in the use of the palm-top computers, which functioned exactly like a mini PC. Field Worker Pro is an application designed specifically for field data collection. The software is easily programmable and offers intuitive data entry screens that minimize incorrect entries through drop down menus and locked data fields. After each day's on-sites, the surveyors would email their Field Worker files to RLW. These files would then be processed electronically into our master database

of field data. This process eliminated the need for data entry and the errors that can often accompany it. Moreover the system saved an extraordinary amount of resources, such as paper, copying, phone calls and faxes, which resulted in even more project savings.

Analysis

The data collected during the 1,258 on-site visits are contained in two final databases. One database contains all appliance and envelope information, and the other contains all the lighting information. These two databases were delivered to the utilities in MS Access format. In addition to the survey information collected on site, the appliance database contains all information linked from the efficiency databases that pertains to the models in the sample, and contains the efficiency categories that were created in order to analyze the data.

The data on each appliance in the appliance database are located in a separate table. Queries have been set up that allow the user to analyze some key questions for each appliance. The same is true of the lighting database. The following is a list of the steps that were taken to ready the databases for delivery:

1. Consolidation of Auditor Information
2. Cleaning of Auditor Information
3. Merge of Weights
4. Acquisition of Efficiency Databases to Link with Auditor Data
5. Creation of Efficiency Categories
6. Creation of Analysis Queries
7. Development of Database Summarization Tool

Consolidation of Auditor Information. During the site visit, the auditors entered all information directly into a palmtop computer as the survey was completed. Each auditor sent their site information in electronic text format to the offices of RLW where it was integrated into a central database using a VB program specifically designed to manipulate the data in the spreadsheet into the individual appliance tables. This was essential in order to enable the analysts to compare the saturation of different appliances in different markets.

Merge of Weights. Once the sites were merged and cleaned in the central database, the sample design case weights for the analysis were merged into the database in the 'General Information' table. Since the sample was originally stratified by rate class, each site in a given rate class was given a corresponding case weight that we define to be the number of sites in the population that the site is thought to represent. These weights were used to expand the sample to the population.

Merging of Saturation and Efficiency Information. The auditors were able to observe make and model number on-site, but in most cases, not energy efficiency. The RLW team used all available resources to match the model numbers collected on-site with a reliable source of efficiency ratings and/or Unit Energy Consumption (UEC). Other sources included the aforementioned CEC databases, ARI databases (for HVAC), AHAM databases, manufacturer-supplied information and other relevant sources of efficiency information. We matched the on-site information by model number with standard efficiency ratings for each end-use when applicable. End-uses that do not have an associated standard efficiency rating (e.g., refrigerators) are characterized in terms of annual unit energy consumption.

Creation of Efficiency Categories. Efficiency categories were developed for each appliance type depending on the distribution of the efficiencies. Size and age ranges were also created for each appliance depending upon the distribution for each appliance. The efficiency, size and age categories were linked to the auditor information using logic statements built into the analysis queries.

Creation of Analysis Queries. Analysis queries for each appliance were created in MS Access in order to answer some key questions on market saturation. These queries were designed to analyze each appliance by age, type, size, and any other energy consumption or efficiency variable. Analysis queries were also established for the lighting database. These analysis queries were designed specifically for the Model Bases Statistical Sampling (MBSS) program to analyze the data using ratio estimation techniques. More information on the format of each query is provided in the appendix of the final report.

Development of Database Summarization Tool. RLW provided a Visual Basic application of MBSS that selects one or more queries in the database, carries out the statistical calculations of stratified ratio estimation (which we use to calculate weighted averages for the population), and creates tables in the database with the results desired. The application tailored for this project has the ability to calculate underlying sample sizes, error bounds, proportions (i.e., proportion of all cooling units that are space/room vs. central), and ratio estimates, (e.g., of the saturation level of secondary refrigerators).

This type of information can be developed for all sites, or classified by the level of efficiency, utility, stratum, type of residence, and all other demographic variables.

Future and Current Uses of the Study Results

The data collected for the CLASS study were primarily intended for use by the utilities for residential program design. The lighting and appliance databases delivered to the four utilities included all the data collected throughout the state. The MBSS database software that was delivered with the databases allowed each of the utilities to do "what if" analyses on the data, "sliced and diced" however they thought to analyze the data. During a one-day training presentation, members of each utility were trained to use the database analysis software using the existing analysis queries. Members were also trained to design new analysis queries to answer questions that had not previously been addressed in the statewide report. In addition to the utilities, RLW also trained members of Lawrence Berkley National Laboratory (LBNL), National Resource Defense Council (NRDC) and the California Energy Commission (CEC).

The CLASS data have assisted researchers such as RLW and LBNL in designing new technologies and energy studies. A few examples of how the CLASS data have assisted various research efforts are listed below.

Appliance Turn-in Scoping Studies

In spring of 2001 Southern California Edison contracted with RLW to do a small scoping study to assess the feasibility and potential impacts of a room air-conditioner (RAC) recycling program. RLW utilized the CLASS appliance database to aid in successfully completing this market assessment. The CLASS data provided key insight into the RAC market in SCE's service territory, specifically in the area of RAC saturation, age, size and efficiency. SCE internally conducted a similar scoping study for electric hot water heaters. Using the CLASS data, RLW assisted SCE in determining the saturation of hot water heaters in their service territory, by fuel type, ownership, home type and number of occupants.

RLW also assisted an un-named Sacramento company in estimating the impact of a statewide refrigerator recycling program. The data allowed RLW to assess easily the quantity of applicable refrigerators and the potential load impacts from such a program.

Lighting

LBNL and the NRDC found the lighting data to be highly useful in estimating the potential impacts of a newly designed type of recessed canister lighting. LBNL had been working on a new energy efficient recessed "can" lighting system, the CLASS data gave them insight into the renovation and new construction market in regard to recessed can saturation. The data revealed that new homes and renovated homes have a much higher saturation of recessed cans. The data also showed which rooms recessed cans are most likely to be found in, the quantities that were installed in these rooms, and how the switching of these fixtures differed. The data were used to aid LBNL in the design specifications of a recessed canister technology that allows several light canisters to operate using a single common ballast.

The CLASS data have also been used to assess the impacts of programs that would target owners of torchiere lamps, specifically by replacing inefficient lamps with more efficient light sources. The data have also been used to better understand the CFL market. The CLASS data provided not only CFL saturation statistics, but also the rooms they are commonly found in, the household demographics of those that purchase them and even the types of fixtures the lamps are and are not commonly found in.

California Statewide Ceiling Fan Study

Lighting data collected for the CLASS study included ceiling fans because in most cases (95%) ceiling fans also have light kits attached. In addition to collecting data on ceiling fans with light kits, RLW/ASW also collected data on ceiling fans without light kits. Like the other lighting fixtures in the home, RLW/ASW also specified the room location of the ceiling fans and the lamp type in use. In Spring of 2001 RLW contracted with SDG&E to conduct a statewide study of ceiling fans that will be used to assist the utilities in assessing the potential impacts of an energy efficient ceiling fan program. The CLASS database was used to select a sample of customers that were known to have one or more ceiling fans. The CLASS data gave RLW a cost-effective way to identify a sample customers with a diverse set of attributes, such as:

- Number of ceiling fans in home
- Fans with light kits
- Homes with and without AC
- Homes new and old

Ultimately the savings from the use of the CLASS data allowed RLW to increase the sample size and in-turn increase the precision of the study findings.

Future Study Recommendations

The following section summarizes some of the lessons learned by the RLW team and suggests alternative approaches for conducting future studies similar to this one.

Others who plan to do similar work should not underestimate an automated model number matching process. To automate the model number matching process, RLW ended up writing more complex queries than had been anticipated. Additional time should be budgeted to hand match model numbers that will not be successfully matched using the automated process. Furthermore, the best source of heating and cooling equipment efficiencies used by RLW (Carrier Bluebook) is not in a database format. Therefore databases should be combined with as much manufacturer data as possible to get the most comprehensive data as possible.

To have unbiased efficiency information, reviewers should look to contractors who propose to match proportionally the age of units by the number of units in the population by age. For example, in

Table 9, 13% of hot water heaters that were able to be matched were manufactured between 1985 and 1989, yet 21% of the population's hot water heaters are of this age. An even distribution of percent matched and age distribution of all water heaters would remove bias of efficiency related to age. Only in 1990-1994 do we have a good match between the two (28% and 29%). Bidders who propose to proportionally match units by age distribution will remove much of the bias introduced when using only existing databases to match appliances. Contractors may be required to work with manufacturers to acquire this more representative data.

A study of the CLASS data could be undertaken to better explain why some model numbers of appliances were matched and why others were not, and what the implications of this may be. For example, 56% of hot water heaters one to five years old were matched while the remaining units were not. Why is this? We know that much more comprehensive information exists and is available for refrigerators and air-conditioners, which led to better overall match rates. And while the data shows that as hot water heaters age a smaller proportion of units are matched, there are most likely other leading factors that should be investigated. For example, the appliances that had the lowest match rates were those that utilized only the CEC efficiency database (because no other sources were available). Possibly because there may be certain manufacturers that have a good market presence, but are not being included in the CEC tests. Other attributes such as unit size and fuel type may also be contributing factors.

Table 9. Manufactured Date of Matched Hot Water Heaters

Age	Number of Units Matched	Period's Matched Water Heaters as a % of all Water Heaters Matched	Age Distribution of all Water Heaters
1995-2000	183	56%	38%
1990-1994	91	28%	29%
1985-1989	41	13%	21%
1980-1984	9	3%	7%
1979 or Older	3	1%	5%
Total	327	100%	100%

RLW's use of the palm-top computer worked well for all intensive purposes. Using electronic mail, auditors were sent daily appointments and could easily communicate day-to-day events. Furthermore, the palm-top provided easy Internet access for direction finding and other research needs. RLW invested in a relatively new software, *FieldWorker Pro*, as the application to run under Windows CE. This software (including Window CE) like many new software products has bugs. RLW spent some amount of hours working through these bugs. We would recommend using the palm-tops again, but would allocate more time to debugging, data cleaning and uploading. It should be said that the amount of resources saved (i.e., paper, copying, phone calls, faxes) as a result of the palm-tops is extraordinary.

Lastly, RLW does not recommend beginning a study that requires residential on-site customer visitation during the Thanksgiving, Christmas and New Year holiday season. On-site surveys for this project began in early December. Appointments during this time were extremely difficult to schedule and difficult for customers to keep. Considerable budget was used on recruiting and missed appointments during this period of the study. Moreover, recruiting refusal rates were much higher during this time of the on-site surveys than it was during the remaining months, which certainly added to non-response bias.

References

1. *U.S. Census Bureau.* 1990. American Factfinder for California. www.census.gov