Economic and Demographic Factors Affecting California Residential Energy Use

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We acknowledge the funding of Utility Consumers' Action Network of San Diego in 2000 of research regarding the load patterns of SDG&E customers by size that is presented in this paper. This material was previously submitted in testimony in SDG&E's 1999 Rate Design Window (A. 91-11-024).

Detailed working papers, including equations produced in the process of preparing this report, can be obtained by contacting greg@jbsenergy.com.

I. Introduction

This paper reports on a detailed analysis of the influence of household size and composition, housing characteristics, and income on residential usage for the three major California investor-owned utilities: Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric Company (SDG&E), and Southern California Edison Company (Edison or SCE). Portions of this analysis were submitted in testimony to the California Public Utilities Commission (CPUC or California PUC) in its Rulemaking 01-05-047 on baseline quantities for residential rate design. (Marcus, 2002, 2002a, Nahigian, 2002)

We were able to conduct this analysis because the California utilities conducted detailed Residential Appliance Saturation Surveys (RASS) of thousands of households for the California Energy Commission in the mid 1990s (1995 for Edison and PG&E and 1997 by SDG&E) and provided data from these surveys to JBS for this analysis. Utilities in most of North America do not make available the breadth of data to enable work like this to be undertaken. We appreciate the availability of this customer-specific data for analysis. Unfortunately, these surveys have been discontinued now that long-run demand forecasts have been devalued by electric industry restructuring and deregulation**.** (See, for example, California Energy Commission, 2000)

Three major variables influence energy use within a given climate zone and usage type: household size, income, and square footage. Typically, larger household size, higher income, and increases in square footage cause increased usage of electricity and gas. Vacation homes use less electricity and gas than permanent residences. In addition, single-family houses use more energy than apartments of the same size. In some parts of the state, households with senior citizens or and households with people who work at home were found to use more energy after controlling for the other variables.

For Southern California Edison, where additional data are available on appliance characteristics that are not available for PG&E and SDG&E, we also conducted a brief investigation of the impacts of central air conditioning and water pumping on usage.

The basic units of analysis for PG&E and Edison were baseline climate zones. These are zones established by the California Public Utilities Commission (CPUC) used to determine baseline quantities -- the lowest rate of a five-tier inverted residential rate structure (California PUC, 2001).[1] Households were also divided into "basic" and "all-electric" customers, which is also a determinant of the allowable baseline quantity. An all-electric customer uses electric heat.

II. Summary of Findings

Our review of electricity and gas use described below yields the following findings:

- Electricity and (to a somewhat lesser extent) gas use increases as income increases.
    - This finding sounds obvious, but many utilities across the country have been recently trying to deny it.[2] This finding is also consistent with recent findings that low-income customers use less electricity and gas than higher income customers by Colton (2002) from national data and Marcus (2002b) using Nevada Low Income Home Energy Assistance Program (LIHEAP) data.

[1] Baseline climate zones were used because the initial purpose of this testimony was for use in a CPUC proceeding relating to the analysis of baseline rates. A different set of climate zones are used by the California Energy Commission in load forecasting.

[2] Nevada Power (Liparelli, 2001), Sierra Pacific (Meacham, 2001), Reliant Arkla (gas) (Theberge, 2001, 2002), and Washington Gas Light (Raab, 2002) have all denied the nexus between income and usage in testimony before regulatory commissions in the most recent 12 months.

- Without controlling for family size and housing characteristics, for all three utilities, electricity use by households with incomes over $100,000 was 200-250% of the use of households under $15,000 in nearly all utilities and climate zones. For SDG&E, where an income level over $150,000 was available, customers with this high income used three times as much energy as customers under $15,000.

- For gas, the disparity was not quite as large but was still significant. PG&E households earning more than $100,000 typically used 150-200% more gas than those earning less than $15,000.

- There is a wide variation in use by income, housing unit size, and number of persons per household for all three utilities. Comparing the use of a single resident earning less than $20,000 per year in a small apartment to use by the largest family with the highest income (over $100,000 per year, 1994-95 dollars for PG&E and SCE, over $150,000 per year, 1997 dollars for SDG&E) in a single-family house of more than 3000 square feet, the high-income family in the large house uses 6 to 8 times as much as the low-income person in an apartment, depending on the utility.

- The impact of income on gas use is somewhat less. The high income large household in a large house referenced above uses 3.5 to 4 times as much gas as the low-income resident of the small apartment in PG&E's climate Zones S and T.

- Much of the increase arises because households with higher incomes are more likely to live in larger dwellings and in single-family units than households with lower incomes.

    - However, there were large increases in usage associated with income over $100,000-$150,000 in many PG&E and Edison electric and gas zones as well as in San Diego, independent and additional

to increases caused by larger dwelling units and a higher percentage of single-family homes among the well-to-do.

- In a number of zones for all three utilities, use was modestly lower (200-400 kWh per year) for households under $20,000 to $30,000 after controlling for housing characteristics and family size.

- In some inland zones in PG&E and Edison and in San Diego, large families with high incomes have a further relatively large increase in use beyond that otherwise explainable by income, family size, and housing characteristics. In one or two PG&E zones, a large family with low income used less than otherwise expected. It was important to disaggregate these interactive variables of family size and income to assure that the impact of family size on use is properly computed.

- After controlling for income and housing characteristics, larger households used more electricity and gas than smaller ones, but generally by a smaller amount than would be predicted from analysis of household size alone without controlling for these other factors.

  - Adding a second person to a household increases use for basic PG&E customers by an average of 125 kWh per month excluding coastal Zone T, where the increase is 75 kWh. A second person in an all-electric household also increases use by an average of 125 kWh. In San Diego, the second person adds 75 kWh per month to a basic household and 65 kWh per month to an all-electric household. For Edison, a second person added 45-100 kWh per month, with the lower figures in coastal baseline zone 10.

- The difference in use between a household of two and a household of six or more[3] averaged 140 kWh per year for basic users and 150 kWh for all-electric users across PG&E climate zones (with higher amounts in the Central Valley) and 150 kWh per year for PG&E all-electric zones. The average increase was 80 kWh per month for SDG&E basic users, and 150 kWh for SDG&E all-electric users. Increasing household size from two to a maximum level on the Edison system also added 80-90 kWh per year.

- In a number of climate zones, use does not clearly increase as more than four persons are included in a household. We have observed it in a number of PG&E zones, as well as for Edison and SDG&E. This finding is probably consistent with needing to spend more income on goods other than electricity in very large families.

- The increase in PG&E gas use going from one to two persons in a household was about 80 therms per year on average.

- For PG&E, after controlling for housing characteristics, which have the most effect on gas use, increases in the number of people beyond two people has a smaller effect on gas use than the increase from one to two people or than the increase in electric use in most zones. The impact was 20 therms in one zone, approximately 50 therms per year in three zones, and 86 to 122 therms in Central Valley Zones S and W.

[3] In some cases, where there was no statistically significant difference or a decline as household size increased, a household size of four or more was used.

- Households with senior citizens tend to use more electricity and gas, although the phenomenon was not observed everywhere in the state.
    - For basic use (excluding all-electric), a household with a senior citizen uses about 40 kWh more per month in San Diego. In PG&E, the impact of a person over 65 varied by region from zero (in three zones) to 15-25 kWh per month (in three zones), to 55 kWh per month in one zone. There was no significant impact for Edison.
    - The addition of a senior citizen to an all-electric household in the Central Valley increases use by about 200 kWh per month. A large portion of this additional use arises in peak winter months. No significant impact could be observed statistically for all-electric households in PG&E's coastal zones, Edison, or SDG&E.
    - The addition of a senior citizen to a gas household in PG&E increases annual use by about 100 therms per year, largely in winter heating costs. The cost impact (difference between baseline and non-baseline rates) is about $20-$25.
- Households with gas heat and a member who works at home use an extra 50 kWh (in PG&E's coastal zone T) and 70-100 kWh per month in most other PG&E zones.[4] The impact on usage of having a worker at home could not be established with statistical significance in most zones for all-electric households and gas customers. The variable was significant in a few zones (about 100 kWh per month in one all-electric zone and 27-46 therms per year in two PG&E gas zones).
- Vacation homes use 50-70% less than permanent residences, with the exception of the Edison low desert (Palm Springs) area, where use is 10-

[4] This issue was not investigated for Edison and SDG&E.

30% less. The lower use in the Palm Springs area is concentrated in the summer months when vacation homes are less likely to be occupied.

III. Methodology

To analyze each utility, we ran several types of equations. Equations were prepared by climate zone that related annual usage only to household size, income, and square footage of dwelling unit. These equations provide simple snapshot views. In addition, for at least one representative basic climate zone for each utility, an equation was prepared which related usage to income and household size without controlling for housing stock. This equation is important for determining whether a utility's rate design proposals might affect a group disproportionately) such as low-income or lower-middle-income large families).

Finally, complete equations were prepared to control for all of the three major effects. In those equations, annual use was related to variables for:

- Number of people in household (up to six categories, corresponding to 1 through 5 people and six and over)
- Square footage (divided into up to nine categories)
- Income (divided into up to nine categories)
- Single-family vs. multifamily
- Whether a senior citizen lived in the home[5]
- Whether anyone worked from home (PG&E only)

Categories were combined (in the income, square footage, and household size variables) if there were no statistically significant differences among them, and variables were deleted if not significant.

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[5] Defined as "65 or over" for PG&E and SDG&E and alternatively as "60 and over" or "retired" for SCE, because the utilities used different definitions in their RASS surveys.

Interactive variables (for example a combination of income and household size) were included in a few cases where they were significant. The inclusion of these variables enabled us to find that in a few climate zones, very low-income people in large households used less than expected after controlling for household size, income, and square footage. Similarly, very high-income people with large households used more than expected in a few zones, particularly in inland zones for PG&E and Edison as well as in SDG&E. Inclusion of the interactive variables was important to assure that consumption associated with income is not attributed to family size.

Several other interactive variables were tested but were generally not statistically significant. These variables include (1) a variable for a low-income household including at least one senior citizen, and (2) a variable reflecting overcrowding (household of more than 4 people in less than 1000 square feet).

All equations were run using the "weighted regression" function in SPSS with the weights specified as equal to the weights given to each data point in each utility's model. A "weighted" regression analysis compensates for the stratified nature of utility sample, where certain customers (e.g., large users, certain climate zones) were over-sampled relative to their percentage of the total of all utility customers.

To prepare all of our analysis, we included all surveyed units with household size greater than zero (i.e., excluded vacation homes)[6] and with electric use in excess of 500 kWh[7] or gas use above 50 therms (to exclude bad data). Units with some missing monthly usage data were also excluded.

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[6] Separate data on vacation homes versus all other units were prepared for three PG&E zones with large numbers of vacation homes as well as for several SCE areas including Palm Springs and southern California mountains.

[7] For Edison, which provided daily usage data, the cutoff was 1.5 kWh per day (547 kWh / year).

Related equations were produced for PG&E to examine the percentage of customers using less than 6000 kWh per year for purposes of analyzing the potential cut-off point for advanced metering technology.

In addition, some demographic data were analyzed to look at the relationship of housing size and type by family size and income. For Edison, which provided data on certain end-uses, the saturation of air conditioning was also related to income, and the effect of water pumping on energy use was examined.[8]

It should be noted that these equations do not constitute a model designed to forecast demand; such a model would require much information on the number and types of appliances which customers have, information which we deliberately did not request in order to make determinations about the relationship of use to family size, dwelling characteristics, and income. Rather, it is a model to describe the relationship of household characteristics to demand.

IV. PG&E Electric Use

A. Simple Analysis of Income, Square Feet, and Household Size

We first ran some equations without the interaction of the variables (household, income, and square footage), to show the impact of each variable, without controlling for the others. (Figures 1-3 provide the information for PG&E's basic customers, corresponding Figures 1A to 3A provide the same information for all-electric customers.) Of these variable types, square footage is the variable with the most explanatory power, but it is correlated to a fairly large extent with income and to a lesser extent with household size.

[8] The water pumping issue was examined because of a rate design policy issue related to water pumping raised at the CPUC by the Regional Council of Rural Counties (RCRC). (House, 2002)

In our analysis of PG&E, it was found that in a few zones (Q and Z for both basic and all-electric, V and W all-electric, and Y basic) there were not enough data points to obtain reasonable results. Zones Q, Y, and Z also have either very few or no gas customers. The small sample also renders a regression analysis for Zone P gas unreliable.

Figure 4 shows an analysis for Zone S (Sacramento Valley) basic customers controlling for family size and income but not for housing characteristics. Lower-middle income households, with incomes slightly above the limits for the rate subsidies provided by the California Alternate Rates for Energy (CARE) program, (represented by the dark line on Figure 4) use substantially more electricity as family size increases, although, as discussed later, part of that increase relates to housing characteristics.

Figure 1

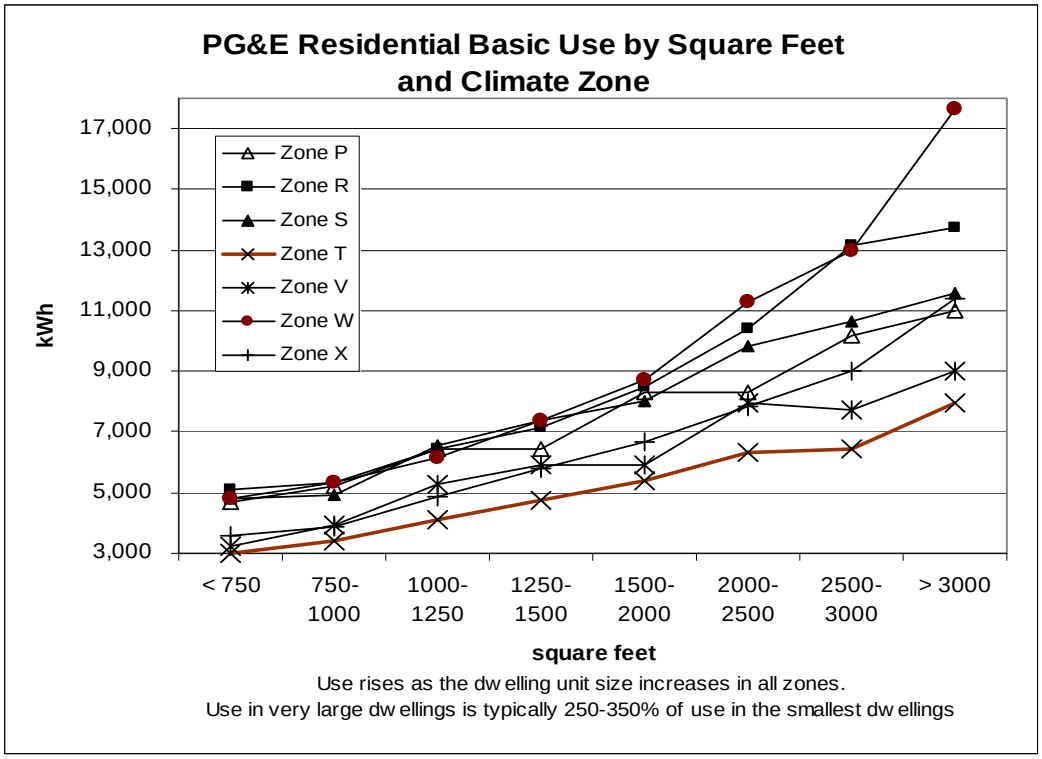


Figure 1A

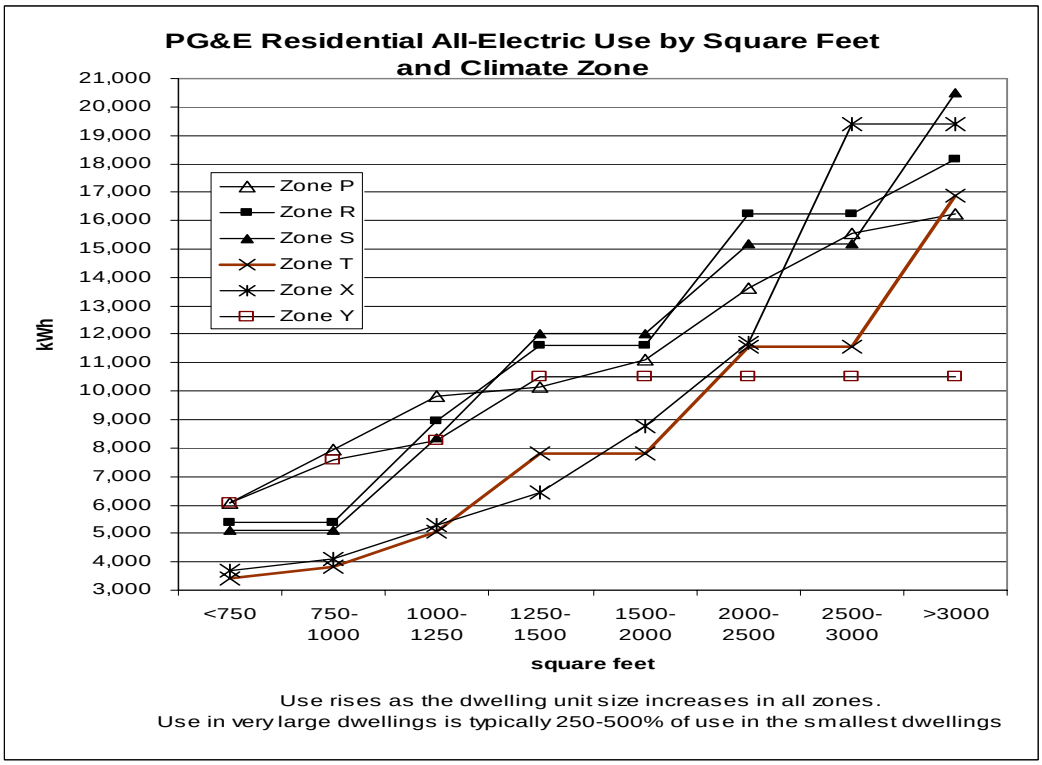


Figure 2

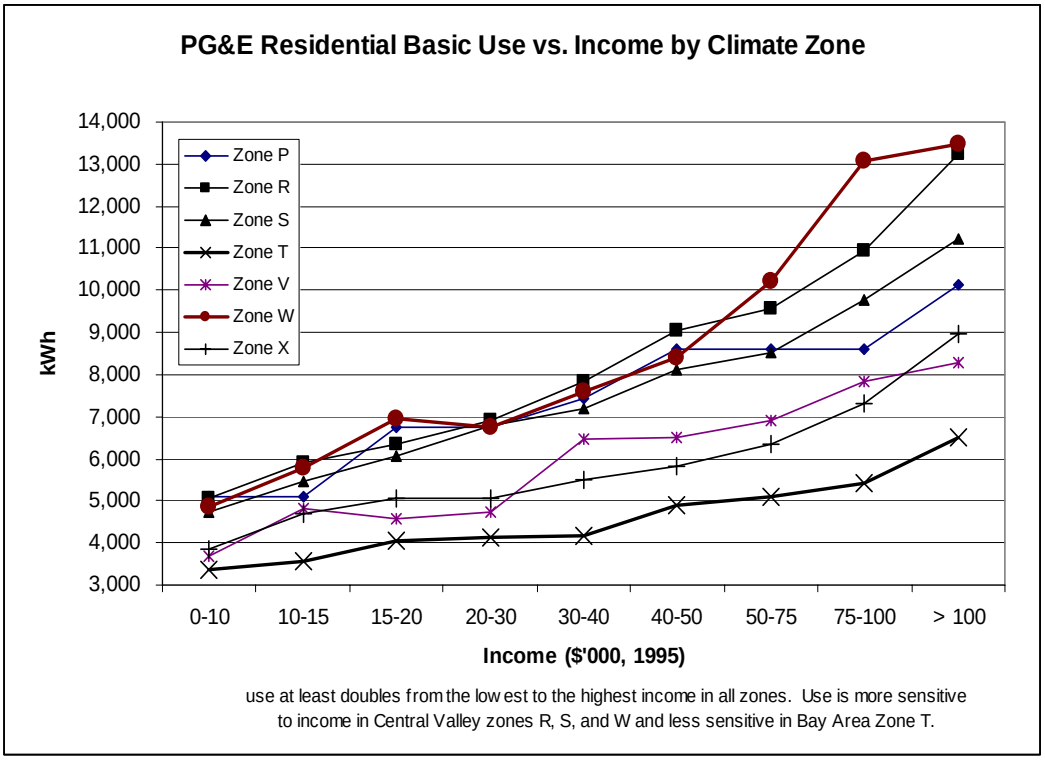


Figure 2A

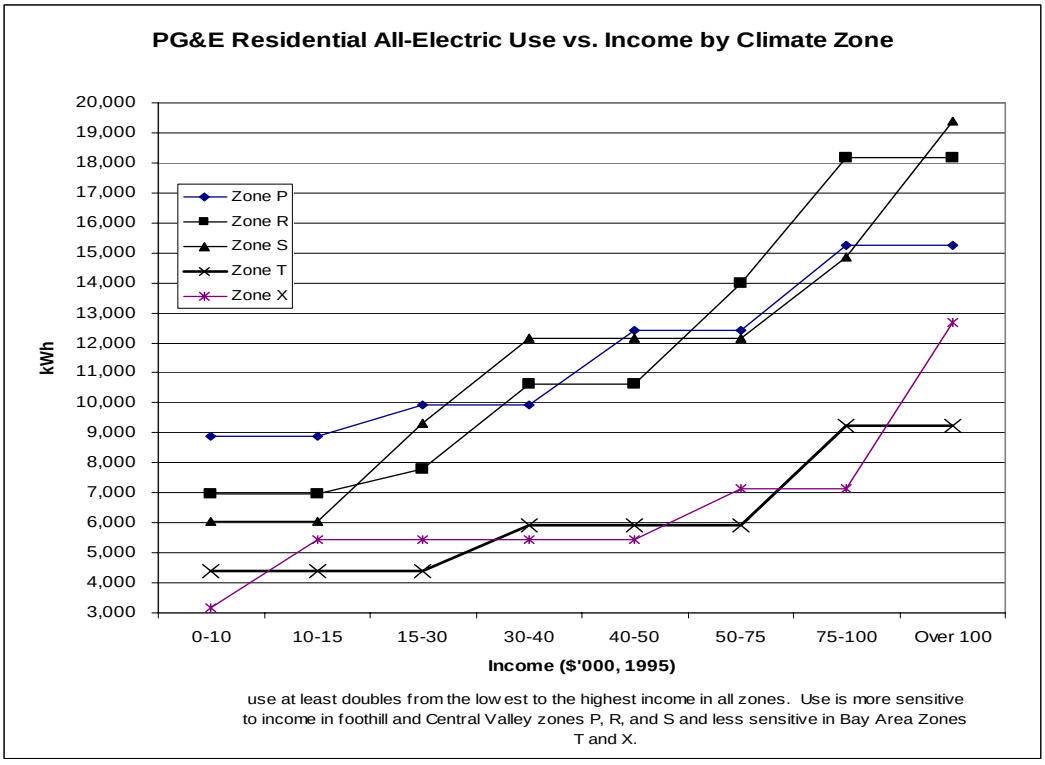


Figure 3

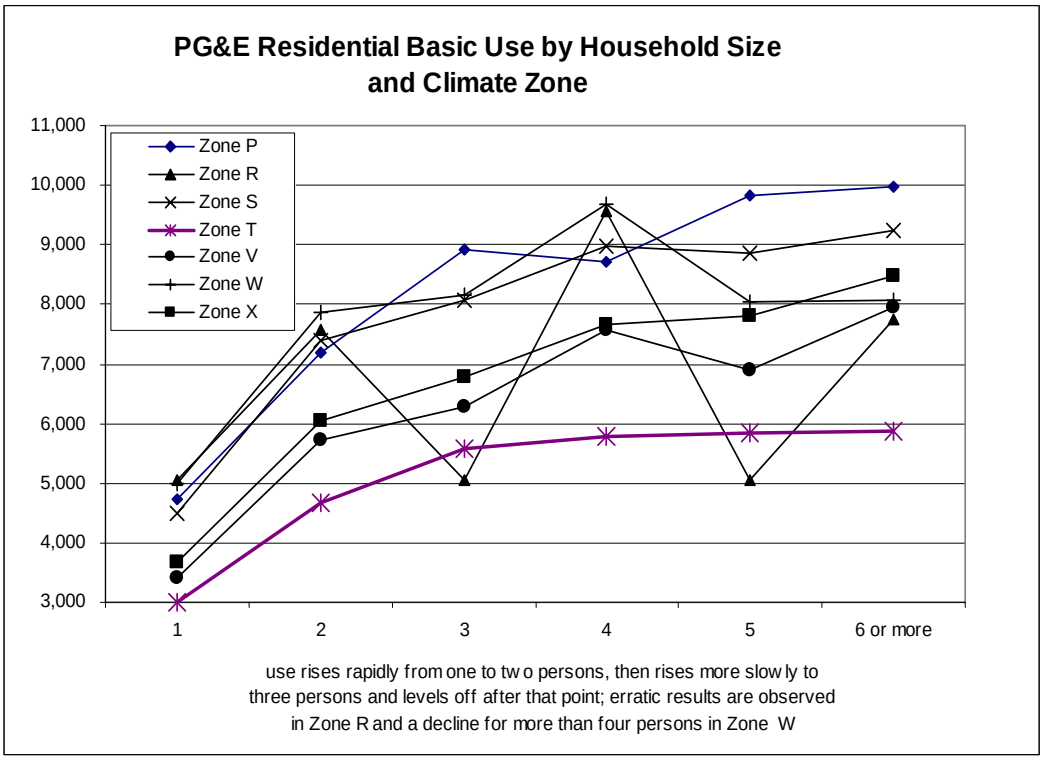


Figure 3A

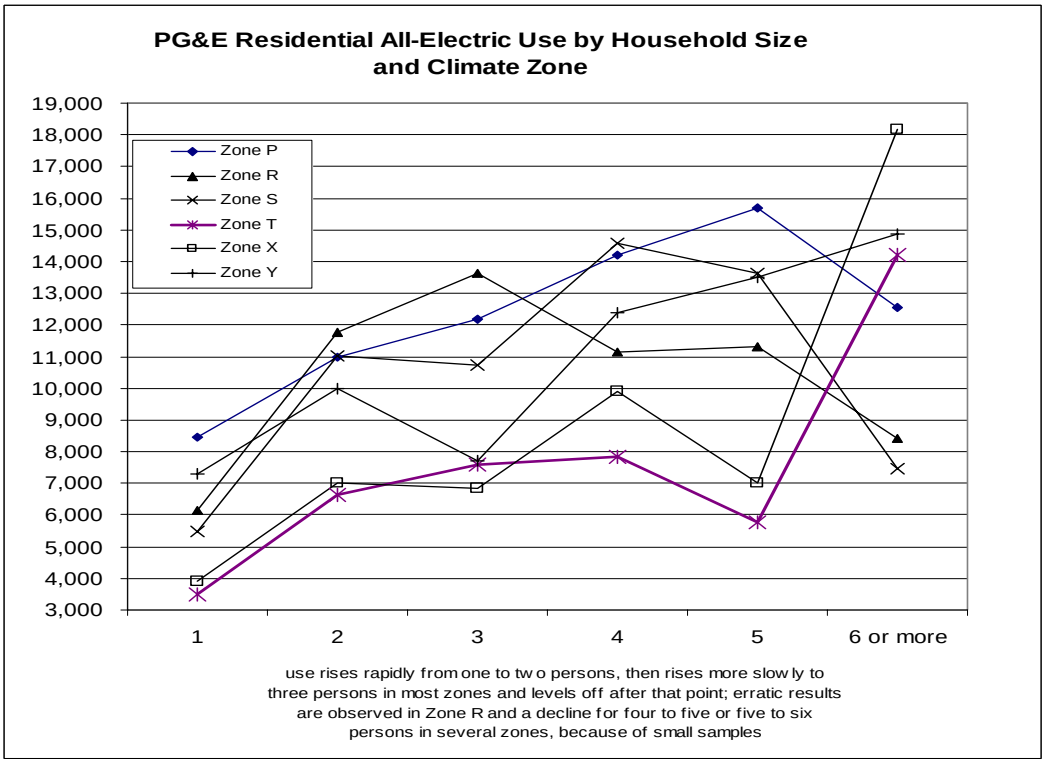
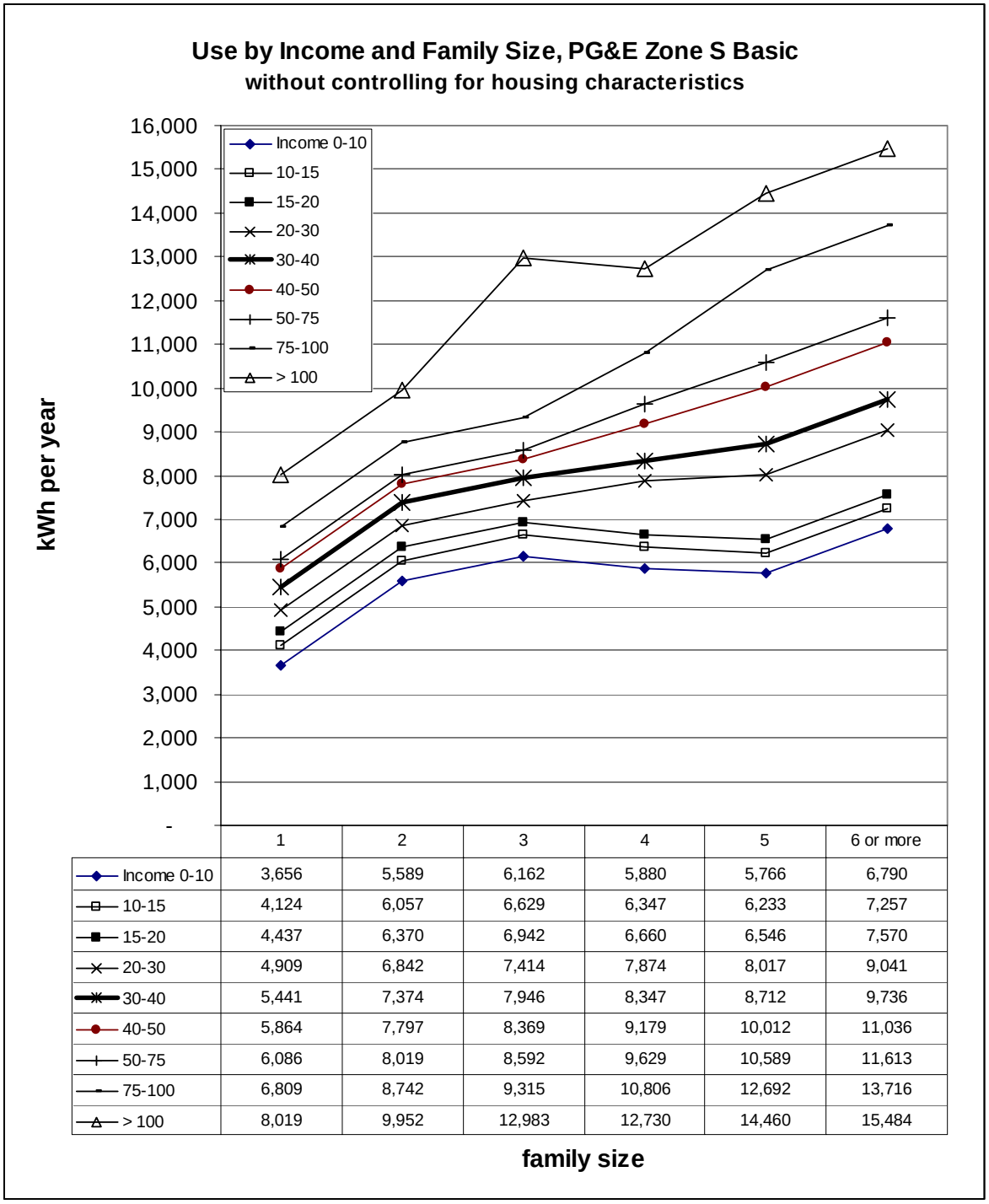


Figure 4



	1	2	3	4	5	6 or more
Income 0-10	3,656	5,589	6,162	5,880	5,766	6,790
10-15	4,124	6,057	6,629	6,347	6,233	7,257
15-20	4,437	6,370	6,942	6,660	6,546	7,570
20-30	4,909	6,842	7,414	7,874	8,017	9,041
30-40	5,441	7,374	7,946	8,347	8,712	9,736
40-50	5,864	7,797	8,369	9,179	10,012	11,036
50-75	6,086	8,019	8,592	9,629	10,589	11,613
75-100	6,809	8,742	9,315	10,806	12,692	13,716
> 100	8,019	9,952	12,983	12,730	14,460	15,484

B. Housing Stock Characteristics and Relationship to Income

PG&E's housing stock varies greatly by climate zone. Zone T (Bay Area and southern coast) has more housing of less than 1000 square feet and less in the range between 1500-2500 square feet than other climate zones. Zone T also has less single-family housing (58%) compared to other regions, which are with one exception (Zone X – Bay Area Hills) above 80% single-family. (Table 1)

Table 1: Percentage of Housing by Square Footage and Single-Family by Baseline Zone

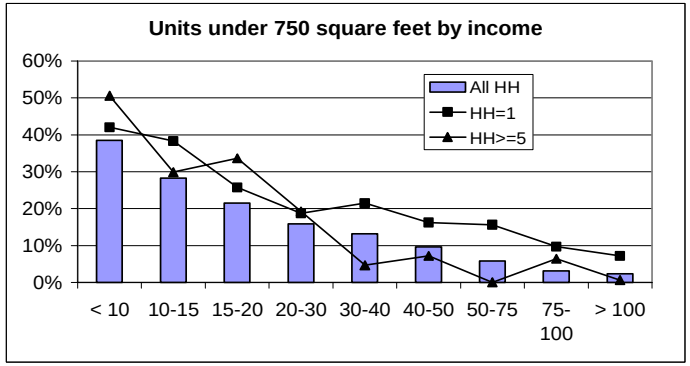
	<750	750-1000	1000-1500	1500-2000	2000-2500	>2500	single family
Zone P - Northern Foothills	7%	13%	33%	27%	12%	8%	94%
Zone Q - Santa Clara	7%	0%	7%	37%	23%	26%	100%
Zone R - Northern and Southern Valley	10%	16%	32%	26%	9%	6%	80%
Zone S - Sacramento Valley	8%	17%	34%	25%	10%	6%	81%
Zone T - Bay Area, Southern Coast	14%	22%	30%	18%	9%	7%	58%
Zone V - Northern Coast	7%	18%	36%	23%	9%	7%	86%
Zone W - Bakersfield Valley	11%	17%	37%	23%	7%	5%	81%
Zone X - Inland Valley	9%	16%	30%	23%	12%	9%	70%
Zone Y - Mountain under 4500'	6%	16%	27%	27%	16%	8%	100%
Zone Z - Mountain over 4500'	0%	5%	19%	29%	19%	27%	88%

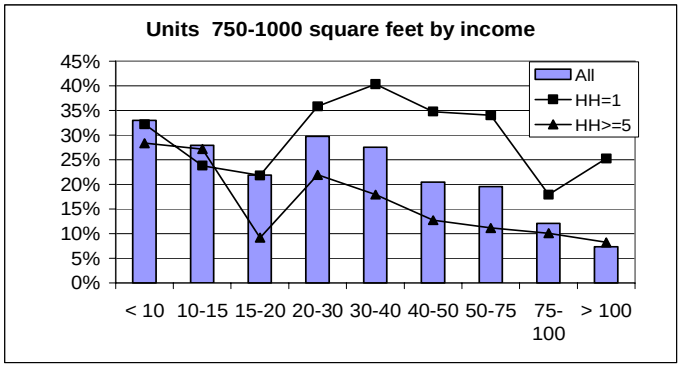
A graphic example from Climate Zone T (Bay Area) showing the relationship of square footage, income, and household size and type is shown on Figure 5. The graphs show percentage of houses in a given size range occupied by a household in a given income range. The bar graph depicts all households, with separate line graphs for households of one person and of five or more people. Figure 6 shows similar information regarding single-family homes.

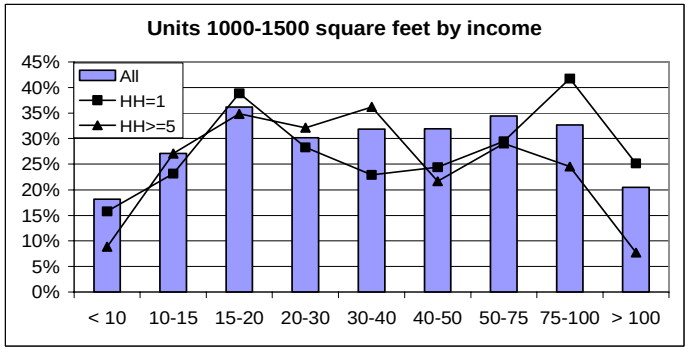
In all incomes except the lowest, one-person households have less square footage than larger households. In the very low-income range, larger households are actually slightly more likely to live in smaller dwelling units (we suspect, because the cost of other necessities leaves them less to spend on housing). The largest dwellings are (obviously) occupied by the largest households in high-income groups. With the exception of low-income one-person households (most likely seniors), the percentage of single-family homes increases with income.

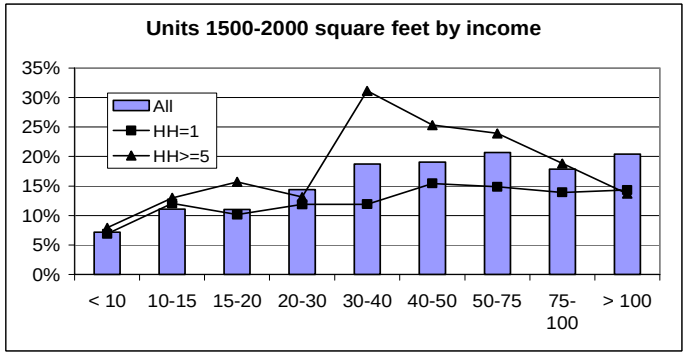
Figure 5: Relationship of Square Footage to Income and Household Size: Zone T

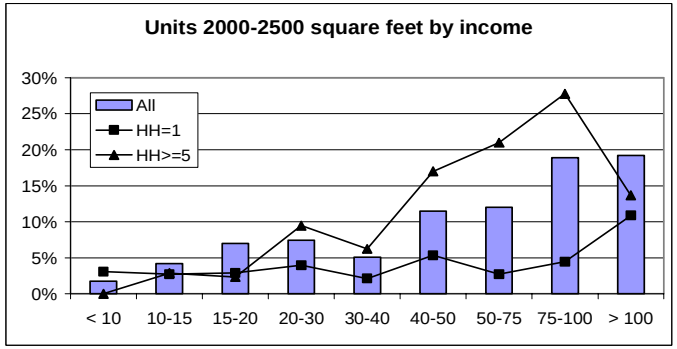
Note: All Charts have X axis of income ($'000, 1995) and Y Axis equal to percentage of households in the given income level in a housing unit of this type.











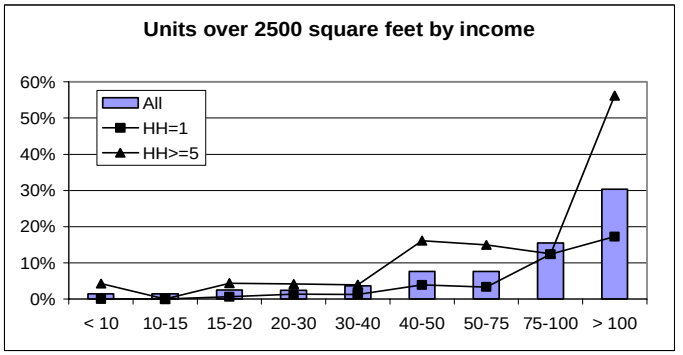
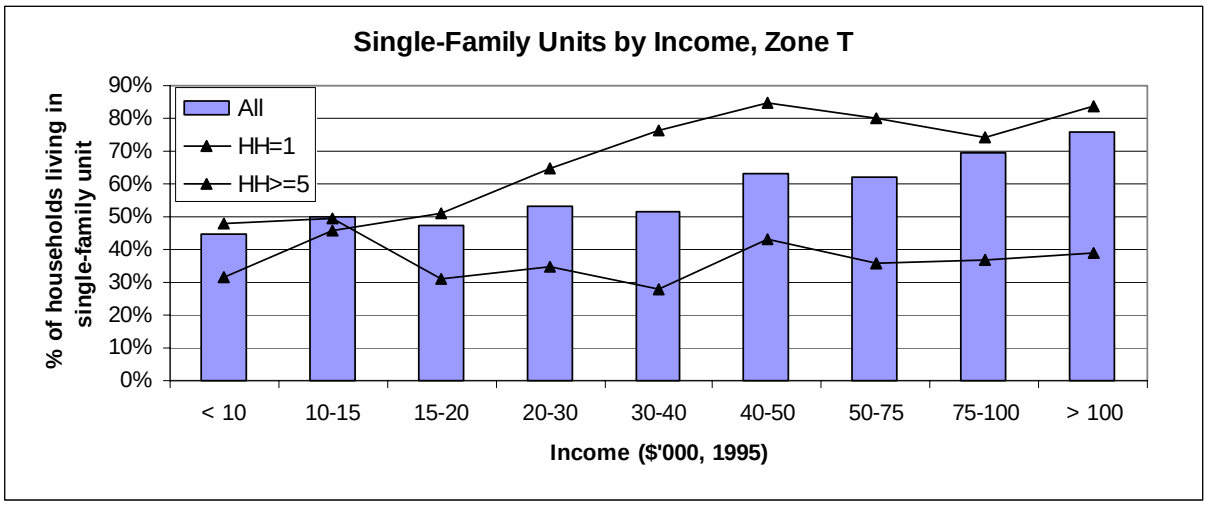


Figure 6: Relationship of Single-Family Units and Income, Zone T



Similar patterns arise in other areas. Thus, it is important to separate impacts of household size from impacts of square footage.

C. Explanation of Results Using Full Equations for Two Zones

We present the results using two equations for basic use in two sample regions, coastal Zone T and Zone S, a Sacramento Valley inland zone. Similar equations were prepared for all PG&E zones except zones Q and Z for both basic and all-electric, V and W all-electric, and Y basic, where there were not enough data points to obtain reasonable results.

1. Zone T "Basic" Example

The following equation shows the results for Climate Zone T (Coastal Bay Area) Basic use. The dependent variable is kWh used in the year 1995. The equation has an adjusted R-squared of 0.315, meaning that it explains 31.5% of the variation in the data.

Table 2: Equation for Average kWh Use by Household Size and Characteristics: Zone T Basic

	Coefficient	t-statistic
(Constant)	3,888	21.81
Over 65 Year Old in Household	340	3.56
No One Works at Home	(496)	(4.27)
Household Size = 2	883	8.08
Household Size = 3	1,730	12.47
Household Size = 4	1,927	12.81
Household Size = 5 or more	2,259	14.82
Square feet <750	(1,542)	(9.50)
Square feet 750-1000	(1,267)	(9.23)
Square feet 1000-1250	(1,016)	(7.72)
Square feet 1250-1500	(572)	(3.98)
Sq Ft 2000-2500	565	3.58
Sq Ft 2500-3000	513	2.27
Sq Ft over 3000	1,923	8.27
Income 0-29999	(243)	(2.27)
Income 50000-99999	279	2.51
Income 100000 or More	873	5.45
Single Family Dwelling Unit	693	8.95

The equation produces expected results. Use increases with household size, with increases in square footage, and with increases in income. Use is also higher for single-family units (at least in part because of higher space conditioning requirements for the same square footage for units that are not attached to other units) and modestly higher for units with a senior present or where someone works at home.

To interpret the equation, the constant term represents a particular household type (in this case a one-person household with no seniors, someone one working at home, with income of $30,000 to $50,000, living in a relatively large apartment (1500-2000 square feet). [9] The average use of a person in this household type is 3,888 kWh per year. While this particular "type" of household may be relatively rare, it is easy to compute any other type of household for which information is

[9] An equation using this type of dummy variables has a fixed point or constant term. The fixed point or constant term is not necessarily chosen as an average, but is simply the point where all other variables have a value of zero. The results for all of the individual data points and the percentage of variation in the data explained by the equation are not affected by the choice of the fixed point.

desired by simply adding coefficients to obtain different kinds of households. For example, three households of the same size but with very different incomes and housing types have widely different energy use:

- A low-income household of four, earning less than $20,000 per year in 1995 and living in a 900 square foot apartment could be expected to use an average of 3,807 kWh.[10]
- A lower-middle income household of four, earning between $30,000 and $40,000 in an 1100 square foot apartment could be expected to use an average of 4,303 kWh.[11]
- A household of four earning over $100,000 in 1995 and living in a 2600 square foot single-family house would use an average of 7,398 kWh.[12]

In other words, the average use of high-income household of four is almost twice as much as the average use of a low-income household of the same size.

The table below shows the variation in use by income, dwelling characteristics, and housing size for Zone T.

Table 3: Variation Between Largest and Smallest User Types: Zone T Basic

	Zone T	
	kWh	%
low income, smallest apartment, 1 person	1,608	
high income, largest house, 6 or more people	9,139	
largest as % of smallest	569%	
difference	7,532	
of which:		
housing characteristics	4,157	55%
income	1,116	15%
family size	2,259	30%

[10] Calculated as 3888 + 1927 (for household size equals 4) – 1267 (for square footage between 750 and 1000 square feet) – 243 (for income less than $30,000) – 496 (for no one working at home).

[11] Calculated as 3888 + 1927 (for household size equals 4) – 1016 (for square footage between 1000 and 1250 square feet)– 496 (for no one working at home).

[12] Calculated as 3888 + 1927 (for household size equals 4) + 513 (for square footage between 2500 and 3000) + 693 (for a single-family home) + 873 (for income over $100,000) - 496 (for no one working at home).

A household in the largest single-family home with six or more people will, on average, use six times as much electricity as a household with the lowest income in the smallest apartment. About 55% of the difference is caused by housing characteristics, 15% by income and 30% by family size.

The table below shows the average annual usage by household size, and income, for representative housing types for Climate Zone T, basic use. The figures were developed from the equation on the previous page. Figures are referenced to the baseline quantity because the five-tiered rate structure is keyed off that quantity. Rates for use up to 130% of baseline are 1 cent / kWh higher than before the energy crisis, but major surcharges (about 5.1 cents / kWh) begin to be applied at 130% of baseline. (California PUC, 2001)

Table 4: Average Annual Use by Income, Square Footage, Household Size, and Housing Type: Zone T Basic

Income	<20	20-30	30-50	50-75	75-100	>100	>100
sq. ft.	<750	750-1000	1000-1250	1250-1500	1500-2000	2000-2500	>3000
type of unit	MF	MF	MF	SF	SF	SF	SF
household size							
1	*1,608*	*1,883*	*2,623*	3,792	4,364	**5,523**	***6,881***
2	*2,490*	*2,765*	3,506	**4,675**	**5,247**	**6,406**	***7,764***
3	*3,338*	3,613	4,354	**5,523**	**6,094**	***7,253***	***8,611***
4	3,534	3,809	**4,550**	**5,719**	**6,291**	***7,450***	***8,807***
5 or more	3,866	4,141	**4,882**	**6,051**	**6,623**	***7,782***	***9,139***

italics -- annual use under baseline
bold -- annual use over 130% of baseline
bold italic -- annual use over 200% of baseline

This exemplary analysis shows that large families with moderate incomes ($30,000 to $50,000) have the potential of being surcharged, but the surcharges are relatively modest on an annual basis.

A similar equation produced for the month of July is also given below. Average use generates moderate surcharges for larger middle-income households. Only households in large houses with more than $100,000 income on average enter the

fourth tier, but families of three or more with incomes of $30,000-40,000 in apartments of 1000-1250 square feet will, on average exceed 130% of baseline.

Table 4A: Average July Use by Income, Square Footage, Household Size, and Housing Type: Zone T Basic

Income	<20	20-30	30-50	50-75	75-100	>100	>100
sq. ft.	<750	750-1000	1000-1250	1250-1500	1500-2000	2000-2500	>3000
type of unit	MF	MF	MF	SF	SF	SF	SF
household size							
1	*121*	*182*	*213*	*247*	309	**353**	***481***
2	*214*	274	305	340	**401**	**446**	***574***
3	283	**344**	**375**	**409**	**471**	**515**	***643***
4	283	**344**	**374**	**409**	**471**	***673***	***801***
5	315	**376**	**406**	**441**	**503**	***705***	***833***
6 or more	331	**392**	**423**	**457**	**519**	***721***	***849***

2. Zone S Basic Example

The equation for the Sacramento Valley Zone S follows. Its adjusted R-squared is 0.329.

Table 5: Equation for Zone S "Basic"

	coefficient	t-statistic
(Constant)	5,877	20.39
Over 65 Year Old in Household	301	2.25
No One Works at Home	(835)	(4.77)
Household Size = 2	1,759	10.97
Household Size = 3	2,495	12.59
Household Size = 4	3,038	14.37
Household Size = 5	3,441	13.44
Household Size = 6 or more	4,285	14.41
Square feet <750	(1,782)	(7.71)
Square feet 750-1000	(1,587)	(8.21)
Square feet 1000-1250	(748)	(4.46)
Square feet 1250-1500	(392)	(2.31)
Sq Ft 2000-2500 (group 7)	1,109	5.83
Sq Ft 2500-3000 (group 8)	1,583	5.66
Sq Ft over 3000 (group 9)	2,346	6.81
Single Family	524	4.60
Income 0-14999	(816)	(3.97)
Income 15000-29999	(333)	(1.75)
Income 40000-74999	389	2.22
Income 75000 or more	1,268	5.65
Income <20000 and hh size 4 or more	(1,221)	(4.50)
Income >100000 and hh size 4 or more	1,917	4.53

This zone shows much higher usage than Zone T (because the climate requires considerable amounts of air conditioning). It also shows larger impacts of square footage than Zone T, again because of the greater need for space conditioning.

Of note in the estimates for this climate zone are the interactive variables for large households with low and high incomes. Usage is 1221 kWh less than otherwise expected (by including only income and household variables) for a low-income household of four or more. Conversely, usage is 1917 kWh more for a household of four or more with an income over $100,000.

The differences among the three illustrative families of four are much larger. The low-income family in the small apartment is projected to use, on average, 4757 kWh. The lower-middle income family (assumed to be in an 1100 square foot single-family home instead of an apartment here, since there are relatively few apartments in this area) is expected to use 7,856 kWh, 65% more than the lower income family. The upper income family is expected to use 12,848 kWh, 64% more than the lower-middle income family.

Table 6 compares usage for a low-income person living in a small apartment and a large household earning more than $100,000 living in a house over 3000 square feet.

Table 6: Variation Between Largest and Smallest User Types: Zone S Basic

	Zone S	
	kWh	%
low income, smallest apartment, 1 person	2,445	
high income, largest house, 6 or more people	15,382	
largest as % of smallest	629%	
difference	12,937	
of which:		
housing characteristics	4,652	36%
income	4,001	31%
family size	4,285	33%

The large user uses six times as much energy as the small one, with approximately equal percentages of the difference associated with housing type, income, and family size.

Unlike Zone T, the climate and baseline allowances in Zone S (and other hot zones) can result in a significant number of lower-middle-income large families paying surcharges for hundreds of kilowatt-hours per month at average levels of usage. Unlike Zone T, the average family of 3 to 6 earning $30,000 to $40,000 and living in a small house will substantially exceed 130% of the baseline allowance on an annual basis and in the peak month of July. (Tables 7 and 7A)

Table 7: Average Annual Use by Income, Square Footage, Household Size, and Housing Type: Zone S Basic

Income	<20	20-30	30-40	40-50	50-75	75-100	>100
sq. ft.	<750	<1000	1000-1250	1250-1500	1500-2000	2000-2500	2500-3000
type of unit	MF	MF	SF	SF	SF	SF	SF
household size							
1	*2,636*	*3,315*	*5,343*	6,088	6,480	**8,857**	**9,330**
2	*4,396*	*5,074*	**7,102**	**7,848**	**8,239**	***10,616***	***11,090***
3	*5,132*	5,810	**7,838**	**8,584**	**8,975**	***11,352***	***11,826***
4	*4,453*	6,353	**8,380**	**9,126**	**9,517**	***11,894***	***14,285***
5	*4,856*	6,756	**8,784**	**9,529**	**9,921**	***12,298***	***14,688***
6	5,700	**7,600**	**9,627**	**10,373**	***10,765***	***13,141***	***15,532***

Table 7A: Average July Use by Income, Square Footage, Household Size, and Housing Type: Zone S Basic

Income	<20	20-30	30-50	50-75	75-100	>100	>100
sq. ft.	<750	750-1000	1000-1250	1250-1500	1500-2000	2000-2500	>3000
type of unit	MF	MF	SF	SF	SF	SF	SF
household size							
1	*242*	*392*	570	**644**	**788**	**918**	***1,013***
2	*438*	588	**766**	**840**	***984***	***1,114***	***1,209***
3	495	**645**	**823**	**897**	***1,041***	***1,172***	***1,266***
4	514	**664**	**842**	**916**	***1,060***	***1,348***	***1,443***
5	553	**703**	**881**	**954**	***1,099***	***1,387***	***1,482***
6 or more	584	**734**	**912**	***986***	***1,130***	***1,419***	***1,513***

italics = less than baseline
normal = 100-130% of baseline
bold = 130-200% of baseline
bold italics small = 200-300% of baseline
bold italics large >300% of baseline

D. System-Wide Analysis of Results

After looking at these two climate zones in detail, the entire PG&E system was analyzed by preparing the same type of equations as for Zones S and T. To analyze the results, we focused on the impact of the tier structure on lower-income households earning more than the CARE limits. The increases in usage resulting from large dwellings and high incomes were not analyzed in detail, although the form of the equations filtered them out of this analysis. We therefore started with a "representative" household type – a two-person household in a dwelling of 1200 square feet (apartment in the more urban Bay Area Zones X and T, single-family in other zones) with a 1995 income between $30,000 and $40,000, with no seniors and with no one working at home. This household type on average uses approximately 120-130% of the current baseline quantity zones P, R, and S, uses 150% of baseline in Zone V Basic,[13] and uses approximately the baseline quantity in the Bay Area coastal and hill zones (T and X) as well as Zone W. We then looked at the impact on usage of adding more people to the household (without changing the income, square footage, or housing type) and of adding someone over 65 to the household. The increases in use resulting from changes in family size only for relatively low-income people in relatively modest housing units are the impacts of the surcharge for which mitigation should be considered.

Table 8 shows the results for basic customers. The chart states the increases as a percentage of the baseline allowance, so that the impact of the surcharge (130% of baseline) can be considered.

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[13] In most zones, the representative household would likely use more than the baseline quantity in warmer and colder months and less in other months.

Table 8: Baseline Quantity, Representative Customer Use, and Impact of Increasing Household Size or Adding a Senior Citizen without Changing Income or Square Footage PG&E Basic Energy Use

	Annual	Base Case		Increase family from 2 to 6		Add Senior	
Baseline Territory	Basic	kWh	% of baseline	kWh	% of baseline	kWh	% of baseline
P	5,233	6,894	132%	2,144	41%	-	0%
Q	3,931						
R	5,504	6,679	121%	1,464	27%	646	12%
S	5,215	6,578	126%	2,525	48%	301	6%
T	3,415	3,258	95%	1,376	40%	340	10%
V	3,488	5,710	164%	1,248	36%	-	0%
W	5,574	5,571	100%	1,148	21%	-	0%
X	4,600	4,231	92%	1,858	40%	199	4%
Y	4,328						
Z	3,382						

The table shows that increasing household size causes use to increase by 21 to 48% of the baseline quantity on average. The largest increases in both total number and percentage terms are in zones P and S, where the representative customer uses more than baseline to begin with. Adding a senior citizen has a smaller impact in several climate zones. Regressions could not be run for Zones Q, Y, and Z.

Table 8A provides a similar table to Table 8 for the month of July. It shows that for nearly all climate zones the reference household uses more than 130% of baseline. Increases in family size added an amount equal to 16 to 45% of baseline in all zones except Zone W (where impacts of family size except for the difference between one person and more than one person were not statistically significant). If one person was over 65, use increased by 19 to 28% in Central Valley locations.

Table 8A: Baseline Quantity, Representative Customer Use, and Impact of Increasing Household Size or Adding a Senior Citizen without Changing Income or Square Footage PG&E Basic Energy Use, Month of July

	July	Base Case		Increase family from 2 to 6		Add Senior	
Baseline Territory	Basic	kWh	% of baseline	kWh	% of baseline	kWh	% of baseline
P	490	680	139%	79	16%	92	19%
Q	264						
R	543	842	155%	178	33%	150	28%
S	490	766	156%	146	30%	77	16%
T	264	305	116%	118	45%	38	14%
V	270	493	183%	87	32%	-	0%
W	580	1,050	181%	-	0%	103	18%
X	378	397	105%	142	38%	19	5%
Y	335						
Z	226						

Table 9 shows the same system-wide analysis for all-electric customers.

Table 9: Baseline Quantity, Representative Customer Use, and Impact of Increasing Household Size or Adding a Senior Citizen without Changing Income or Square Footage PG&E All-Electric Energy Use

	Annual	Base Household		Increase from 2 to 6		Add Senior	
Baseline Territory	All-Electric		% of baseline	kWh	% of baseline	kWh	% of baseline
P	9,252	9,739	105%	2,180	24%	-	0%
Q	5,912						
R	9,465	7,657	81%	1,613	17%	2,256	24%
S	9,270	7,955	86%	1,787	19%	1,785	19%
T	5,397	5,512	102%	1,218	23%	-	0%
V	7,259						
W	9,681						
X	6,093	5,328	87%	2,275	37%	-	0%
Y	8,347	8,514	102%	4,079	49%		
Z	7,878						

In the all-electric cases, the impact of adding people to a household was similar in absolute terms and less in dollar terms than in the basic case. Because much of the energy in an all-electric zone is used for space heating, the square footage variables tend to be much larger in magnitude than in the same climate zones for basic use, while the variables relating to household size do not change greatly in magnitude. The only exception is Zone Y, but the small size of the sample (only 120 observations) means that the results for this zone may not be as valid as other samples with more observations.

In two central valley climate zones (R and S), the impact of adding someone over 65 to a household is larger than for the other zones and is large relative to the baseline allowances. There is a smaller senior impact on January use in Zone T. This is similar to the finding that we discuss below for gas. We re-analyzed these zones for the month of January (peak heating month) to determine if there are significant impacts on households with seniors. (Table 9A)

Table 9A: Baseline Quantity, Representative Customer Use, and Impact of a Senior Citizen without Changing Income or Square Footage
PG&E All-Electric Energy Use, Month of January

	January	Base Case		Add Senior	
Baseline Territory	Baseline Allowance	kWh	% of baseline	kWh	% of baseline
R	921	1,318	143%	273	30%
S	967	1,051	109%	204	21%
T	592	622	105%	131	22%

E. Vacation Homes

Approximately 1.7% of residences in PG&E's service area are vacation homes, but they are concentrated in three areas, a resort area near Clear Lake (5.1%) (7,000 units) and the two climate zones in the Sierra Nevada with 20% and 53% respectively (total 15,000 units). Table 10 shows their location.

Table 10: PG&E Vacation Homes by Climate Zone

Zone P	Clear Lake & foothills	5.1%
Zone Q	Santa Clara	0.0%
Zone R	Central Valley	1.1%
Zone S	Central Valley	1.4%
Zone T	Bay Area/ South Coast	2.1%
Zone V	North Coast	1.1%
Zone W	Central Valley	0.6%
Zone X	Coast Range Hills	0.7%
Zone Y	Sierras 1500-4500'	19.5%
Zone Z	Sierras over 4500'	53.7%

On average, vacation homes use 50-70% less energy than dwellings occupied by permanent residents. (Table 11)

Table 11: Use of Permanent Residents and Vacation Homes, Three PG&E Climate Zones

	Permanent	Vacation Home	Difference
Basic			
Zone P	7,245	2,987	-59%
Zone Y	6,428	1,835	-71%
Zone Z	4,899	2,520	-49%
All-Electric			
Zone P	11,183	3,809	-66%
Zone Y	9,659	3,458	-64%
Zone Z	sample size too small (18)		

Customers in vacation homes also tended to have higher incomes. (Table 12)

Table 12: Percent with Income Over $75,000 by Residency Status

	Permanent	Vacation Home
Zone P	10%	25%
Zone Y	10%	30%
Zone Z	32%	44%[14]

F. Use Under 6000 kWh per Year

Customers using less than 6000 kWh per year are concentrated in the Bay Area and coastal zones (T and X), (Figure 7) and are more likely to live in smaller dwelling units and in apartments than larger users (Figure 8). Figures 9A, 9B, and 9C provide data on the relationship of use under 6000 kWh to income and household size for three climate zones (S, T, and X).

[14] Difference not statistically significant in Zone Z because of small sample size.

Figure 7: Percent of Customers Using Less than 6000 kWh by Baseline Zone

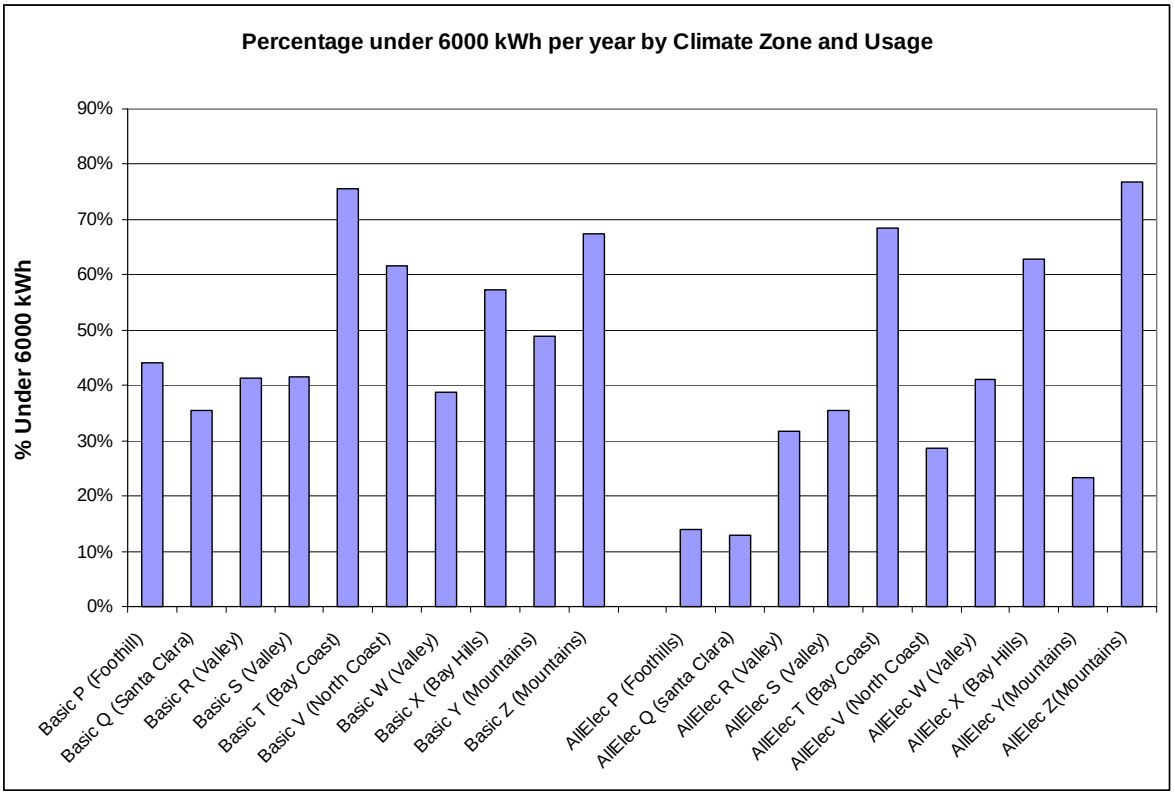


Figure 8: Percent of Customers Using Less than 6000 kWh by Size and Type of Dwelling

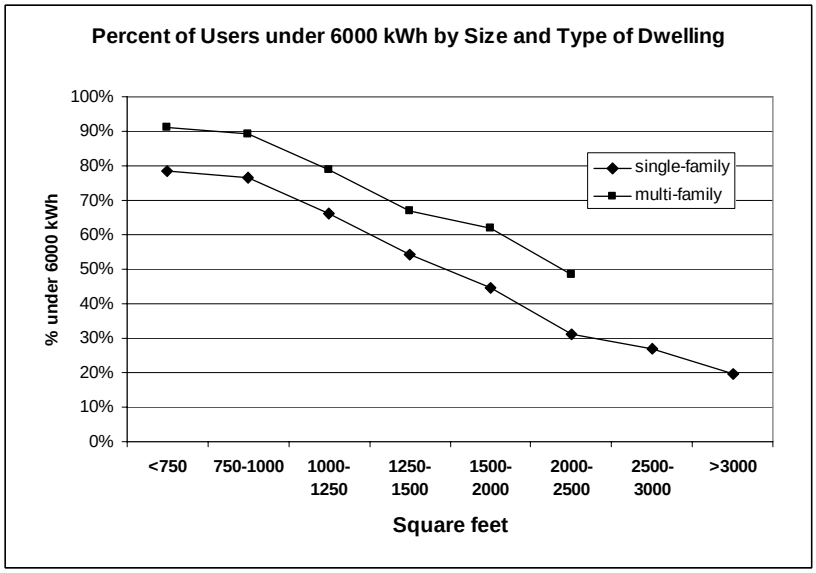


Figure 9A: Percent Under 6000 kWh by income and Household Size, Zone T (Bay and Coast)

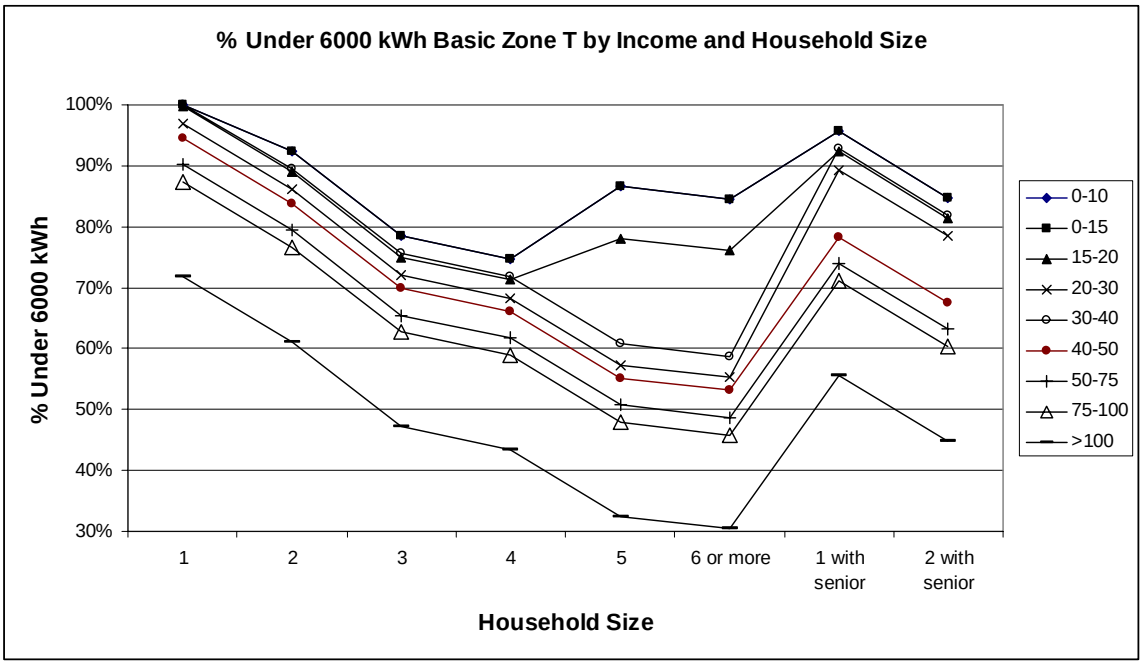


Figure 9B: Percent Under 6000 kWh by income and Household Size, Zone X (Bay Hills)

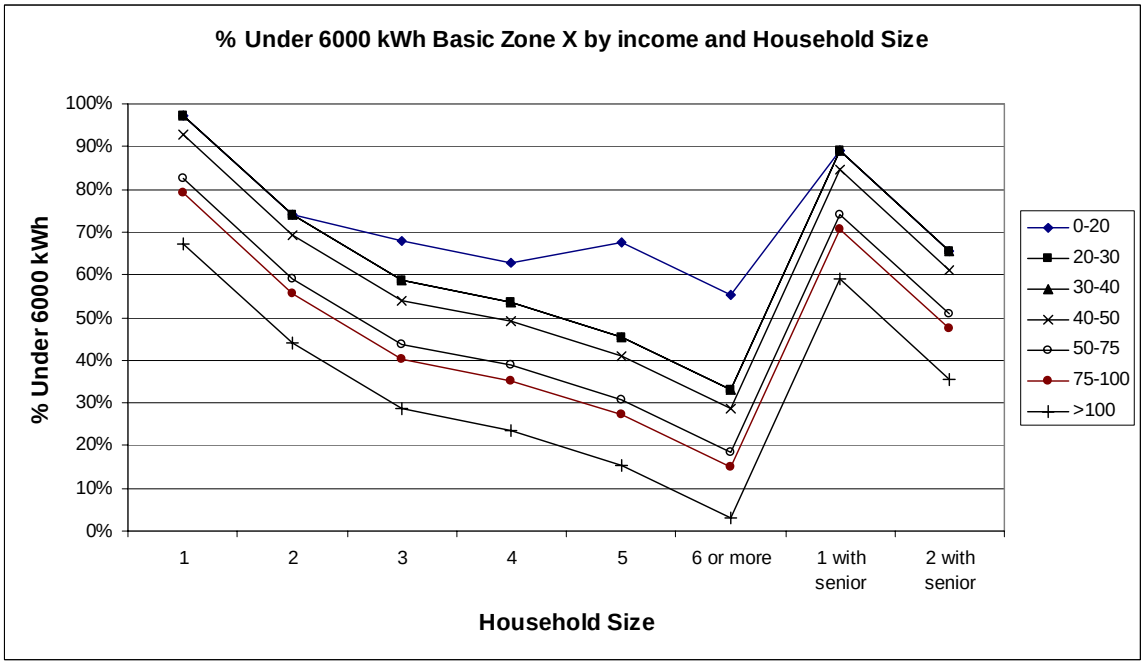
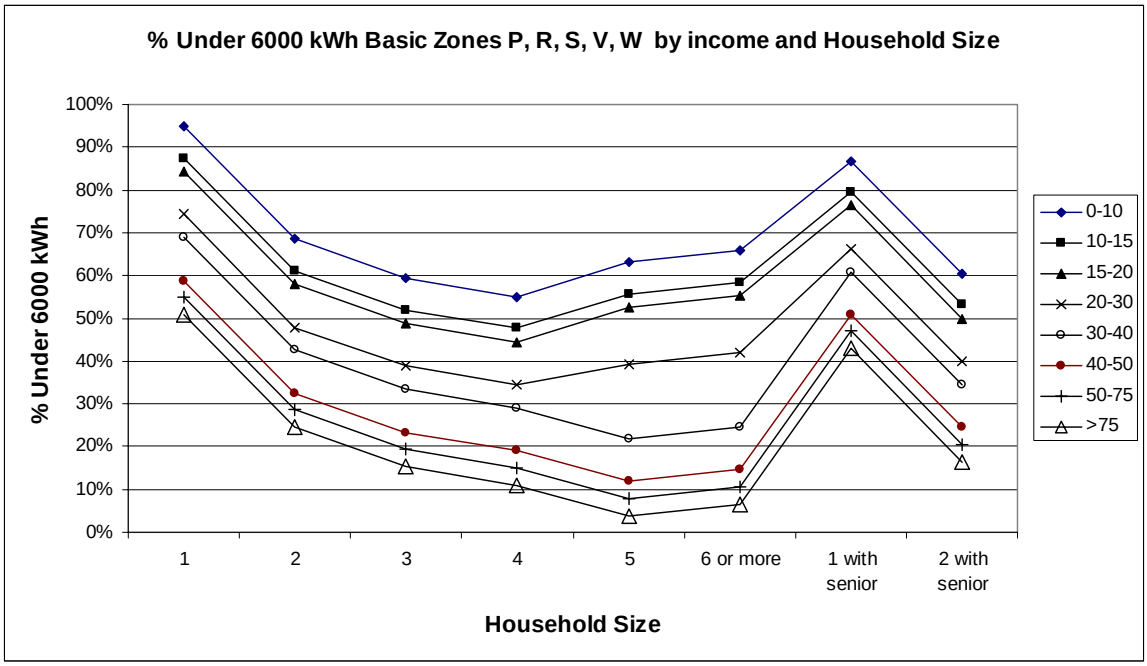


Figure 9C: Percent Under 6000 kWh by income and Household Size, All Other Zones



G. Findings for PG&E Electricity

1. PG&E electrical use is greatly related to housing characteristics and income. For basic customers, the largest household earning over $100,000 and living in the largest house in PG&E's climate Zones S and T uses six times as much electricity as single person earning under $20,000 living in a small apartment. Much of the difference arises because households with higher incomes are more likely to live in larger dwellings and in single-family units than households with lower incomes. There were increases in usage associated with income over $100,000 in many PG&E zones, even after controlling for larger dwelling units and a higher percentage of single-family units.

2. Adding a second person to a household increases use for basic PG&E customers by an average of 125 kWh per month excluding coastal Zone T,

where the increase is 75 kWh. A second person in an all-electric household also increases use by an average of 125 kWh.

3. The difference in use between a household of two and the largest household averaged 140 kWh per year for basic users and 150 kWh for all-electric users across PG&E climate zones (with higher amounts in the Central Valley) and 150 kWh per year for PG&E all-electric zones.

4. Households of three or more people with lower-middle incomes ($30,000 to $40,000 in 1995) and living in moderate sized dwellings[15] on average use more than 130% of baseline on a year-round basis, with even higher use in peak summer months. The cost impact of this usage is larger in PG&E's Central Valley (up to $100 in rate surcharges alone for the average customer) than in the Bay Area, but the phenomenon is prevalent everywhere.

5. Households with at least one member over age 65 tend to use more electricity. The impact on basic users is small, ranging from zero (in three zones) to 15-25 kWh per month (in three zones), to 55 kWh per month in one zone. However, the addition of a senior citizen to an all-electric household in the Central Valley (but not in PG&E's coastal zones) has a greater effect, raising use by about 200 kWh per month. A large portion of this additional use occurs in peak winter months when the customer on average is likely already to use more than 130% of the all-electric baseline quantity.

6. Vacation homes use 50-70% less electricity than other homes. This fact is important in setting baseline allowances in the three climate zones with large numbers of vacation homes, as permanent residents' allowances are

[15] Units of 1000-1250 square feet, apartments in the urban Bay Area zones T and X and single-family in other PG&E climate zones.

reduced because of the low consumption of vacation home customers. (Nahigian, 2002)

H. Timing of Electricity Use Versus Size of Residential Customers

An analysis of the usage patterns of PG&E customers by size using PG&E's load research sample was conducted by TURN in PG&E's last rate design case. (Marcus, 2000a) The results showed that small customers had a smaller percentage of their use than larger customers during the 12 pm-6pm hours in the summer when California loads peak. Smaller customers also had higher load factors measured by coincidence with the system peak.

TURN conducted a regression analysis of the usage pattern of 675 customers included in PG&E's 1997 load research sample. [16] TURN ran two sets of regressions relating summer peak use and coincident peak loads in the residential class, one with regional variables and one without. Both were weighted by PG&E's sample weightings, because PG&E oversamples large customers, all-electric customers, and rate groups E-7 and E-8 in its stratified sample process. (Tables 13 and 13A summarize the regression equations.

Table 13: Regression Equations Relating PG&E Summer On-Peak Use and Coincident Peak Demand to Size of Customer and Residential Rate Subclass, No Regional Variables

Summer On-Peak Period Use (kWh/day) = -0.477 + 0.2304 * Summer Use (kwh / day) - 0.0182 * Summer Use by All-Electric Customers + 0.0441 * Summer Use by E-7 customers + 0.0284 * Summer Use by E-8 Customers

Adjusted R-squared = 0.878, Standard Error = 1.195, all coefficients significant at 1% level.

Summer Coincident Peak = + 0.5649 * Summer Peak Use (kwh / day) - 0.0855 * Summer Peak Use by E-7 Customers – 0.0313 * Summer Mid-Peak and Off-Peak Use

Adjusted R-squared = 0.597, Standard error = 1.337, all coefficients significant at 1% level, constant not significant, deleted

[16] Rate class EM (master metered apartments) was left out of the analysis, because a "customer" is a whole apartment building, not a household.

Table 13A: Regression Equations Relating PG&E Summer On-Peak Use and Coincident Peak Demand to Size of Customer and Residential Rate Subclass, With Regional Variables

Summer On-Peak Period Use (kWh/day) = -0.435 + 0.2234 * Summer Use (kwh / day) - 0.0240 * Summer Use by All-Electric Customers + 0.0416 * Summer Use by E-7 customers + 0.0284 * Summer Use by E-8 Customers + 0.0125 * Summer use by Valley climate zone customers.

Adjusted R-squared = 0.880, Standard Error = 1.188, all coefficients significant at 1% level.

Summer Coincident Peak = 0.5404 * Summer Peak Use (kwh / day) - 0.0651 * Summer Peak Use by E-7 Customers + 0.520 if Customer is in Valley – 0.1515 * Summer Peak use by coastal customers – 0.0318 * Summer Mid-Peak and Off-Peak Use

Adjusted R-squared = 0.616, Standard error = 1.305, all coefficients except E-7 usage significant at 1% level, E-7 usage significant at 5% level, constant not significant, deleted

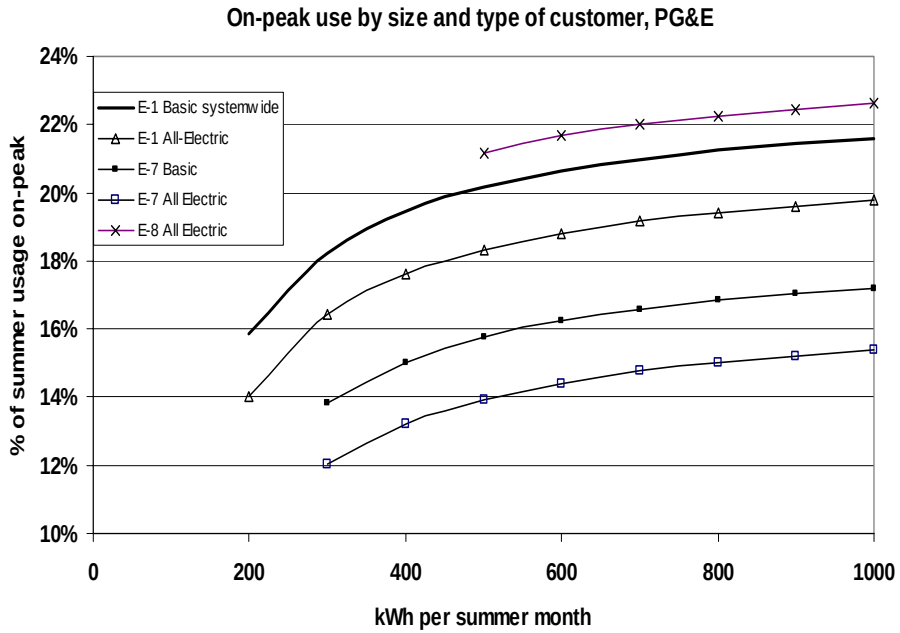
These regression results are shown graphically in the four charts comprising Figures 10-13 on the next page. These figures show that large customers contribute disproportionately to both summer peak energy use and coincident demand.

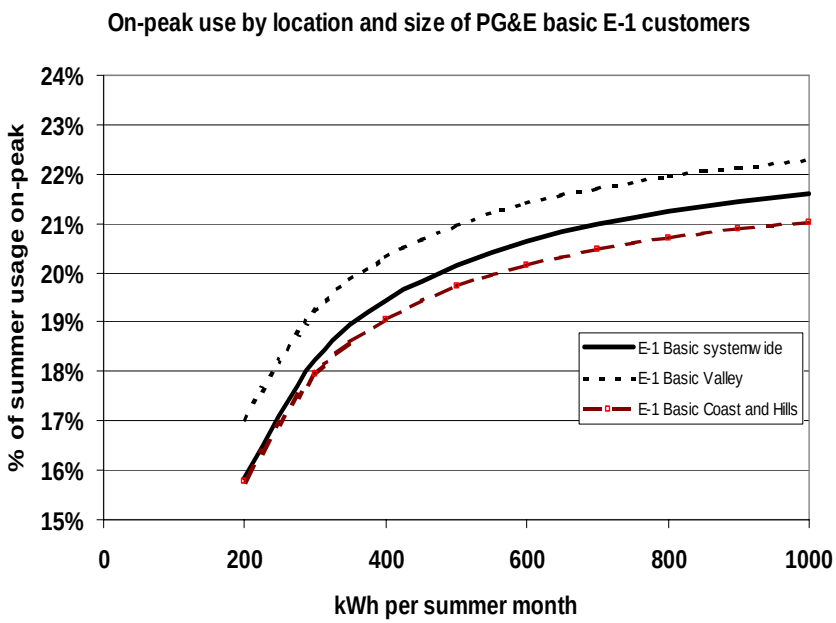
Figures 14 and 15 show similar information based on analysis of the weighted raw data in four different summer usage categories: up to 10 kWh per day (roughly 300 kWh), 10-20 kWh / day, 20-30 kWh / day and over 30 kWh per day.

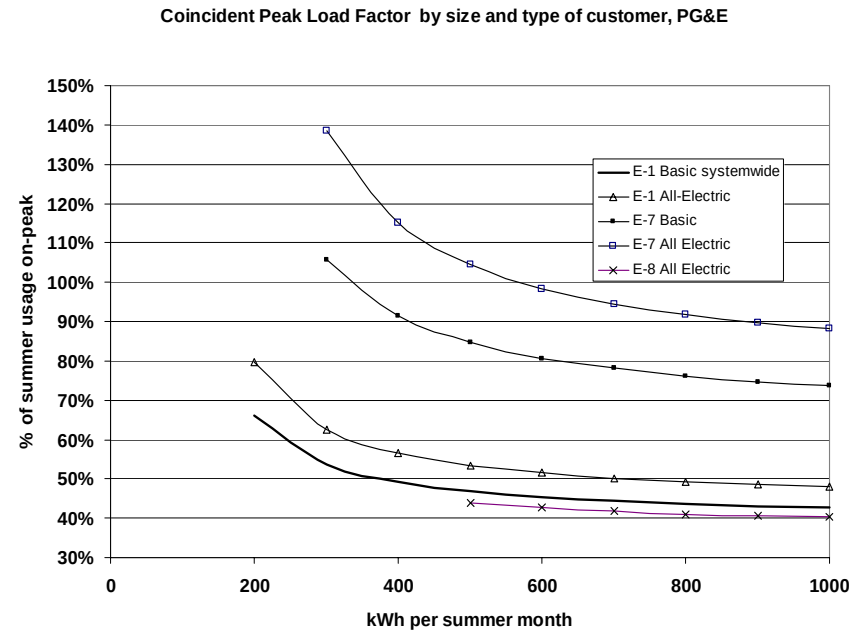
These two figures illustrate several key findings:

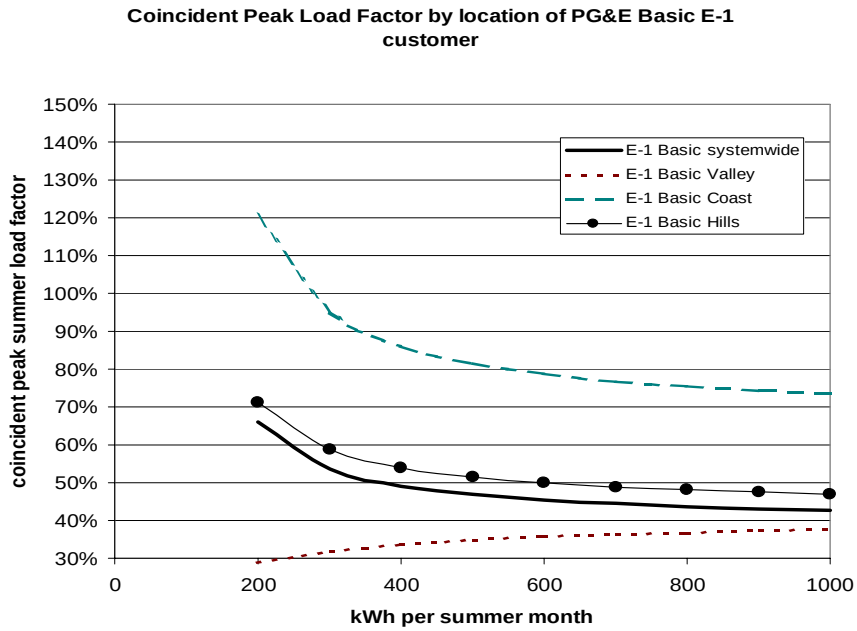
- Rate E-7 (time of use) customers use proportionally less peak demand and on-peak energy than E-1 (standard residential rates) customers of the same size. Large E-7 customers use approximately the same percentage of peak energy as small E-1 customers but have higher load factors.

- Rate E-8 customers (seasonal rates with high customer charges and no time of use provisions) use proportionally more peak demand and on-peak energy than basic E-1 customers of the same size. This is particularly important considering that virtually all E-8 customers are all-electric and should thus be compared with other all-electric customers.


On-peak use by size and type of customer, PG&E
% of summer usage on-peak
kWh per summer month
E-1 Basic systemwide
E-1 All-Electric
E-7 Basic
E-7 All Electric
E-8 All Electric
24%
22%
20%
18%
16%
14%
12%
10%
0
200
400
600
800
1000


On-peak use by location and size of PG&E basic E-1 customers
% of summer usage on-peak
kWh per summer month
E-1 Basic systemwide
E-1 Basic Valley
E-1 Basic Coast and Hills
24%
23%
22%
21%
20%
19%
18%
17%
16%
15%
0
200
400
600
800
1000


Coincident Peak Load Factor by size and type of customer, PG&E
% of summer usage on-peak
kWh per summer month
E-1 Basic systemwide
E-1 All-Electric
E-7 Basic
E-7 All Electric
E-8 All Electric
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
0
200
400
600
800
1000


Coincident Peak Load Factor by location of PG&E Basic E-1 customer
coincident peak summer load factor
kWh per summer month
E-1 Basic systemwide
E-1 Basic Valley
E-1 Basic Coast
E-1 Basic Hills
150%
140%
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
0
200
400
600
800
1000

- All-electric customers use proportionally less peak demand and on-peak energy than basic customers of the same size. This finding is expected, because many of these customers have electric water heaters that consume energy at a relatively high load factor. Still, large all-electric customers use a greater proportion of peak demand than small basic customers.
- As expected, Central Valley customers use a higher percentage of their summer energy on peak than other customers and coastal customers use a lower percentage of summer energy on peak.
- Even when controlling for location of the customer, small basic customers use proportionally less peak demand and peak energy than larger ones.

In sum, those customers who on average use less than 300 kWh per summer month use only 17% of their summer energy on peak and have an annual coincident load factor of 103% (i.e., their use in the peak hour is less than their average use in all hours. Customers who use over 750 kWh per month in the summer use approximately 7 times as much summer energy as customers using less than 300 kWh per month. However, they use nearly 9 times as much summer on-peak energy, and their single-hour coincident peak demand is almost 15 times higher.

Figure 14

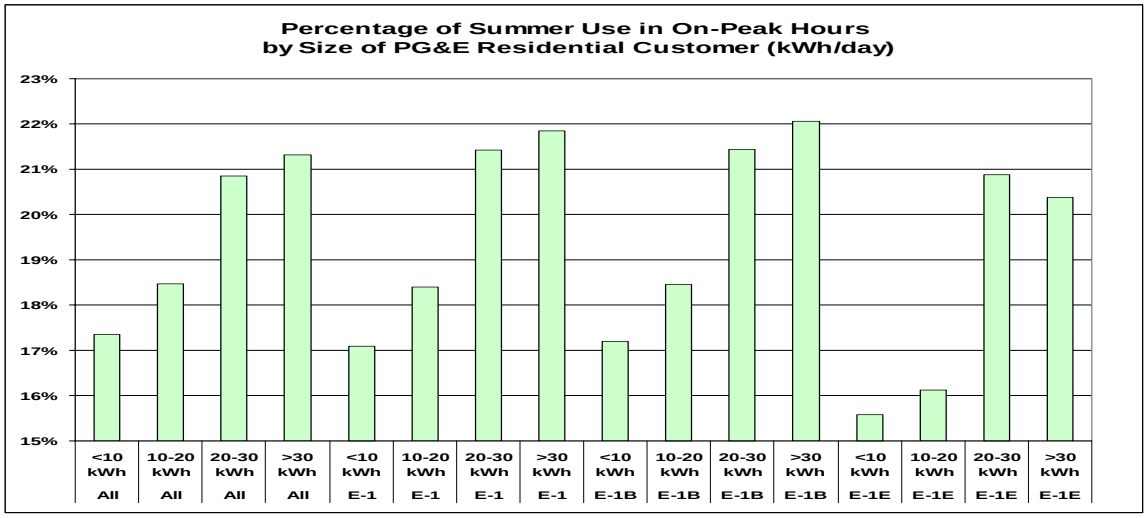


Figure 15

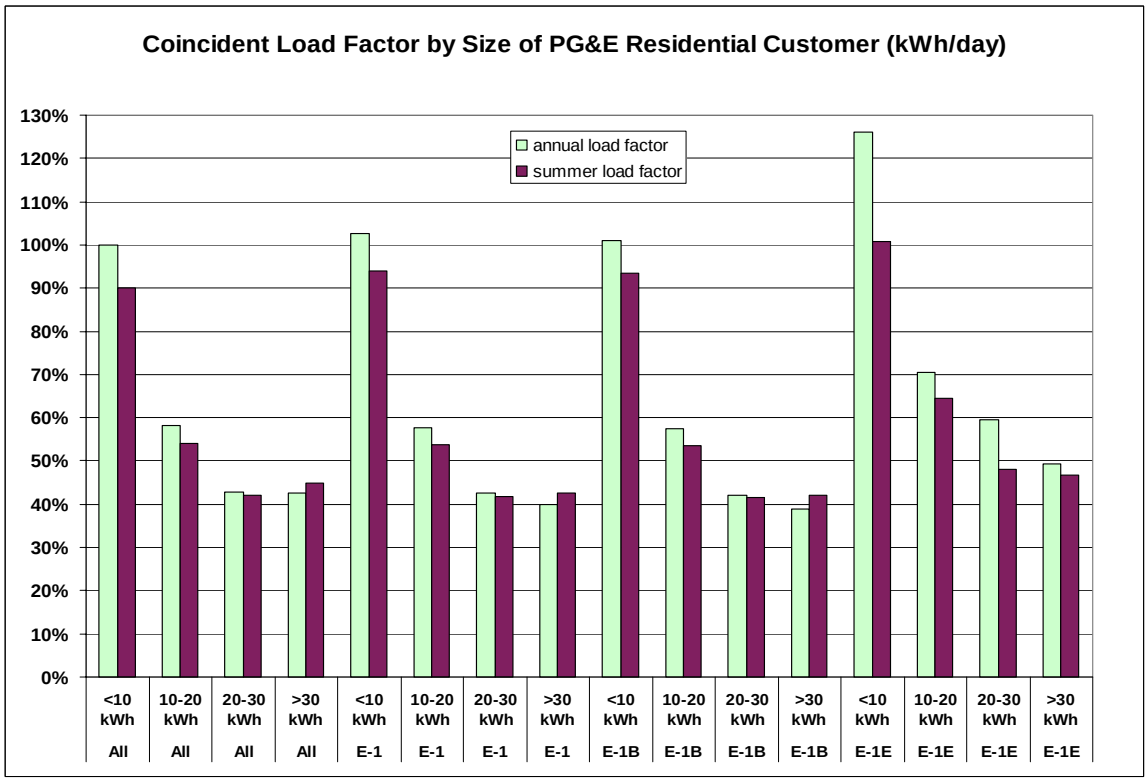


Table 14 (computed from the regression equations in Table 13) shows that customers using less than 6000 kWh per year use on average less than 300 summer on-peak kWh in Zone T and mo more than 414 kWh on the rest of the

PG&E system. By comparison, customers over 6000 kWh on average, use 842-1201 kWh during the summer peak hours.

Table 14: Estimated Summer Peak Usage by Size of PG&E Residential Customer

	Annual kWh	Summer kWh	Summer Peak (12-6pm) from PG&E load equation	% Summer Peak
Over 6000 kWh Zones T, V	8,599	4,036	842	21%
Over 6000 kWh Zone X	9,371	4,611	975	21%
Over 6000 kWh other zones	10,040	5,595	1,201	21%
Under 6000 kWh Zones T, V	3,416	1,608	283	18%
Under 6000 kWh Zone X	3,858	1,852	339	18%
Under 6000 kWh Other zones	3,965	2,176	414	19%

This fact has implications for the deployment of advanced metering. Small customers simply cannot recover the cost of meters through load shifting At $3 per month ($36 per year) and a rate differential of 20 cents between on-peak and other use, it is necessary to shift 180 kWh relative to the class average (about 20% of kWh during on-peak hours) to break even with the meter cost. Because of their better load patterns, the smallest residential customers have already shifted about 30 kWh relative to the system average, but the remaining 150 kWh represent as much as half of their existing peak load. Larger customers, by contrast must shift an average of only 15% or thereabouts to recover meter costs. Therefore, the feasibility of installing meters for small customers is questionable.

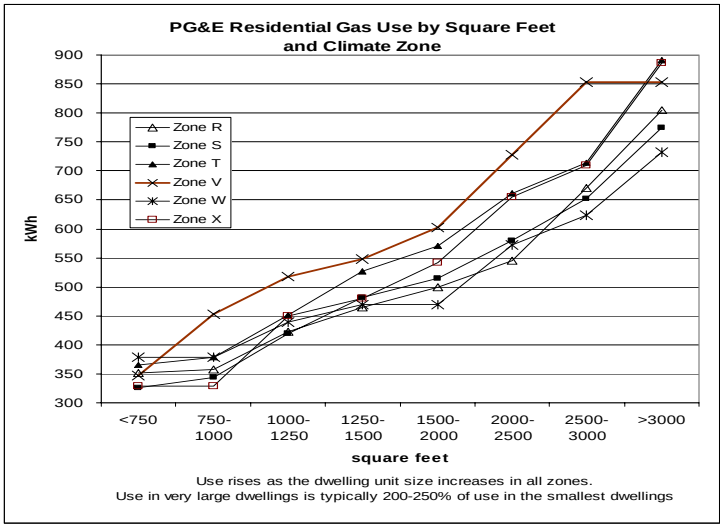
V. PG&E Gas Analysis

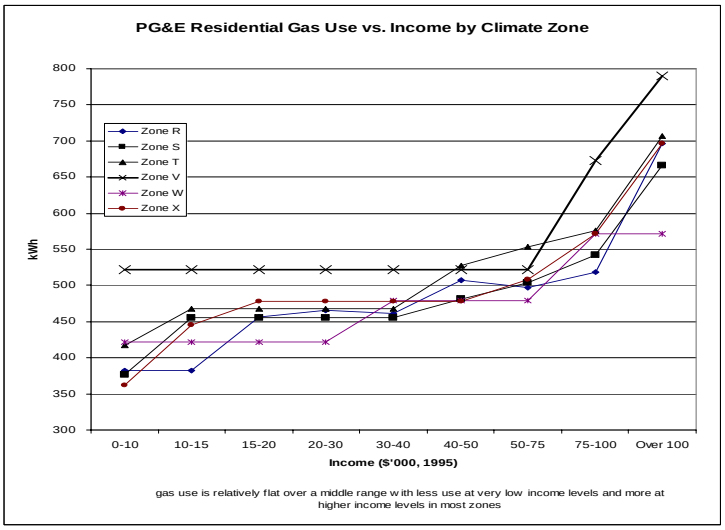
We ran regressions relating gas use to square feet, housing size, and income on the PG&E system, without controlling for other factors. The regressions for various climate zones are graphed in Figures 16-18 on the following page.

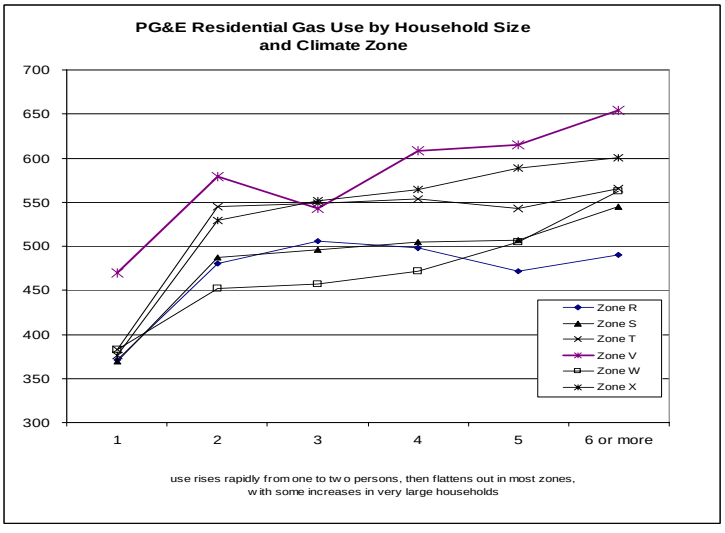
These figures show a relatively linear relationship of gas use with square feet, which is the most important variable. Unlike electricity, household size is not a critical variable. One-person households use less than others, and there is a trend in some zones for the very largest households to use more. With respect to income, there is lower usage at the lowest income level, flat usage across remaining low and lower-middle income levels, with a gradual rise to $100,000 and a strong increase for incomes over $100,000.

Differences in gas use were small across PG&E climate zones, which can be expected since the variations in winter climate are less than those in the summer climate between coastal and inland zones.

Figure 16-18: Relationship of Gas Use to Square Feet, Income, and Household Size







We ran a similar set of full regressions for the PG&E gas use. Our findings were that number of people in the household had only a modest effect, but the presence of one or more people over 65 in a household added a significant amount (approximately 100 therms per year) to gas consumption in all zones. We could not obtain reasonable results for Zones P and Y due to the small sample, and there were no gas customers at all sampled in Zones Q and Z.

The Equation for Coastal Zone T is shown below (adjusted R-squared 0.224):

Table 15: Equation for PG&E Zone T Gas

	coefficient	t-statistic
(Constant)	339.55	19.23
Household Size = 2	86.45	5.66
Household Size = 3	95.11	4.91
Household Size = 4 or more	106.81	6.17
Single Family	83.39	8.03
Sq Ft under 1000 (groups 1-2)	(101.02)	(6.59)
Square feet 1000-1250	(69.71)	(4.26)
Sq Ft 2000-2500 (group 7)	79.17	3.71
Sq Ft 2500-3000 (group 8)	119.46	3.90
Sq Ft over 3000 (group 9)	280.66	8.69
Income 50000-99999	38.40	2.75
Income 100000 or More	125.71	5.99
Over 65 Year Old in Household	126.59	9.69

Again, all variables are of expected sign and direction. The table shows that a single person in an apartment of 1250-2000 square feet uses, on average 340 therms. There is an increase of 86 therms with the addition of one more person to the household, but only 20 therms more for larger households. Usage changes greatly with square footage. Usage is also 83 therms higher for a single-family home than an apartment. This difference is much larger than for electricity and can be expected because single-family homes have more exposure to heat loss to the outside than attached multifamily units. Upper income households and households with at least one person over 65 use more than others after controlling for household size and characteristics.

Returning to the sample households of four examined in electric regressions:

- A low-income household of four, earning less than $20,000 per year in 1995 and living in a 900 square foot apartment could be expected to use an average of 346 therms.
- A lower-middle income household of four, earning between $30,000 and $40,000 in an 1100 square foot apartment could be expected to use an average of 378 therms.
- A household of four earning over $100,000 in 1995 and living in a 2600 square foot single-family house would use an average of 775 therms.

The highest income household uses about twice the energy of the lowest income household of the same size. Regressions for the other zones are quite similar.

Table 16 summarizes a system-wide analysis aimed at determining the extent to which the presence of more people or household members over 65 influences consumption above baseline levels.

Table 16: Baseline Quantity, Representative Customer Use, and Impact of Increasing Household Size or Adding a Senior Citizen without Changing Income or Square Footage Gas Energy Use

	Annual	Base Household		Increase from 2 to 6		Add Senior	
Baseline Territory	Gas	therms	% of baseline	therms	% of baseline	kWh	% of baseline
P	532						
Q	532						
R	459	410	89%	50	11%	107	23%
S	477	408	86%	86	18%	102	21%
T	495	356	72%	20	4%	126	25%
V	476	480	101%	45	10%	108	23%
W	440	425	97%	122	28%	96	22%
X	513	388	76%	56	11%	116	23%
Y	586						
Z							

Equations were prepared to analyze gas use in the peak month of January. In this month, the only difference of family size was that single-person households used less (and in a few cases, very large households used more). The lack of significance in January, coupled with significant but small differences in the annual regression suggests that most of the difference caused by extra family members was in the base (non-heating) use. Extra use associated with household

members over 65 remained strong, accounting for 14-22 therms in that one peak month alone. (Table 16A)

Table 16A: Baseline Quantity, Representative Customer Use, and Impact of Increasing Household Size or Adding a Senior Citizen without Changing Income or Square Footage Gas Energy Use, Month of January

	January	Base Household		Increase from 2 to 6		Add Senior	
Baseline Territory	Gas	therms	% of baseline	therms	% of baseline	therms	% of baseline
P	74						
Q	68						
R	62	74	120%	-	0%	22	35%
S	65	67	103%	-	0%	15	23%
T	62	66	106%	-	0%	21	34%
V	59	66	112%	-	0%	14	23%
W	59	78	133%	21	36%	14	23%
X	68	58	85%	-	0%	18	26%
Y	74						
Z							

Overall findings were:

1. Reference customers, again defined as two-person households in 1200 square foot units (apartments in T and X, single-family elsewhere) with an income of $30,000 to $40,000, have expected average usage less than annual baseline quantities in most zones. However, they are likely to exceed baseline quantities in peak winter months and consume less than baseline quantities in "shoulder" months such as November and April.

2. Gas use (largely for space conditioning) is more sensitive to square footage and less sensitive to number of people than electric use. Except in one zone with a higher impact and one with a lower impact, the effect of family size on usage is 10-18% of total baseline quantity after controlling for square footage and income.[17] Therefore, family size is not a significant issue for gas. The peak month regression suggests that most consumption increases caused by an increase in family size are related to base gas use (water heating, cooking, clothes drying).

3. The relationship of gas use and income is more complex than for electricity. The very poor use less gas and the very wealthy use more gas after controlling for other factors, but gas use increases with income more slowly across all levels largely because of the correlation among income and housing characteristics.

[17] The exception, Zone W, has a relatively small sample size.

4. The presence of a senior citizen in the household has a much larger proportional impact on gas use than electric use and is consistent across climate zones. In almost every climate zone, the presence of one or more residents over 65 in a household adds over 100 therms per year (20--25% of annual baseline quantities. The peak month regression suggests that most extra gas use associated with senior citizens is for space heating.

VI. SDG&E Electric Use

A. Analysis of Income, Square Feet, and Household Size

We first ran some equations without the interaction of the variables (household, income, and square footage), to show the impact of each variable, without controlling for the others. (Figures 19-21) Use increases strongly and approximately linearly with square footage, quadrupling as square footage increases from the smallest size to the largest. Use approximately doubles as income rises from less than $15,000 to the $100,000 to $150,000 category and increases more dramatically in the highest income groups above $150,000. Use increases up to 4 persons in a household and then levels off or falls slightly.

Figure 19

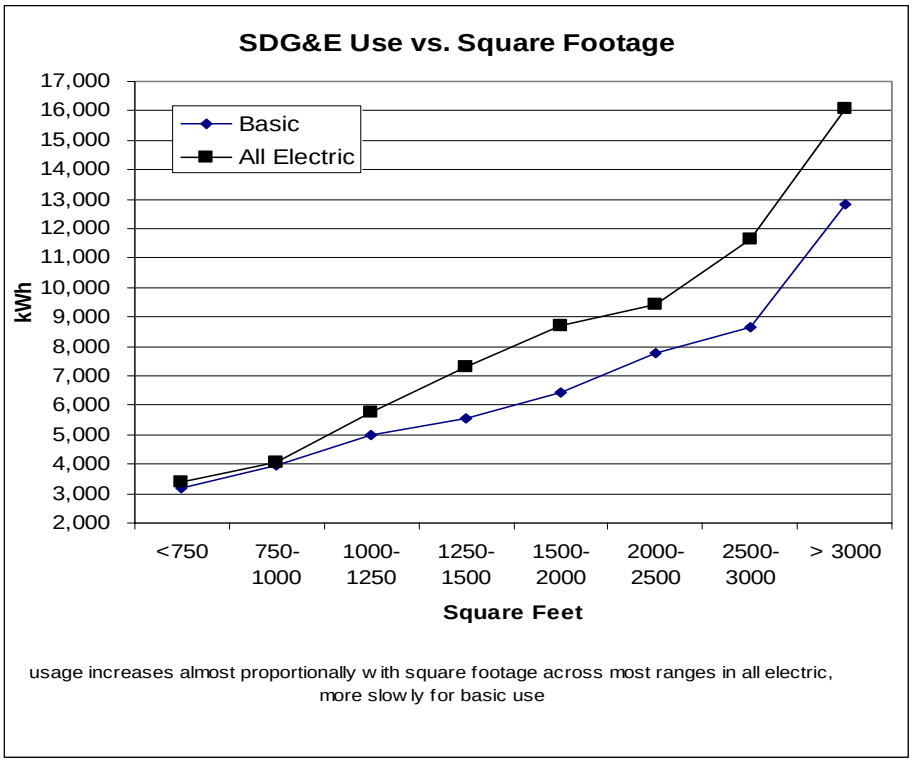


Figure 20

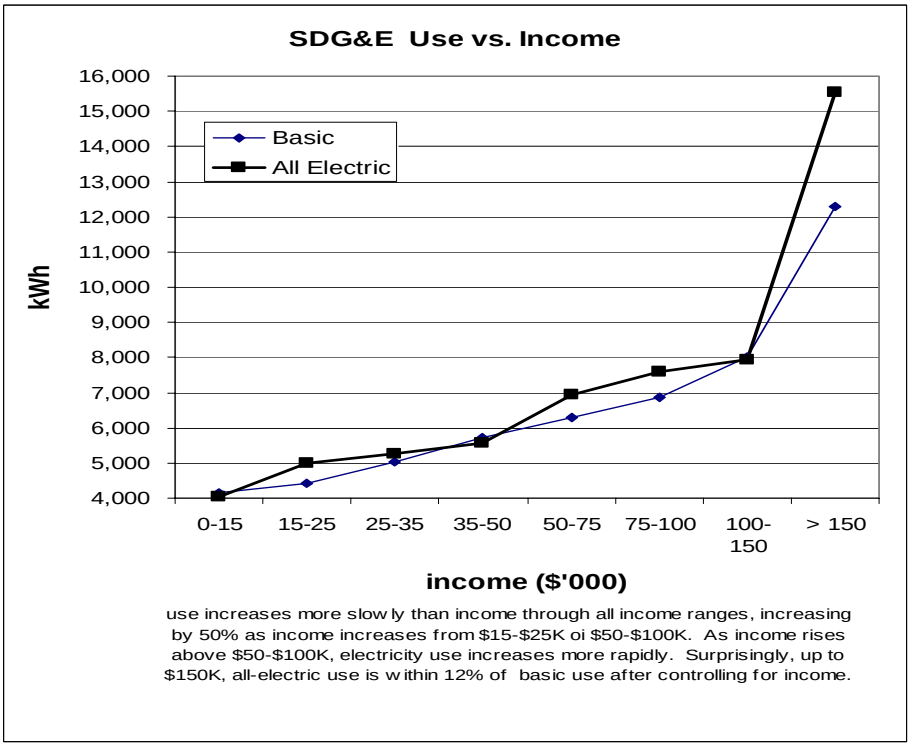
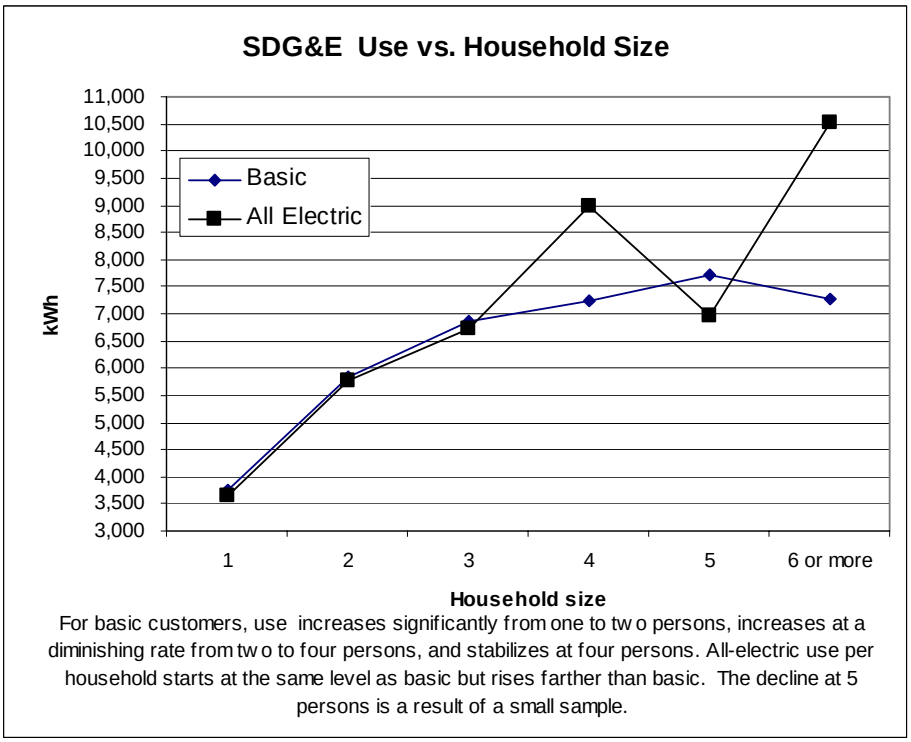


Figure 21



For basic customers, use increases significantly from one to two persons, increases at a diminishing rate from two to four persons, and stabilizes at four persons. All-electric use per household starts at the same level as basic but rises farther than basic. The decline at 5 persons is a result of a small sample.

B. Housing Stock Characteristics

For SDG&E, Basic and All-Electric customers occupy very different types of dwelling units. About 39% of all multifamily units are all-electric, but only 8% of single-family units are all-electric. All-electric units constitute 35% of units under 1000 square feet, 21% of units between 1000 and 1250 square feet, and 11% of units over 1250 square feet (with no significant differences by size above that level). As a result of being concentrated in the smallest size ranges, all-electric units tend to have customers with smaller household sizes. About 28% of one-person households live in an all-electric unit, compared to 18-21% of households of two to four persons, and less than 15% of households of more than five. Because all-electric housing units are disproportionately small units and apartments, a higher percentage of lower income customers are all-electric than upper-income customers. (Table 17)

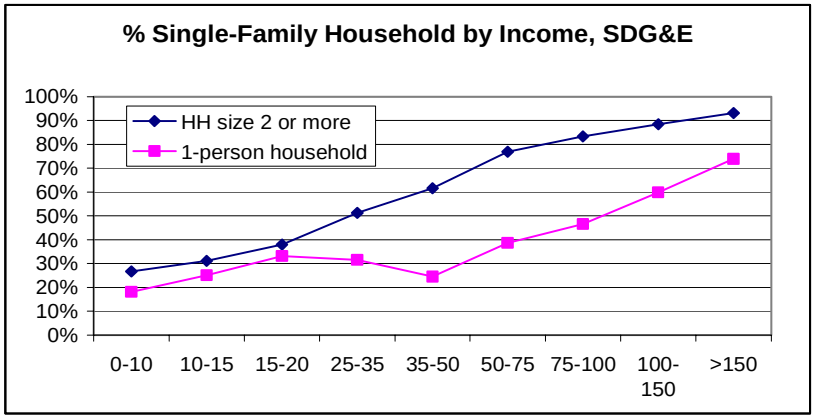
Table 17: Percentage of SDG&E Customers Who Are All-Electric by Income Level

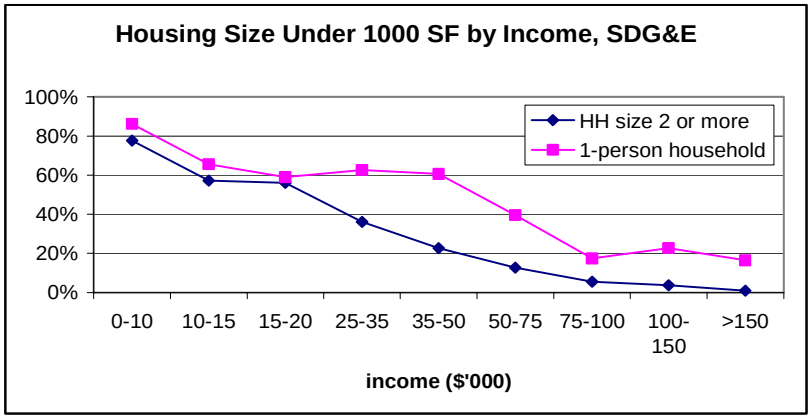
< 15	32%
15-25	28%
25-35	25%
35-50	21%
50-100	15%
100-150	15%
> 150	11%

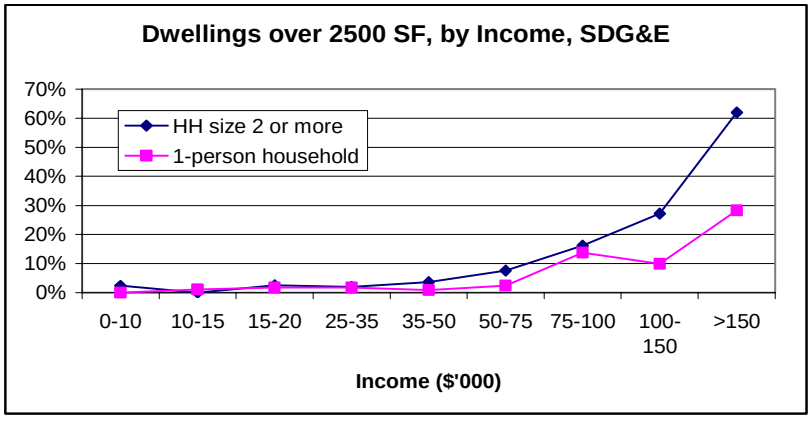
Some further data is provided in Figures 22-24 (below) showing the relationship of square footage, income, and household size and type.

About 70% of the lowest income customers (and 80% of lowest-income single person households) live in multifamily units while 90% of the richest households of more than one person live in single-family houses. Expected relationships between income and size of dwelling also appear.

Figures 22-24: Relationship of Square Footage to Income and Household Size and Type (percentage of customers of a given income in the dwelling type that is graphed, incomes in thousands of dollars)







C. Analysis of Full Equations for SDG&E

1. Basic Use Equation

The equation explaining basic use as a function of household size and income for SDG&E is given below.

Table 18: SDG&E Basic Use Equation

	coefficient	t-statistic
(Constant)	4,362	21.59
SQ750UN	(1,962)	(8.87)
Sq Ft 750-999	(1,551)	(7.14)
Sq Ft 1000-1249	(964)	(5.23)
Sq Ft 1250-1499	(685)	(3.79)
Sq Ft 2000-2499	867	4.59
Sq Ft 2500-2999	1,512	5.76
Sq Ft 3000 or more	4,888	15.70
Single Family Only	866	6.04
Household Size 2	872	5.55
Household Size 3	1,738	9.45
Household Size 4 or more	1,819	10.93
Income 150K or more and HH Size 4 or more	3,101	5.10
Household member over 65	487	3.53
Income 0-29999	(271)	(2.00)
Income 100000-149999	615	2.95
Income 150000 and over	1,546	3.96

The equation explains 39.0% of the variation in the data (adjusted R-squared). The coefficients have expected signs. Usage increases as square feet rise and increases for single-family houses relative to apartments. Use also increases as household size increases, although somewhat less strongly than for PG&E, but the variable reflecting the presence of a senior citizen has a somewhat stronger effect than for most PG&E basic zones. After accounting for square footage and dwelling type, income is only significant at the lowest and highest levels. In addition, an interactive variable shows that large households with high incomes use 3101 more kWh than would be projected by analyzing income and family size in isolation.

To interpret the equation, the fixed point again represents a particular household type (a one-person household with no one over 65 and income between $30,000 and $100,000 in a 1500-2000 square foot apartment). The average use of a person in this household type is 4,362 kWh per year. One can again compute average use for any other type of household for which information is desired by simply adding coefficients to obtain different kinds of households. For example, let us look at four different four-person households with very different incomes and housing types:

- A low-income household of four, earning less than $20,000 per year and living in a 900 square foot apartment could be expected to use an average of 4,359 kWh.
- A lower-middle income household of four, earning between $30,000 and $40,000 in an 1100 square foot apartment could be expected to use an average of 5,217 kWh.
- A middle-income household of four earning between $50,000 and $75,000 in a 1400 square foot house would use an average of 6,352 kWh.
- A household of four earning over $150,000 in 1995 and living in a 2600 square foot single-family house could be expected to use an average of 11,387 kWh.

In other words, the average use of a very high-income household of four is 261% of the average use of a low-income household of the same size.

Table 19 shows the impact of income, household size, and dwelling size and type on usage.

Table 19: Effects of Income, Household size, and Dwelling Characteristics on Electricity Use SDG&E Basic

Income	<20	20-30	30-50	50-75	75-100	>100	>150
sq. ft.	<750	750-1000	1000-1250	1250-1500	1500-2000	2000-2500	>3000
type of unit	MF	MF	MF	SF	SF	SF	SF
household size							
1	*2,129*	*2,540*	*3,398*	4,543	**5,228**	**6,709**	***11,661***
2	*3,001*	*3,412*	4,270	**5,415**	**6,099**	**7,581**	***12,533***
3	3,867	4,277	**5,136**	**6,281**	**6,965**	***8,446***	***13,399***
4 or more	3,948	4,359	**5,218**	**6,362**	**7,047**	***8,528***	***16,582***

italics -- annual use under baseline
bold -- annual use over 130% of baseline
bold italic small -- annual use over 200% of baseline
bold italic large -- annual use over 200% of baseline

The table shows that, on average, basic customers with low-to-moderate incomes and relatively modest dwellings will exceed 130% of baseline as a family of three or more. Use over 200% of baseline occurs, on average, only for customers earning over $100,000 or in large single-family houses.

2. All-Electric Equation

A similar analysis was done for all-electric customers, producing the following equation, which explains 52.0% of the variation in the data (adjusted R-squared).

Table 20: SDG&E All-Electric Equation

	Coefficient	t-statistic
(Constant)	5,550	11.73
Sq Ft Under 750	(2,708)	(5.55)
Sq Ft 750-999	(2,405)	(5.02)
Sq Ft 1000-1249	(1,315)	(2.81)
Sq Ft 1250-1499	(869)	(1.70)
Sq Ft 2500-2999	2,429	2.57
Sq Ft 3000 or more	4,831	5.64
Single Family Only	2,477	6.22
Household Size 2	767	2.40
Household Size 3	1,571	4.04
Household Size 4 or more	2,569	6.76
Income 150K or more and HH Size 4 or more	7,781	5.13

This equation yields numerical results very similar to the basic equation for small apartments but shows much higher average use for single-family units and very large units. Household size has a larger effect than for the basic regression, and

income variables (with the exception of the interactive variable between high income and large family size) are not significant after controlling for housing characteristics. The variable for presence of a household member over 65 was also not significant in this equation.

3. Impact of Adding Household Members or of a Senior Citizen, Compared to Baseline Quantities.

Table 21 compares annual baseline allowances[18] to the use of a lower-middle-income family of two, living in an apartment of 1000-1250 square feet. The increase of moving from two to the highest number of family members and from having a household member over 65 is computed. In addition, peak summer and winter months are computed for the basic sector and a peak winter month for all-electric.

Table 21: Analysis of Adding Persons or Senior Citizen to SDG&E Reference Household

	Annual Basic	September Basic	January Basic	Annual All-Electric	January All-Electric
baseline quantity	3,832	306	335	5,388	614
reference household	3,885	454	390	5,001	524
% of baseline	101%	148%	117%	93%	85%
increase size	1,025	74	66	1,802	160
% of baseline	27%	24%	20%	33%	26%
over 65 in household	487	49	33		
% of baseline	13%	16%	10%		

The increase in kilowatt-hours from adding the maximum number of people to a two-person household is 15-20% of the baseline quantity and averages 80 kWh per month for basic use and 150 kWh per month for all-electric use. These figures are smaller than for PG&E, where the smallest impact for basic usage was over 1100 kWh per year and most PG&E zones showed larger impact. The

[18] Since SDG&E did not provide baseline zones with its data, we made our calculations assuming coastal baseline allowances. To the extent that some usage has higher allowances, our calculations overstate reference household usage and the impacts of adding more people or having a senior citizen as a percentage of baseline.

impact of adding a senior citizen is somewhat larger than for PG&E, for basic usage, but still only 17% of annual baseline quantities. There was no statistically significant difference of the presence of a person over 65 in an all-electric household.

The peak summer and winter regressions for a basic customer show that the reference household uses more than the baseline allowance – considerably more in a warm summer month. As a result, a significant portion of the consumption associated with additional family members is likely to be subject to surcharge. We checked the impact of an all-electric home by running a regression to analyze use in the month of January. However, the usage of the reference household was only 85% of the winter baseline quantity. Increasing the household size would add 26% of the baseline quantity.

D. Usage by Time Period and Size of Customer

Using SDG&E's load research data, Marcus (2000) demonstrates that large SDG&E residential users use more summer peak energy and have a higher coincident peak demand. The results of a regression analysis of the usage pattern of the 183 customers included in SDG&E's load research sample are summarized in Figures 25 and 26. Customers with heavy summer use have a higher percentage of on-peak energy and higher coincident peak loads than customers with less summer use.

Figure 25

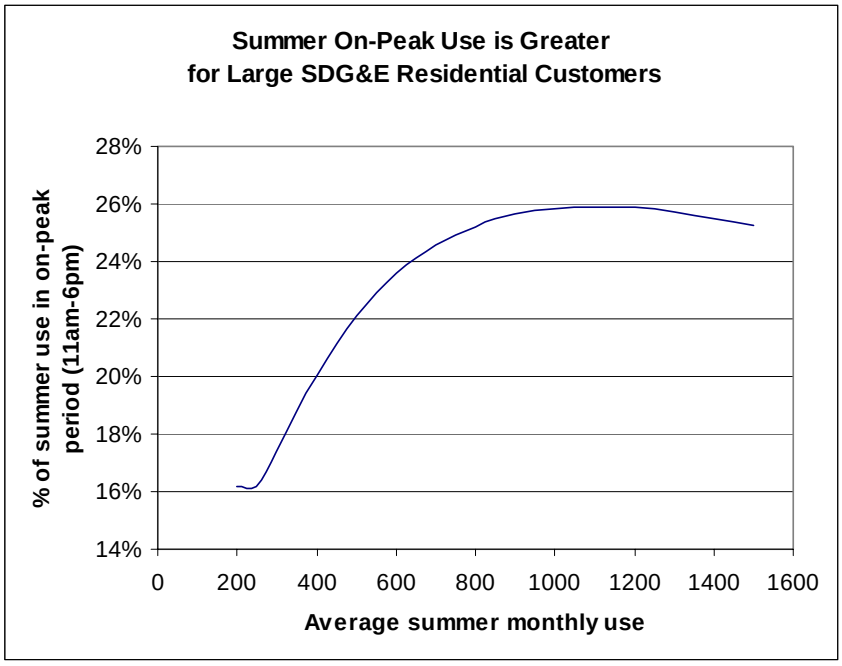


Figure 26

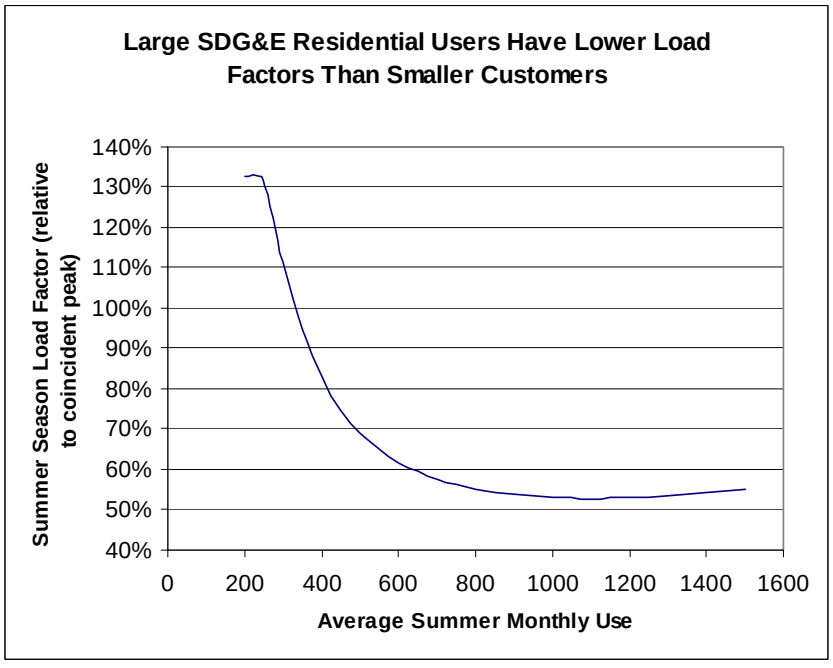


Table 22 shows the numbers for summer peak energy usage and coincident peak and coincident load factor for varying usage levels.

Table 22:
Summer Usage by Time Period and Coincident Peak Demand by kWh Sales Levels, SDG&E Residential Customers

KWh sales		Average Summer Month Use				Annual coincident peak
		Total	On-peak	Mid-peak	Off-peak	(CP)
0-250	energy kWh / peak kW	197	35	58	104	0.29
	% of use by time period		17.7%	29.5%	52.8%	
	CP annual load factor					110.5%
250-400	energy kWh / peak kW	333	66	102	166	0.70
	% of use by time period		19.7%	30.5%	49.7%	
	CP annual load factor					72.7%
400-600	energy kWh / peak kW	500	111	141	248	1.08
	% of use by time period		22.2%	28.1%	49.6%	
	CP annual load factor					67.2%
600-800	energy kWh / peak kW	691	163	192	336	1.64
	% of use by time period		23.6%	27.7%	48.6%	
	CP annual load factor					57.9%
800-1000	energy kWh / peak kW	912	233	246	434	1.90
	% of use by time period		25.5%	26.9%	47.6%	
	CP annual load factor					58.7%
>1000	energy kWh / peak kW	1365	343	360	661	3.41
	% of use by time period		25.2%	26.4%	48.4%	
	CP annual load factor					46.1%

Those customers who on average stay use less than 250 kWh in the summer months use less than 18% of their summer energy on peak. Their annual coincident load factor is 110% (i.e., their use in the peak hour is less than their average use in all hours). Total summer on-peak use is about 210 kWh.

As loads increase, the percentage of on-peak use increases (through 800 kWh), and the coincident annual load factor decreases.

In other words, looking at the both ends of Table 21, customers who use over 1000 kWh per month in the summer use about 7 times as much summer energy as customers using less than 250 kWh per month. However, they use nearly 10

times as much summer on-peak energy, and their coincident peak demand is almost 12 times higher.

E. Summary of Findings

- SDG&E's electricity use is heavily influenced by square footage and housing type.
    - Single people with gas heat living in the smallest apartments use less than 2,500 kWh of electricity on average (2129 kWh for a person with less than $20,000)
    - A wealthy family of four or more with gas heat in a 3200 square foot single-family house will, on average, use almost 8 times as much (over 16,000 kWh)
    - Of the difference between the two households, 53% (7715 kWh) arises from differences in housing type and square footage, 13% from family size, and 34% (4,919 kWh) comes from income and the interaction of income and family size. JBS' previous work with SDG&E's load research data[19] suggests that customers using more energy in the summer months also use disproportionate amounts of peak period (noon to 6 pm) energy and coincident peak demand. These are clearly well-to-do customers in larger dwellings.
- Until income exceeds $100,000, it does not play a major role in explaining electricity use independent of dwelling type and size. However, as expected, households with higher incomes live in larger housing units. A relatively small effect is found for customers with incomes under $30,000,

[19] Filed for UCAN in SDG&E's year 2000 Rate Design Window A. 91-11-024.

who use about 25 kWh per month less than customers with incomes from $30,000 to $100,000, all else held equal.

- SDG&E's all-electric customers appear to consist of a large number of people in relatively small apartments and a smaller number of people in relatively large houses. The baseline allowance for all-electric therefore exceeds the average use of most people in apartments and is less than the average use of most people in houses.

- A reference household (of two with an income of $30,000 to $50,000 in an apartment of 1000-1250 square feet) with gas heat uses more than the baseline allowance in peak summer and winter months and less in other months. Average annual use is approximately equal to the allowance.

- The reference household in an all-electric configuration uses less than the baseline allowance in peak winter months.

- The number of members in a household (up to 4) significantly impacts usage after controlling for size and type of dwelling and for income. Moving from two to four or more people increases use by about 85 kWh per month for basic use and 150 kWh per month for all-electric use.

- A basic household with a person over 65 will use about 40 kWh per month more than a household with no one over 65, all else held equal. No statistically significant impact of a senior was found for all-electric use.

- Small customers use a smaller proportion of their energy during peak periods than larger customers.

VII. Southern California Edison Electric Use

A. Methodological Issues Unique to Edison

To prepare all of our analysis, we included all surveyed units with household size greater than zero (i.e., excluding vacation homes),[20] with at least 300 days of metered use, with kWh / day usage in excess of 1.5 kWh per day (about 550 kWh per year) from July 1994 through June 1995 (to exclude bad data), and excluding master-metered customers. Equations were prepared in kWh per day, but results were multiplied by 365 for comparability to results for PG&E and SDG&E. Because the Edison sample was drawn by the California Energy Commission's climate zones rather than the CPUC's baseline climate zones, we also had to run data through a separate Edison database that correlated zip codes with baseline climate zones. In that process, almost 40% of the Edison data became unusable for a climate zone analysis because a large number of zip codes include customers in more than one baseline climate zone. All data from those zip codes could not be used without massive amounts of work to identify customers' climate zone by street address.

As a result of small samples, we were unable to obtain any useful information for a number of Edison zones. Zones 14 and 16 basic and Zones 13-16 all-electric had less than 100 customers each and therefore produced unreliable estimates. Zone 15 (Palm Springs area) appears to have a problem with the coding of vacation homes, as results produced in the analysis did not make economic sense. Zone 17 all-electric also had a different sampling problem. The average use of the sampled customers was less than the baseline allowance, which is supposed to be set at 60-70% of average use.

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[20] Separate cross-tabs of vacation homes versus all other units were prepared for two zones.

B. Simple Analysis of Square Footage, Income, and Household Size

We first ran some equations without the interaction of the variables (household, income, and square footage), to show the impact of each variable, without controlling for the others. (Figures 27-29 show the results; only some basic zones and only zones 10 and 17 all-electric produced reasonable results)

Figure 27

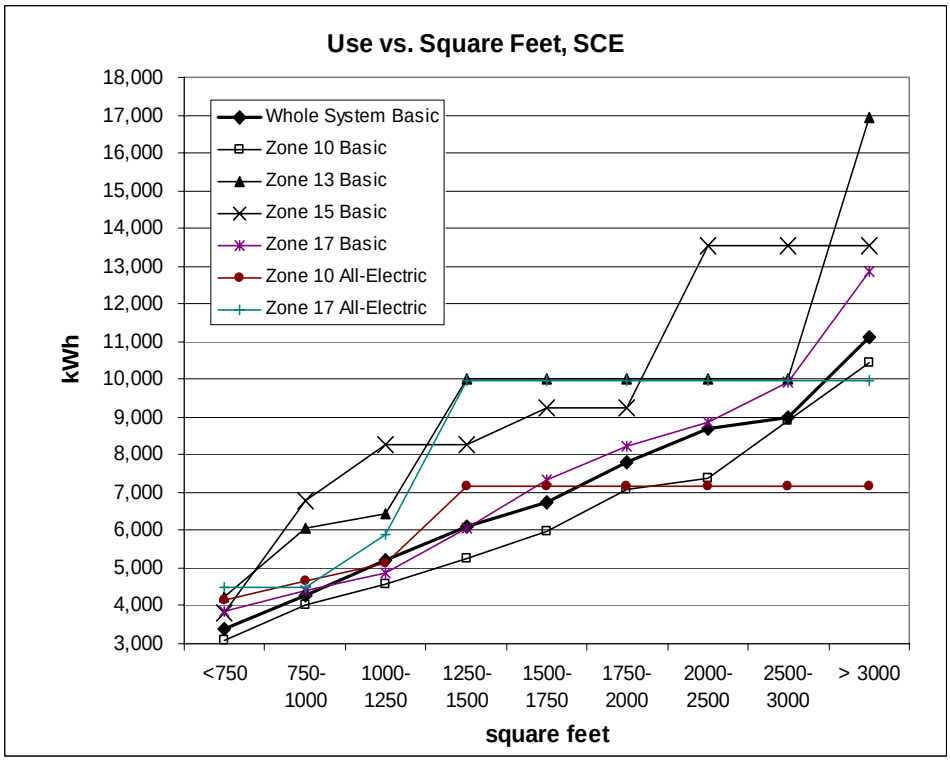


Figure 28

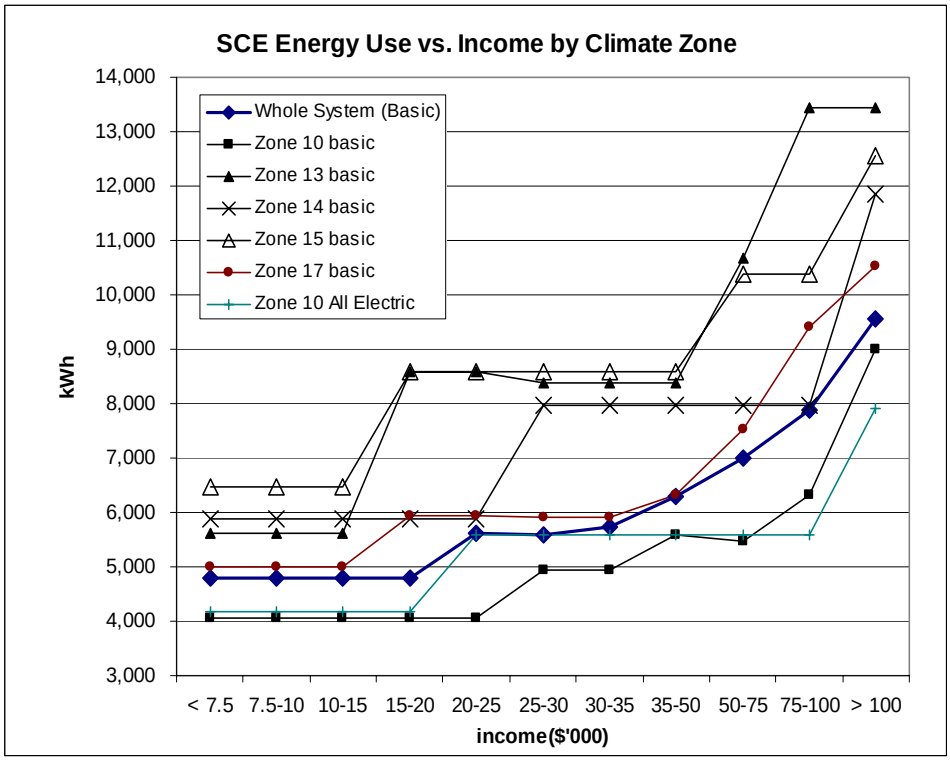
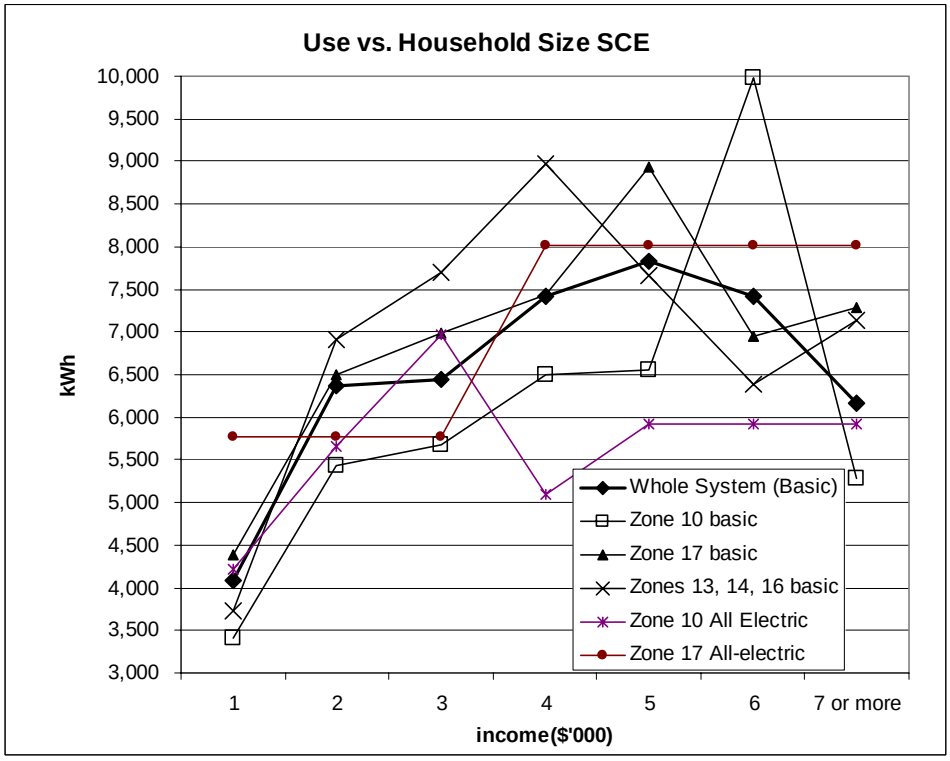


Figure 29



Across the Edison system, there is a pattern where usage levels off and even falls at the highest household size levels. In reviewing the data, we found that income falls as household size increases from 4 to 7, which may affect the results. This pattern is also observed after controlling for income and square footage in the full equations discussed below. In addition, for Edison usage is relatively constant in a broad middle-income range in a number of climate zones.

Figure 19 shows an analysis for basic users on the Edison system as a whole controlling for family size and income but not for housing characteristics. It shows that usage increases rapidly as household size rises from 1 to 5 and then decreases for very large households. Lower-middle income households, with incomes slightly above CARE limits, (dark lines on Figure 30) show a 70-80% increase as household size changes from one person to four; however, part of the increase relates to housing characteristics.

Figure 30

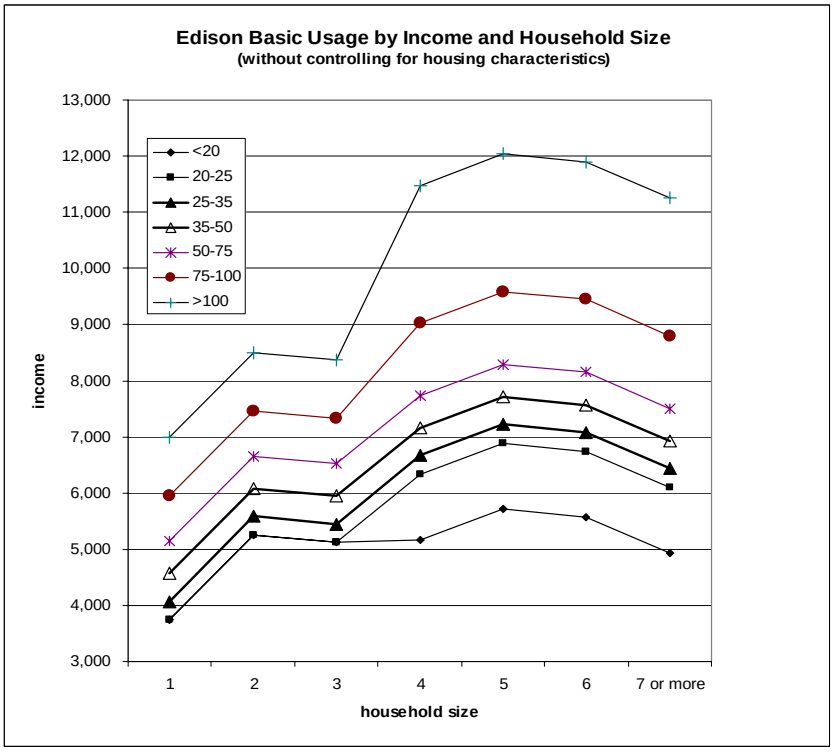
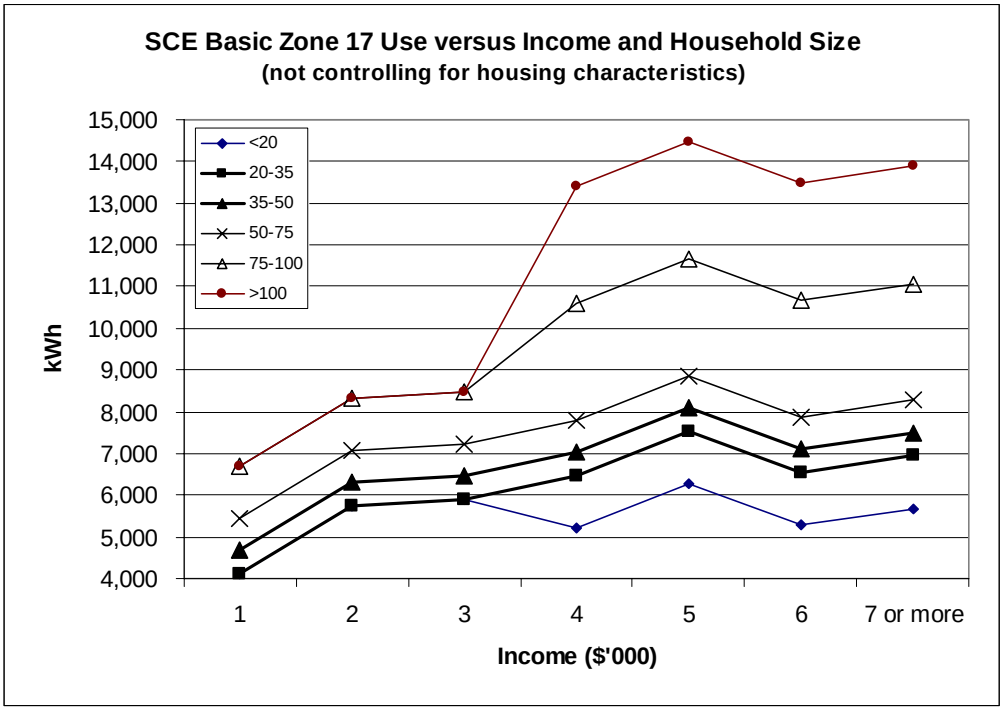


Figure 30A provides a similar chart for one zone – Zone 17 (inland hills). On this chart, the data suggest that, on average, large families with lower-middle incomes are paying surcharges for use in excess of 130% of baseline, as the baseline quantity for this zone is 4,722 kWh per year and 130% of baseline is 6,138 kWh. However, the increase in use with family size in this zone is much more pronounced for incomes over $75,000, where interactive variables between income and household increase the usage of large households.

Figure 30A



C. Relationship of Household Characteristics and Income

Similar relationships are observed for Edison as for PG&E and SDG&E between household size and type and income. Figures 31 through 33 show the relationship of square footage and single-family housing units to income for the Edison system.

Figure 31

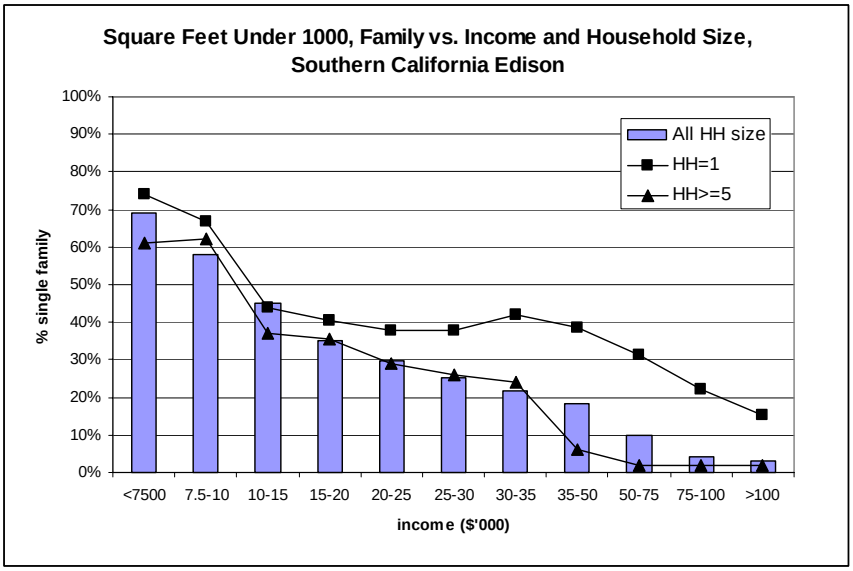


Figure 32

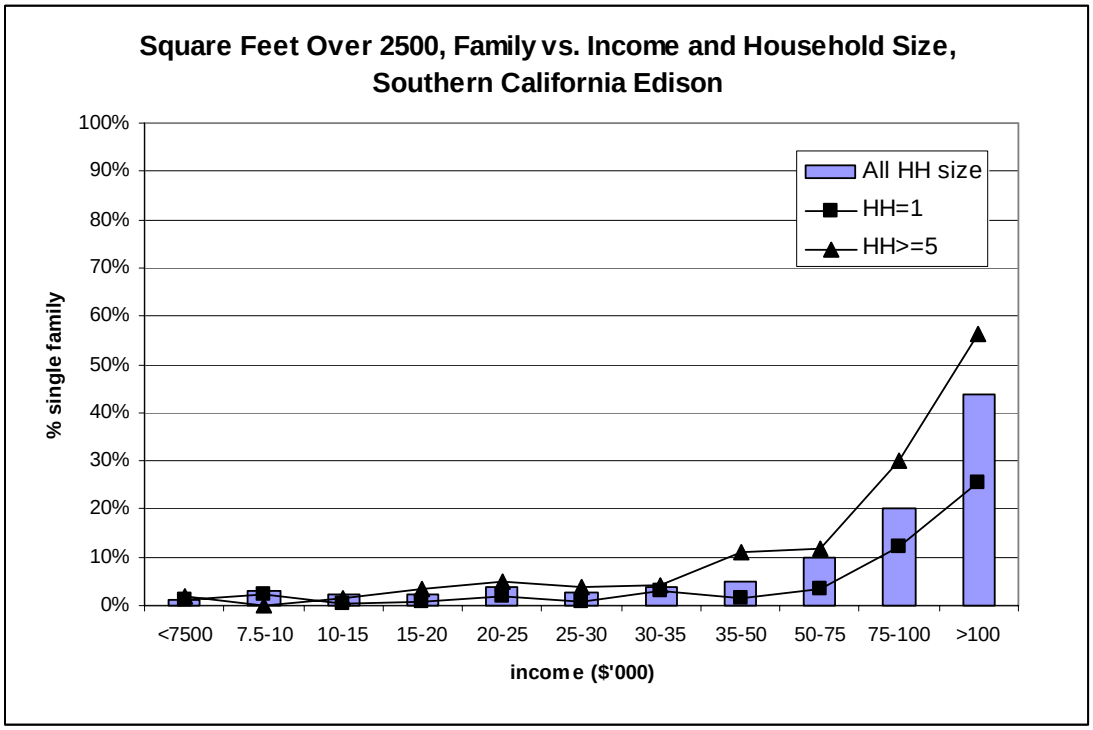
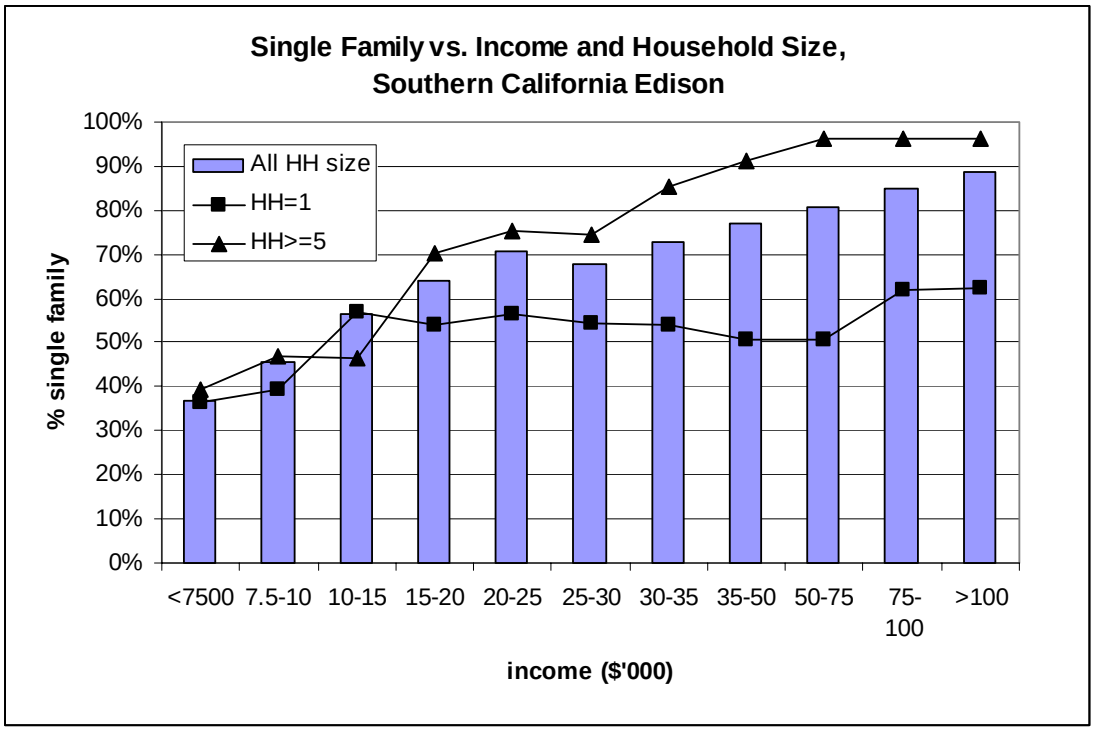


Figure 33



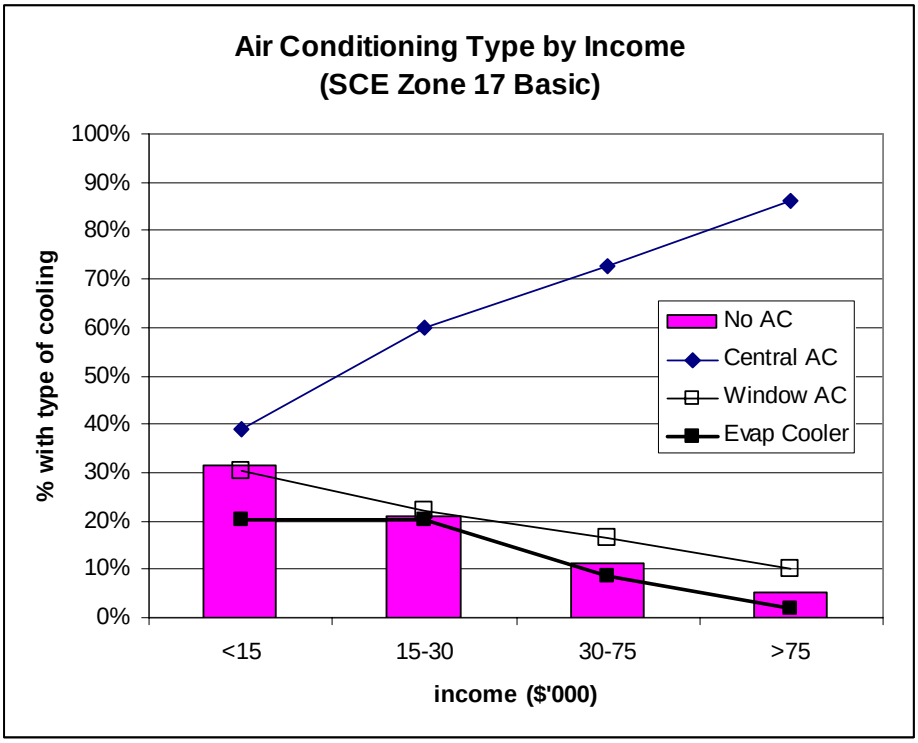
D. Air Conditioning, Income Levels, and Usage

Edison provided us with additional end-use data not provided by other utilities, which provides some additional information as to how income and square footage affect energy use. Central Air Conditioning is a key determinant of use; the average Edison customer without central air uses 5,267 kWh, while a customer with central air uses 7,818 kWh. Almost 70% of customers without central air conditioning use less than 6000 kWh, while less than 40% of those with central air use less than 6000 kWh.

From this end use data, air conditioning saturation as a function of income was extracted for the hill climate Zone 17. (Figure 34) It shows that 86% of households with income over $75,000 have central air conditioning, as compared to 39% of households with income under $15,000. About 30% of low-income customers and 5% of higher income customers have no mechanical air conditioning at all, and the saturation of window air conditioners and

evaporative coolers is much higher in the low- income groups. This is one of the key reasons why upper income customers use more electricity.

Figure 34



E. Explanation of Results Using Equations for Two Zones

We present the results using two equations for basic use in two sample regions, coastal Zone 10 and Zone 17, a large zone immediately inland from Zone 10.

1. Zone 10 "Basic" Example

The following equation shows the results for Climate Zone 10 Basic use. The dependent variable is average number of kWh used per day from July 1994 to June 1995. The adjusted R-squared for this equation was 0.472, meaning that the equation explains 47.2% of the variation in the data.

Table 23: Equation for Average Use by Household Size and Characteristics: SCE Zone 10 Basic

	coefficient	t-statistic
(Constant)	15.05	23.44
Sq Ft less than 500	(6.32)	(6.81)
Sq Ft 500-999	(4.35)	(7.15)
Sq Ft 1000-1499	(3.08)	(5.91)
Sq Ft 2500-2999	7.49	8.26
Sq Ft 3000 or more	12.38	13.73
Household Size=2	1.45	2.46
Household Size=3	1.76	2.83
Household Size=4 or more	4.48	7.43
Multi-Family Use Code	(3.13)	(6.38)
Income less than 25000	(1.26)	(2.78)
Income 100000 or more	3.33	4.97

The equation produces expected results. Use increases with household size, with increases in square footage, and with increases in income. Use is also higher for single-family units. Variables representing the presence of a person over 60 or a retiree were not significant and were therefore not included.

To interpret the equation, the constant term or fixed point represents a particular household type (in this case a one-person household with income of $25,000 to $100,000, living in a single-family home of (1500-2500 square feet). The average use of a person in this household type is 15.05 kWh per day or 5,491 kWh per year. One can compute any other type of household for which information is desired by simply adding coefficients to obtain different kinds of households. For example, three households of four with different incomes and housing types have different expected levels of use.

- A low-income household of four, earning less than $20,000 per year in 1995 and living in a 900 square foot apartment could be expected to use an average of 3,937 kWh.

- A lower-middle income household of four, earning between $30,000 and $40,000 in an 1100 square foot apartment could be expected to use an average of 4,860 kWh.
- A household of four earning over $100,000 in 1995 and living in a 2600 square foot single-family house would use an average of 11,075 kWh.

In other words, the average use of high-income household of four is 2.8 times as much as the average use of a low-income household of the same size.

The table below shows the variation in use by income, dwelling characteristics, and housing size for Zone 10.

Table 24: Variation Between Largest and Smallest User Types: SCE Zone 10 Basic

	Zone 10	
	kWh	%
low income, smallest apartment, 1 person	1,582	
high income, largest house, 6 or more people	12,860	
largest as % of smallest	813%	
difference	11,278	
of which:		
housing characteristics	7,968	71%
income	1,675	15%
family size	1,635	15%

A household in the largest single-family home with four or more people will, on average, use eight times as much electricity as a household with the lowest income in the smallest apartment. About 70% of the difference is caused by housing characteristics, 15% by income and 15% by family size.

Table 25 shows average annual usage by household size, and income, for representative housing types for Climate Zone 10, basic use. The figures were developed from the equation on the previous page.

Table 25: Average Annual Use by Income, Square Feet, Household Size, and Housing Type: Zone 10 Basic

Income	<20	25-30	30-50	50-75	75-100	>100	>100
sq. ft.	<750	750-1000	1000-1250	1250-1500	1500-2000	2000-2500	>3000
type of unit	MF	MF	SF	SF	SF	SF	SF
household size							
1	*2,302*	*2,761*	4,368	4,368	**5,491**	**6,707**	***11,225***
2	*2,833*	*3,292*	**4,899**	**4,899**	**6,022**	**7,238**	***11,756***
3	*2,944*	3,403	**5,010**	**5,010**	**6,133**	**7,349**	***11,867***
4 or more	3,937	4,396	**6,003**	**6,003**	**7,127**	***8,343***	***12,860***

italics -- annual use under baseline

bold -- annual use over 130% of baseline

bold italic -- annual use over 200% of baseline

large bold italic -- annual use over 300% of baseline

This exemplary analysis shows that large families with moderate incomes ($30,000 to $50,000) have the potential of being surcharged, but the surcharges are relatively modest on an annual basis. Households earning more than $100,000 will be in the second or third tier on an annual average basis depending on the size of their dwelling.

2. Zone 17 Basic Example

The equation for Zone 17 is also provided below. The adjusted R-squared for this equation was 0.429.

Table 26: Equation for Average Use by Household Size and Characteristics: SCE Zone 17 Basic

(Constant)	16.31	24.06
Sq Ft less than 750	(8.21)	(9.24)
Sq Ft 750-999	(6.01)	(6.93)
Sq Ft 1000-1249	(6.70)	(11.03)
Sq Ft 2500-2999	4.84	5.29
Sq Ft 3000 or more	9.55	8.42
Multi-Family Use Code	(1.67)	(2.30)
Household Size=2	3.24	4.34
Household Size=3	3.86	4.68
Household Size=4	4.72	5.69
Household Size=5 or more	6.01	7.50
Income 75000-99999	2.18	1.99
Income 100000 or more	3.33	3.28
Income 75-100K and HH>=4	3.87	2.45
Income >100K and HH>=4	9.06	5.48

In this climate zone, the impact of the range of housing square feet is about equivalent to Zone 10; there is a larger impact of household size, and the income difference between the lowest and highest incomes is about the same, but there is no separate impact of low income reducing usage after controlling for housing characteristics and housing stock.

As shown in Table 27, the largest user category uses about 7 times as much as the smallest user in this zone. Unlike Zone 10, only 51% of the difference in use is explained by housing characteristics, with 33% explained by income (including the interaction of income and family size), and 16% by family size irrespective of income.

Table 27: Variation Between Largest and Smallest User Types: SCE Zone 17 Basic

	Zone 17	
	kWh	%
low income, smallest apartment, 1 person	2,348	
high income, largest house, 6 or more people	16,157	
largest as % of smallest	688%	
difference	13,810	
of which:		
housing characteristics	7,090	51%
income	4,525	33%
family size	2,195	16%

Table 28 shows the average annual usage by household size, and income, for representative housing types for Climate Zone 17, basic use.

Table 28: Average Annual Use by Income, Square Feet, Household Size, and Housing Type: Zone 17 Basic

Income	<20	25-30	30-50	50-75	75-100	>100	>100
sq. ft.	<750	750-1000	1000-1250	1250-1500	1500-2000	2000-2500	>3000
type of unit	MF	MF	SF	SF	SF	SF	SF
household size							
1	*2,348*	*3,149*	3,506	5,953	**7,170**	**7,366**	***10,851***
2	*3,531*	*4,332*	*4,689*	**7,136**	**8,353**	**8,550**	***12,035***
3	*3,756*	*4,557*	4,914	**7,361**	**8,578**	**8,775**	***12,260***
4	*4,072*	4,873	5,230	**7,677**	***10,308***	***12,398***	***15,883***
5 or more	*4,543*	5,344	5,701	**8,148**	***10,779***	***12,869***	***16,354***

italics -- annual use under baseline

bold -- annual use over 130% of baseline

bold italic -- annual use over 200% of baseline

large bold italic -- annual use over 300% of baseline

In Zone 17, the baseline allowances are considerably higher than in Zone 10 (4721 kWh per year vs. 3699 kWh in Zone 10). Thus larger families of relatively modest incomes on average are unlikely to reach 130% of baseline. This finding is different from both PG&E and SDG&E, as well as for Zone 10.

F. Analysis of Other Zones and of All-Electric Customers

Zone 13, like the PG&E Central Valley zones which it adjoins, involves a situation where household earning $30,000 to $40,000 in modest sized houses (1000-1250 square feet) will significantly exceed 130% of baseline. Average use for a household of more than one person with this income and housing type is 8382 kWh per year, while baseline is 5382 kWh and 130% of baseline is 6994 kWh.

There are not enough data to make a reliable estimate for Zone 14, although the limited data from the income regression that could produce reliable results suggests that moderate income households are likely to pay surcharges, with use of about 8000 kWh for an income of $30,000, compared to 6329 kWh as 130% of baseline.

The Palm Springs Zone 15 exhibits relatively unusual results, possibly because some vacation homes may not have been properly identified. There is very little sensitivity to household size in this zone, although dwelling unit size has a significant impact. Only the very lowest income level uses less energy, but there is no high-income increase. We cannot draw any conclusions from the sample regarding this area, although it appears that usage by size of residence does not exceed baseline until the residence reaches 1500 square feet, possibly because of inclusion of vacation homes.

Zone 16, like the mountain zones of PG&E, has a very small sample from which virtually no information can be drawn. Again, there may be a problem with mis-identified vacation homes in some parts of this zone, as use is (counter-intuitively) negatively correlated with income although positively correlated with square footage in this zone.

Only the All-Electric Zones 10 has an adequate sample sizes to develop even small amounts of information. In Zone 10, average use by a family of two earning $30,000 in a small house is 106% of baseline. The difference caused by adding more people to the family is 19% of baseline.

In Zone 17, there were only 145 observations, so firm conclusions cannot be drawn. Data for Zone 17 may not be representative as the average use of sampled all-electric customers was 6299 kWh per year, while the baseline allowance is 7283 kWh. Nevertheless, we ran a regression and found that the only variables that were significant from this sample were several square footage variables (up to 1500 square feet using less than those with larger dwellings). The average use of a family of two in a 1000-1250 square foot house was 5093 kWh – well below the baseline allowance of 7283 kWh. The equation suggested that use by a family of four increased use relative to a smaller family by 1,054 kWh or 14% of baseline, but that figure was barely insignificant at a 10% confidence level.

G. Water Pumping

Because end-use information was available from Edison, a quick review of the impact of water pumping on energy use was conducted. We added a variable indicating the presence of a water well to economic and demographic equations for basic uses in Zones 10, 13, and 17. The presence of a well was associated with increased consumption of 170 kWh / month in Zone 13 and 225 kWh / month in Zone 17. The presence of a well in Zone 10 had no statistically significant impact.

H. Vacation Homes

Most vacation homes on the Edison system are concentrated in Zones 15 (Palm Springs and associated desert) with about 15.8% vacation homes and 16 (southern mountains). In Zone 15, 15.8% of basic users and 13.9% of all-electric users were vacation homes. In Zone 16, the percentages were higher (26.7% basic, and 44.2% all-electric. No other zone had more than about 5% of these homes. Table 29 provides usage data in Zones 15 and 16.

Table 29: Use by Permanent Residents and Vacation Homes, SCE Zones 15 and 16

		Permanent	Vacation	Difference
basic				
	15	9,282	8,451	-9%
	16	6,540	2,439	-63%
all-electric				
	15	11,631	8,449	-27%
	16	sample size =12		

Differentials in use between vacation homes and permanent residents are somewhat smaller in Palm Springs than in PG&E zones with vacation homes. However, because vacation homes are occupied more in the winter months, differences are largely concentrated in the hotter summer season.

The results are similar to PG&E's mountain users in SCE's Zone 16, with a 63% reduction in use. Zone 16 results are also similar to those of Bear Valley Electric (BVE) a small utility serving the Big Bear Lake region in the southern mountains.

BVE's permanent residents used an average of 450 kWh per month, while vacation homes used 63% less or 165 kWh per month. (Switzer, 2002)

I. Findings

1. Because a large number of observations had to be discarded due to the inability to match zip codes to baseline zones, there were limitations arising from the sample size for Edison that were not as evident as for PG&E, and as a result, the findings are generally not as conclusive as for PG&E and SDG&E, for which larger samples were generally available. Very little information is available about basic use in Zones 13-16 and all-electric use in all but Zone 10.

2. Edison, like PG&E and SDG&E shows a wide spread in usage by income and family size, with a seven-fold difference between the lowest and highest basic users in the two largest baseline zones.

3. Again, a large fraction of the difference between lower and higher income households results from housing characteristics. Much of the increase arises because households with higher incomes are more likely to live in larger dwellings and in single-family units than households with lower incomes.

4. On the Edison system, explicit income variables appeared after controlling for housing characteristics in Zone 10 and 17. In Zone 10, they were more modest than in Zone 17, which is consistent with differences between coastal and inland zones of PG&E. In Zone 17, variables also showed that usage increased as a result of the combination of large household size and high income in Zones 10 and 17. The presence of interactive variables of income and family size in Zone 17 was also more consistent with patterns found in PG&E inland areas.

5. The influence of family size on usage was somewhat less for Edison than for the other two utilities.

    a. In Zone 10, adding a second person added only 45 kWh per month; it was 100 kWh per month in Zone 17. These figures are slightly less than the 75 kWh per month in coastal zones for PG&E and SDG&E and 150 kWh per month in PG&E's inland zones.

    b. Going from two to four persons in a household adds 80-90 kWh in Zones 10 and 17 basic and Zone 10 all-electric. These figures are lower than the 150 kWh per month added in most PG&E zones comparable to the 80-90 kWh per month added in SDG&E.

    c. In Zone 13, there was a very erratic pattern of usage by number of people after controlling for square footage and income, probably resulting from the small sample. Adding a second person increased use by 240 kWh per month – an amount higher than observed in any PG&E basic zone, but adding additional people increased use by only 5 kWh per month.

    d. Interactive variables showing greater use by large families with high incomes appeared in Edison's Zone 17 Basic equation.

    e. The very largest size families actually tended to use less than families of four or five in almost all zones. This phenomenon was so widespread that I believe it not to be an artifact of the data but to be a real factor in describing use by Edison's customers.

6. Presence of a person over 60 or a retiree in a household had virtually no influence on usage in any of the zones, unlike the other two utilities.

7. The presence of a water well is likely to increase use. The average increase found was 170-225 kWh per month for basic customers in Zones 13 and 17. No statistically significant impact was found in Zone 10.

8. Vacation homes use less than permanent residents. The difference is smaller in the low desert than in the southern mountains. However, the difference is concentrated in the summer months in the low desert because many vacation residents only spend the winter there.

9. Large households earning slightly above the CARE eligibility level are not as likely to exceed 130% of baseline as those served by PG&E and SDG&E.

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