Is Energy Efficiency Enough? An Exploration of California Per Capita Electricity Consumption Trends

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ABSTRACT

California's Global Warming Solutions Act of 2006 (AB32) mandates that the long-standing pattern of ever-increasing energy consumption from fossil fuels be summarily reversed. How this is to be accomplished is still largely an open question. This paper focuses on California's success in achieving relatively stable per capita energy usage within the context of a growing population and a vibrant economy. Using publicly available historical data, the authors raise a number of questions about the extent to which estimates of savings from utility energy efficiency programs and state building and appliance standards, can *fully* account for the state's ability to hold per capita electricity consumption relatively stable. Focusing on the residential sector, they point to a number of other characteristics that could have contributed to California's relatively stable per capita electricity consumption.

Introduction

In 2005 California energy policy makers and regulators established energy efficiency (EE) as California's highest priority resource for meeting energy needs in a clean, reliable, and low-cost manner.[1] In 2006, the California legislature and governor positioned energy conservation and efficiency as the cornerstone of the state's Global Warming Solutions Act. The Act mandates a 2020 statewide limit on GHG emissions to 1990 levels. Compliance will be nothing short of Herculean: California will have to reduce per capita energy usage in a manner that accommodates continued brisk population growth and protects the state's economy from economic dislocations and recessionary pressures.

The CEC and CPUC point to California's historical record in saving energy (Figure 1), coupled with its current stable per capita electricity U.S. relative to the balance of the U.S. (Figure 2), as proof that it is up to this formidable challenge:

"Because of its energy efficiency standards and program investments, electricity use per person in California has remained relatively stable over the past 30 years, while nationwide electricity use has increased by almost 50%." (CPUC and CEC, 2006, 2) [2]

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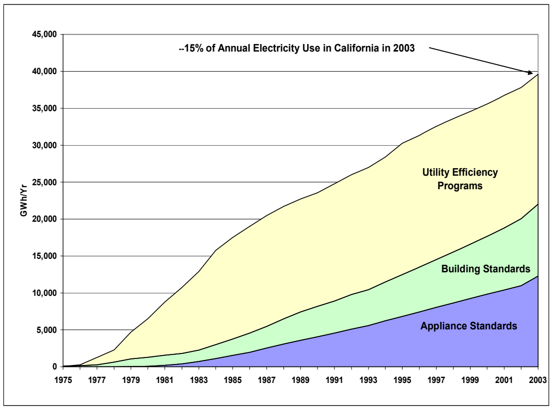
[1] California's *Energy Action Plan II* adopted in 2005 by the California Public Utilities Commission (CPUC) and California Energy Commission (CEC) established a "loading order" of preferred resource -- placing EE as the state's top priority procurement resource -- and set aggressive long-term goals for EE (CPUC and CEC, 2005).

[2]. See also the CEC's 2007 Integrated Energy Policy Report (IEPR), adopted December 5, Executive Summary at 2 (CEC, 2007):

"Largely as a result of these [energy efficiency] policies, California has the lowest electricity use per person in the nation. While the United States has increased by nearly 50 percent over the past 30 years, California's per capita electricity use remained almost flat, demonstrating the success of a variety of cutting-edge energy efficiency programs and cost-effective building and appliance efficiency standards." (emphasis added).

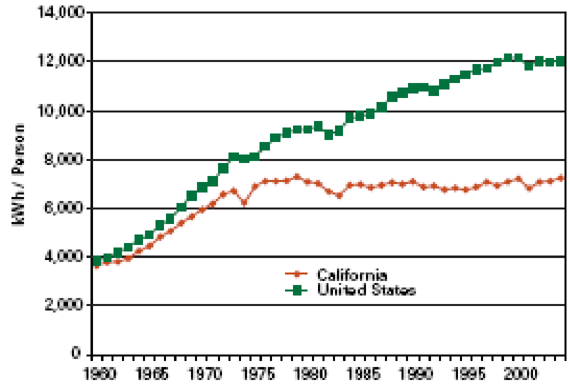
Further, see CPUC and CEC, 2008, 7:

Figure 1. California Cumulative Energy Gwh Savings: Utility EE Programs and State Bldg. & Appliance Standards



Source: Data supplied by the CEC.

Figure 2. Per Capita Electricity Use in the United States and California: 1960-2004



Source: CPUC and CEC, 2006, Figure 1.

Figure 1 shows that the CEC and CPUC take credit for saving on a cumulative statewide basis from 1975 to 2004 about 40,000 GWh, or the equivalent of 15% of annual electricity, through a combination of utility EE programs and state building and appliance standards. Figure 2 illustrates the trend in average per capita total consumption in California and the U.S. between 1960 and 2004. It shows that until the mid-1970s, total electricity use in California and the U.S. increased at about the same rate. After that California's usage leveled off, while usage in the U.S. as a whole continued to increase. [3]

California's GHG reduction policy appears in large part premised on the state having already achieved a strong and direct "cause and effect" between energy savings (utility EE programs and building and appliance standards) and energy consumption. The authors decided to explore this connection, and the extent to which there are factors in addition to EE savings in California that could have contributed to the state's relatively stable per capita electricity consumption trends.

There are several possible approaches to assessing the role of EE savings in electricity consumption trends. One approach looks at the extent to which EE savings have a <u>direct</u> impact on electricity consumption. This approach explores how <u>annual</u> changes between California savings (and other key variables such as electricity prices and weather) and are linked to <u>annual</u> variations in California per capita consumption. A second approach considers how California's <u>long term trends</u> in electricity prices, weather, household size, housing size, "conservation ethic", and industrial mix, differ from the rest of the U.S., and as such could help explain California's

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"Below we have included one of <u>California's famous graphics of success in energy efficiency</u>. As Figure3 indicates ["U.S. v. California Per Capita Electricity Sales"], electricity use per person in California has remained relatively stable over the past 30 years, while nationwide electricity use has increased by about 50 percent.

<u>While this stabilization of per capita electricity use is something we are proud of</u>, it is not nearly enough to meet our AB 32 goals. To address this emissions reduction challenge for electricity, we will need to bend this curve downward, because, among other reasons, the population of California continues to grow rapidly, causing overall electricity use in the state to continue to rise by between one and two percent every year." (emphasis added)

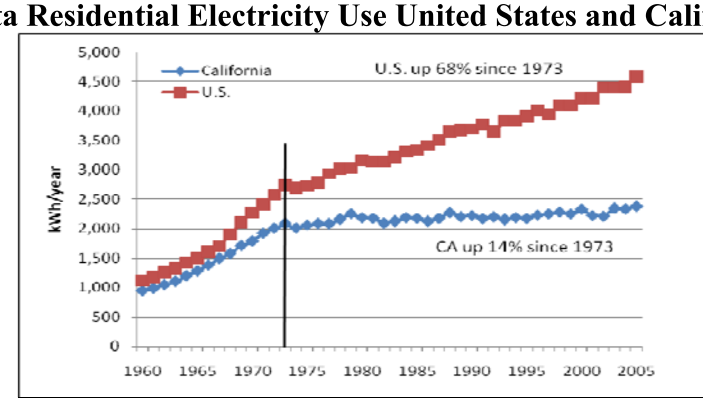
[3] Note Figure 2 reflects total per capita consumption, which includes or has embedded in it economic structural changes over time. To isolate this effect on per capita consumption from EE savings, in our statistical analysis to the extent data was available we utilized residential per capita consumption.

divergence in per capita consumption trend. A third approach considers the relationship between California and the rest of the U.S. electricity savings and per capita consumption by first quantifying the effect of other variables such as price, weather, household size; and then through an indirect "process of elimination" establishes the remaining "gap" between California and the U.S. as attributable to EE program savings. In this paper, we outline our attempts to observe a relationship between EE program savings and per capita electricity consumption via both (a) the annual changes and (b) the long term trend differences in California and the U.S. We conclude with a call for more research on both these issues.[4]

Attempts to Observe a Correlation between EE Savings Data and Consumption Data through Annual Variations

In this section of the paper, we describe our efforts to observe a correlation between savings data and per capita electricity consumption. [5] To increase the likelihood of finding a relationship, this analysis focused on the per capita consumption of *residential* electricity. Confining the analysis to the residential sector made taking into account annual fluctuations in economic structure and economic activity less imperative. Also, the CEC's new historical savings estimates that we worked with did not include a series for total savings.[6] The divergence between California and the U.S. in terms of per capita total electricity consumption shows a similar pattern in the residential sector as for total consumption (Figure 3).

Figure 3. Per Capita Residential Electricity Use United States and California: 1960-2004



Source: EIA State Energy Data System

[4] We offer two major caveats about the data used. First, the CEC's EE savings data are *estimates* based on utility reported savings adjusted for various factors and *estimates* of savings from state building codes and appliance standards (see CEC, 2007, 25-26). From the published data, there is no way of knowing the extent to which this data series reflects the actual savings from utility EE programs, state codes and standards. Second, we should note that per the recommendation of the peer review of this paper in draft, we have updated our analysis using a new CEC residential sector data series that differs substantially from the historical series it replaced, especially with regard to the savings from utility EE programs.[4] (It appears that the CEC's updated residential sector EE savings from utility programs data series is on a long-term cumulative basis much lower than the old series it replaced. Because the entire data set has not been made available to us, it is not appropriate to infer that the entire updated EE savings data series is lower on a long term cumulative total basis. We did not run a multiple regression on the earlier data series, but the simple regressions using both series showed similar results.) This reinforces the first point above, about the precision of the savings estimates.

[5] We used regression analysis to do this.

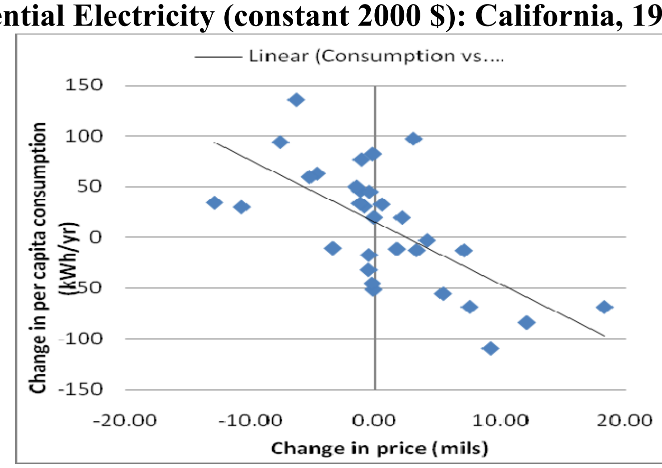
[6] Series for the residential and commercial sectors have been published, but to date we have not been able to obtain an historical series of total savings.

The following analysis is based on residential sector savings data from the CEC for 1975-2005 (savings from utility EE programs and state building and appliance standards); 1975-2005 residential electricity consumption data, population estimates, and the price of residential electricity (in constant 2000$, using the EIAs price deflators) from the Energy Information Administration's state and historical database, and California Population-Weighted Cooling Degree Days data from the National Climatic Data Center, NOAA.

This initial analysis focuses on the extent to which *annual variations* in per capita consumption are correlated with *annual changes* in estimates of cumulative savings (i.e. annual savings) from utility EE programs and state building and appliance standards, and annual changes in annual savings.[7] Annual variations in per capita consumption in California are very large relative to the annual savings. In order to try to account for some of this variability in consumption, we included in the analysis annual changes in residential electricity prices and annual changes in the number of cooling degree days.

Figures 4, 5 and 6 plot the change in annual per capita residential electricity consumption against the independent variables (single variable regression analysis). Figures 4 and 5 show that there is a fairly clear pattern to the relationship between changes in consumption and price (Figure 4) and changes consumption and cooling degree days (Figure 5). The data points are far more widely scattered in Figure 6 (the change in consumption versus annual savings).

Figure 4. Change in Per Capita Residential Electricity Use vs. Change in Price of Residential Electricity (constant 2000 $): California, 1975-2005

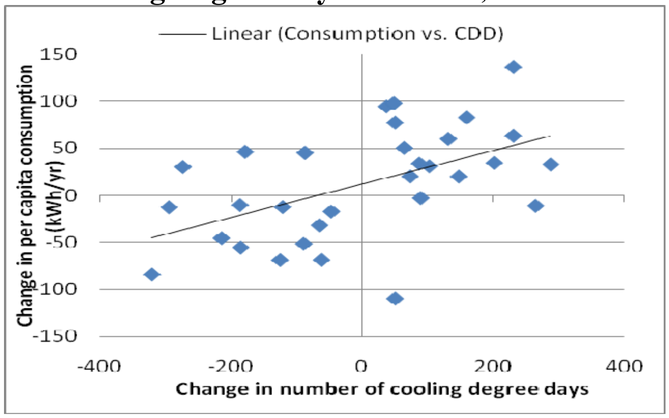


Source: EIA State Energy Data System

[7] That is, we used two savings variables in the analysis both of which were based on cumulative savings data. The data we refer to as "annual savings" are simply the annual increment to the cumulative savings data. The data we refer to as "change in annual savings" are the changes in the annual savings levels. For example:

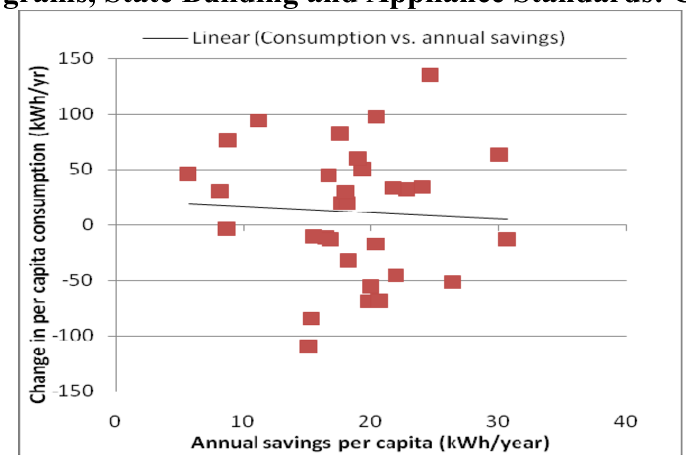
	Cumulative savings	Annual savings	Change in annual savings
Year 1	100		
Year 2	200	100	
Year 3	400	200	+100
Year 4	500	100	-100

Figure 5. Change in Per Capita Residential Electricity Use vs. Change in Number of Cooling Degree Days: California, 1975-2005



Source: EIA State Energy Data System; National Climatic Data Center, NOAA

Figure 6. Change in Per Capita Residential Electricity Use vs. Annual Savings Per Capita from Utility EE Programs, State Building and Appliance Standards: California, 1975-2005



Source: EIA State Energy Data System; CEC, 2007b, Appendix A

In probing the historical data and information, we did not succeed in finding a statistically significant relationship between EE savings levels and annual consumption patterns. A big challenge to finding a correlation is that the annual changes in per capita consumption are huge relative to the annual changes in EE savings. For example, between 1975 and 2005 the mean annual variation in per capita residential electricity consumption was 12 kWh (on average, consumption is increasing every year). However, the standard deviation of the annual change in consumption was 59 kWh. In contrast, the mean annual EE savings per capita was 18 kWh, but with a standard deviation of just 6 kWh. Moreover, the changes in annual EE savings were even smaller, with a mean of close to zero and a standard deviation of 4 kWh.

To try to account for some of the variation in annual electricity consumption, we incorporated into the analysis residential electricity prices and the number of cooling degree days. A multiple regression with savings, prices, and cooling degree days as independent variables and residential electricity consumption as the dependent variable showed that prices and weather do affect consumption (increases in price are associated with relative decreases in consumption, and increases in the number of cooling degree days are associated with relative increases in consumption). The price and cooling degree days variables were statistically significant at the 95% level, with the coefficients for these variables showing both the expected signs, and considerable stability in different configurations of the regression. We were, however, unable to observe a statistically significant relationship between consumption and annual savings, or changes in annual EE savings, despite running many versions of the regression with and without single and multiple lags on the EE savings data and its derivative (the change in annual savings).[8] The coefficients for annual savings per capita were fairly stable, being consistently negative (higher annual savings were associated with relative decreases in consumption), but also not significant in any of the regressions. The coefficients for changes in annual savings were sometimes positive and sometimes negative, depending on the number of years the data were lagged.[9] A positive coefficient would mean that an increase in savings led to an increase in consumption. This variable was not statistically significant in any of the regressions. A basic version of the regression is presented below (Table 1). Tests for first, second, and third order autocorrelation and heteroskedasticity indicated that these were not significant issues in this regression.

Table 1. Regression Results for Annual Change in Per Capita Residential Electricity Consumption in California: 1975-2005 Relative to Changes in Price, Cooling Degree Days, Annual Savings and Changes in Annual Savings

Regression Statistics						
Multiple R	0.7563					
R Square	0.572					
Adjusted R Square	0.5062					
Standard Error	41.3107					
Observations	31					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	4	59309.4896	14827.3724	8.6884	0.0001	
Residual	26	44370.8456	1706.571			
Total	30	103680.3352				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	34.454	25.0364	1.3762	0.1805	-17.0091	85.9171
Change in price (mils)	**-5.1541**	1.2708	-4.056	0.0004	-7.7662	-2.542
Change in CDD	**0.104**	0.0477	2.1805	0.0385	0.006	0.202
Change in annual savings per capita kWh*	**2.7796**	1.917	1.45	0.159	-1.1608	6.72
Annual savings per capita kWh*	**-1.1746**	1.3017	-0.9024	0.3751	-3.8502	1.501

* = not statistically significant at the 90% or 95% level

We also tried using moving averages of the data to soften some of the spikes in the original data, thus distributing some of the variation across several years. The price and cooling degree variables remained significant in these regressions (with expected coefficients), but the EE savings variables remained problematic.[10]

8 We tried lagging the annual savings and change in annual savings data by 1, 2, and 3 years. In none of these analyses were the savings coefficients statistically significant at the 90% or 95% level.

9 See footnote 7.

10 The results of these additional analyses are available from the authors.

The results presented in Table 1 show that the independent variables in this regression (change in price, change in CDD [cooling degree days], change in annual savings, and annual savings) explain about half of the variation in per capita residential electricity consumption (the dependent variable). The coefficients of the price and CDD variables (-5.1541 and 0.1040, respectively) are statistically significant (i.e. they are significantly different from zero). The coefficients of the savings variables are not statistically significant (2.7797 and -1.1746). The regression indicates that price is negatively correlated with consumption (higher prices lead to lower relative consumption), while the number of cooling degree days is positively correlated with consumption (increases in the number of CDDs lead to increased relative consumption). The coefficient for annual savings is negative, which means that higher savings lead to lower relative consumption, but, paradoxically the coefficient for the change in annual savings is positive (that is, *increases* in annual savings correlate with *increases in* relative consumption).[11]

This preliminary analysis shows that more of the annual variation in consumption needs to be controlled for, and/or more detailed data are needed, before we can understand the impact of savings in explaining the variance in per capita consumption. Given this, and the limitations of using estimated savings data, we conclude that it is more productive to focus on variables that could explain the difference between California and the U.S. as regards long term per capita consumption trends.

Additional Long-Term Trends Distinguishing CA's Divergence in Per Capita Consumption from the Rest of the U.S.

The analysis above suggests that in order to understand the factors influencing California's overall trend in consumption we need to look beyond annual fluctuations in CA EE savings, electricity prices, and weather (cooling degree days). In this section we look at the same factors as in the previous section, as well as some additional factors, but instead of focusing on annual changes in consumption we focus on the extent to which these factors could have contributed to the different long term consumption trends evident in California and the U.S. That is, we have sought to identify a number of ways in which California is different from the rest of the country that, in addition to the savings from utility EE programs and state building and appliance standards, could help explain the longer term divergence between California and the U.S. as regards per capita consumption of residential electricity. Our preliminary work on this broader perspective indicates that there are a number of distinctions between California and the rest of the U.S. that could influence the state's overall consumption trend. In addition to EE savings, electricity prices, and weather, the effect of household size and housing mix could influence long-term consumption trends. Likewise, data on energy use in California and the rest of the U.S. indicate that a "conservation ethic" may have developed in California which changes consumer behavior and reduces consumption. As regards total electricity consumption (as opposed to residential consumption), shifts in underlying economic structure could be important in helping to account for the California trends. This section aims to identify some to the factors that could contribute to the difference between consumption patterns in California and those in the U.S. We do not seek to quantify their effects. Our itent is simply to raise the question of

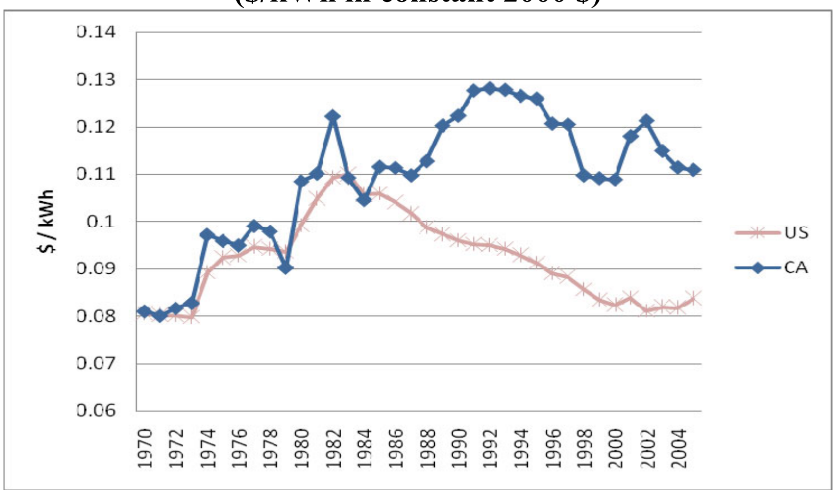
[11] As noted above, however, the sign on the coefficient for change in annual savings switched from positive to negative depending on the number of years the data were lagged. Moreover, we can have little confidence in either of the savings results, because of the high "p values" (> 0.05) associated with the coefficients (see footnote 8 for a brief explanation of "p" values).

whether factors other than EE savings could have played a role in helping to stabilize California's per capita consumption of residential electricity. To this end we looked at factors that could contribute to reducing electricity consumption, for which California is currently distinct from the country as a whole. For several of these factors, we also looked for evidence of a diverging trend between California and the U.S. since the 1970s.

Price of Residential Electricity

Figure 7 illustrates that since the late-1980s residential electricity prices in California have been consistently higher than in the U.S. as a whole, and that over the past thirty years a pattern of divergence is evident.

Figure 7. Real Price of Residential Electricity California and U.S: 1970-2005 ($/kWh in constant 2000 $)



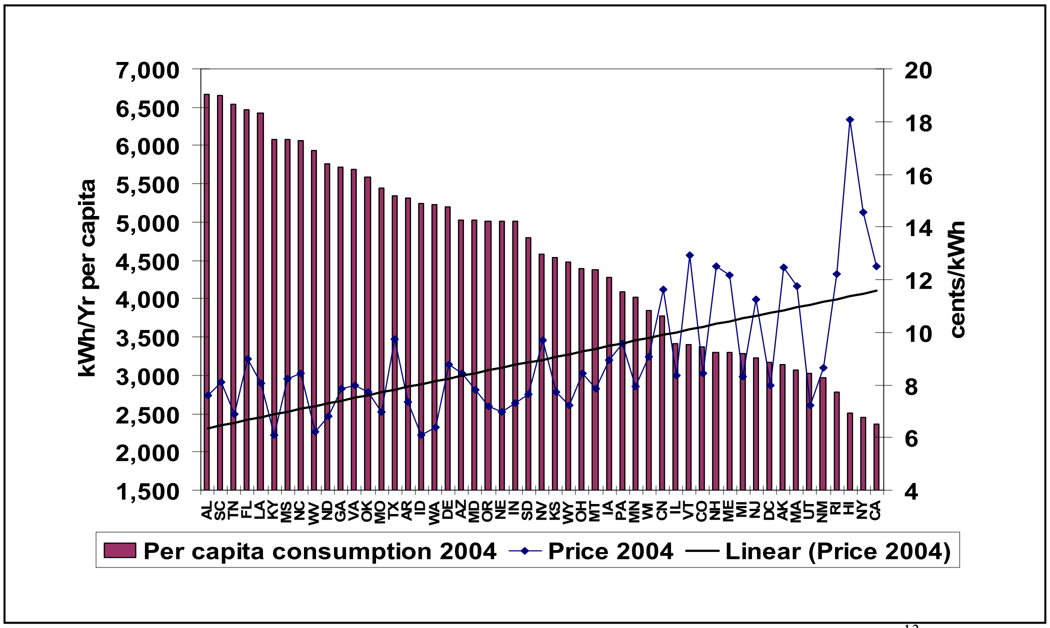
Source: Energy Information Administration, State Energy Data System

Between 1970-2005, the price of residential electricity in the US as a whole remained fairly constant in real terms. California prices began the period at a similar level to those in the U.S. but have increased by 37 per cent since 1970. These patterns may have contributed to the divergence between the U.S. and California as regards per capita electricity consumption because there is a fairly strong relationship between price and consumption. National data on residential energy prices and residential per capita consumption indicate that those states with higher energy prices have lower per capita consumption and vice versa (Fig. 8).

If there is a planetary imperative to reduce overall energy consumption, and California's marked in departure in historical per capita consumption trend to the balance of the U.S. is in large part, energy price induced, one might ask, why not just raise energy prices further? California energy policymakers and regulators discuss EE as the one component of the state's aggressive GHG emissions reduction policy that will keep money in state and local economies, while all of the other GHG reduction strategies will cost a lot of money. In other words, California is counting on EE program to help moderate energy prices and keep the economy going.[12]

[12] See CPUC and CEC, 2006, 3: heading "Supports Economic Development and Creates Jobs in California".

Figure 8. Per Capita Residential Electricity Consumption and Price of Residential Electricity: 2004 by State



Source: Energy Information Administration, State Energy Data System. [13]

Climate

California has a relatively moderate climate which greatly affects the amount of residential electricity that is used for space cooling in the summer. Heating is less of an issue for this paper because of the dominance of gas heating in the state. A good summary measure of the difference between California and the U.S. as regards climate is the annual number of cooling degree days each experience. For the period between 1975 and 2005, California had an average of 932 cooling degrees annually. This is substantially less than the U.S. average of 1,274 cooling degree days, and represents an average difference of 342 CDDs (data from National Climatic Data Center).

Household Size

One of the factors that distinguishes California from the U.S. as a whole is household size. California households are larger than the average for the U.S: in 2004 they contained an average of 2.9 persons compared to a U.S. average of 2.6 persons. Furthermore, since 1980, the

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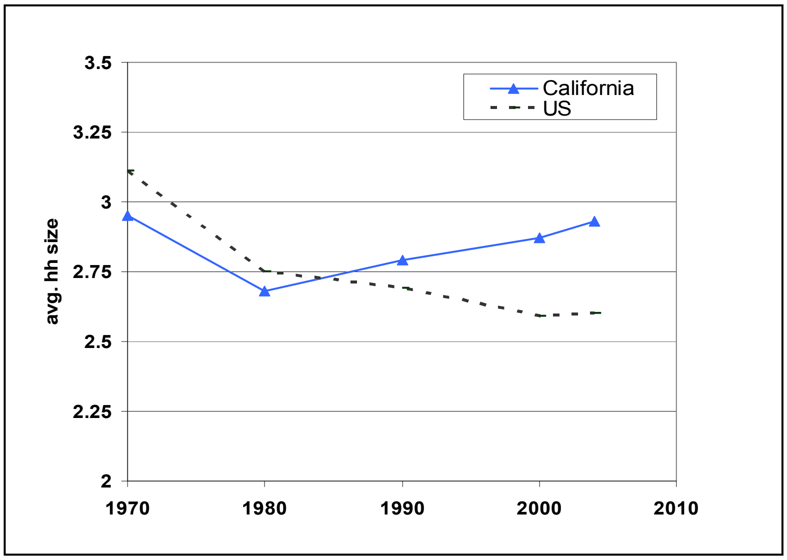
"Energy conservation and energy efficiency support economic development and create jobs by lowering energy cost, which allows businesses and households to make greater investments in non-energy goods, equipment, and services and reduces the outflow of money spent on imported energy supplies**."**

[13] Note: Physical unit prices for States are calculated for all four sectors as the average revenue per kwh of sales by all electric power retailers reporting sales to a State. Revenue and sales data: Form EIA-861 "Annual Electric Power Industry Report" database, as published in the EIA *Electric Sales and Revenue*, are used to calculate physical unit prices. Prices for the residential and industrial sectors are based directly on the database (see EIA, 2005 for details)

trend in household size in California has followed a different pattern than in the country as a whole, with household size increasing rather than decreasing (Fig. 9).

Figure 9. Average Household Size in California and the United States



Source: U.S. Census Bureau

Household size is important because while each additional person in a household adds to household consumption, they do so by a declining amount (Marcus, Ruszovan & Nahigian, 2002, Figure 3). This is the case, even when housing type (and square footage) is controlled for.[14] Given that larger households consume less electricity per person than smaller households, these trends in household size may have contributed to the divergence between California and the U.S. in terms of residential electricity consumption.

Housing Mix

California has become more highly urbanized with multi-family and attached housing accounting for 39 per cent of total units in 2000, compared to an average of 31 per cent in the rest of the U.S. In addition, the state has diverged from the rest of the U.S. in this respect: since 1970 the proportion of total units accounted for by multi-family and attached housing has increased in California, whereas in the rest of the country it has remained stable.

Housing mix may influence per capita consumption because multi-family units tend to use less electricity even after other factors have been controlled for. In the study cited above, the independent effect of a single family unit (with household size, household income, and square footage held constant) was to increase electricity consumption by 693 kWh per year (Marcus, Ruszovan & Nahigian, 2002, Table 2). The authors indicate that this is "at least in part because

[14] For example, in the study above, a two-person household in a multi-family unit of 1,000 to 1,250 sq ft was predicted to use 3,506 kWh per year. A four-person household in the same type of housing was predicted to use 4,550 kWh, with use rising to 4,882 kWh per year for a household of 5 persons or more. That is, doubling the number of people in the household led to an increase of 30 per cent in electricity consumption (Marcus, Ruszovan & Nahigian , 2002, Table 4, 20).

of higher space conditioning requirements for the same square footage for units that are not attached to each other.” (Marcus, Ruszovan & Nahigian, 2002, 18)

California’s “Conservation Ethic”

While we found that the issue of how well annual changes in savings from EE programs predict changes in per capita consumption of electricity in California needs to be explored further, the state’s focus on EE and conservation issues, along with the impact of price differentials, may have helped to create a “conservation ethic”. Data from the Residential Energy Consumption Survey 2001 show that California households are more likely than those in the U.S. overall to report that they lower their winter temperature settings, either when no one is home or during sleeping hours. The Residential Energy Consumption Survey (RECS) data indicate that 58.5 per cent (with a 95% confidence interval of ± 5.9%) of California residents lower their winter temperature settings when no one was home compared to 44.1 per cent (with a 95% confidence interval of ± 1.8%) of all U.S. residents. Furthermore, 56.9 per cent (± 5.6%) of Californians lower their temperature settings during sleeping hours compared to 42.7 per cent (± 1.7%) of US residents. While this does not contribute significantly to reduced electricity usage, it is in keeping with other data that support the idea on a California “conservation ethic”. For example, in California a smaller proportion of households report using a clothes dryer than is the case for the U.S. as a whole (65% compared to 74%) and fewer households have a freezer separate from their refrigerator than nationally (RECS, 2001, Table CE4-7c and RECS, 1997, Table HC5-7a). These findings likely reflect the state’s efforts with regard to EE and the promotion of energy conservation.

The Economy and Total Electricity Consumption

The discussion above has focused on characteristics that could affect the consumption of residential electricity in California relative to the U.S. California also has shown a divergent pattern in terms of total electricity consumption. One of the factors that can influence a state’s total consumption of electricity, and energy, is the type of industries that dominate the economy. The manufacturing sector is second only to transportation in terms of its share of total energy consumed nationally, and so can heavily influence overall consumption levels. This part of the paper looks at the manufacturing economy in California, and raises the issue of whether within manufacturing differences between California and the U.S. could have played a role in keeping total per capita consumption of electricity in the state relatively constant.

In aggregate terms, California very much mirrors the rest of the U.S., with the service-providing sector accounting for about 83 per cent of employment. In terms of value added, the California service-providing sector is a little more dominant than in the rest of the U.S. (in 2005, 81 per cent of California GSP was accounted for by the service-providing sector compared to 77 per cent nationally [U.S. excluding California]). In the year 2000, manufacturing industries accounted for 13 per cent of employment and 14 per cent of Gross State Product (GSP)[15] in California, values that were similar to those for the rest of the U.S. Since then, the downturn in manufacturing, especially in industries such as the manufacture of computers and electronic

[15] Gross National Product (GNP) and Gross State Product (GSP) is a measurement of the value of all the goods and services produced in an economy (national or state), plus the value of the goods and services imported, less the goods and services exported.

products that have a strong representation in California, has meant that the manufacturing sector's share of GSP has fallen to 10 per cent. In the rest of the U.S. it is higher, at 13 per cent (Bureau of Labor Statistics, 2005).

The mix of industries in California may be a contributing factor to the state's relatively stable consumption trend. Our analysis suggests that the manufacturing sector has contributed both to the relatively low levels of per capita consumption of electricity in California, and the divergence between trends in consumption in the state and those in the rest of the U.S. The California manufacturing economy is more heavily dominated by non-energy intensive industries than is the case nationally and between 1990 and 2005 employment in energy-intensive industries declined more in California than was the case for the rest of the U.S.

In terms of value added, California industry groups that include the EIA's energy-intensive industries[16] account for 37 per cent of the manufacturing sector, compared to 41 per cent in the rest of the nation. The only industry group which accounts for a higher proportion of manufacturing GSP in California than manufacturing GDP nationally (excluding California) is petroleum and coal products (in 2005, this industry group accounted for 9 per cent of California manufacturing GSP and 4 per cent of national (excluding California) manufacturing GDP). The other energy intensive industry groups account for a lower proportion of manufacturing GSP in California than in the rest of the country. In addition, in California the petroleum industry group has increased its share of manufacturing GSP in recent years – in 2000, for example, the difference between this group's share of manufacturing value added in California and the rest of the country was less marked (2 per cent vs. 4 per cent).

As regards employment, in California energy-intensive manufacturing accounted for about 23 per cent of total manufacturing employment in 2005 compared to 28 per cent in the rest of the U.S. (U.S. excluding California). We were able to break the employment data down into finer industry categories, and found that within the chemical sector, pharmaceuticals dominate in California, accounting for over 50 per cent of employment in the chemical industry in 2005 compared to 31 per cent in the rest of the U.S. The pharmaceutical industry is distinct from the "bulk chemical" manufacturing industry, which is the energy intensive part of the chemical industry group. If the pharmaceutical industry is excluded from the employment data, the proportion of manufacturing employment accounted for by energy- intensive industries falls to 20 per cent in California and 26 per cent in the U.S. (Bureau of Labor Statistics, 2005).

In terms of trends over time, in California energy-intensive manufacturing industries have shown greater reductions in employment than is the case for the rest of the U.S. This helps explain the divergence between the two in terms of overall energy consumption per capita. Between 1990 and 2005, employment in the groups of industries characterized by high energy use fell by 20 per cent in California compared to 16 per cent in the rest of the U.S.[17]. Trends within the primary metal industries provided additional evidence to suggest that employment in the specific industries that are particularly energy intensive declined to a greater extent in California than nationally. In California, employment in the energy intensive aluminum industry declined by 40 per cent compared to 31 per cent in the rest of the U.S. Conversely, employment in the *less* energy intensive pharmaceutical industry (a sub- industry within the chemicals group) grew more rapidly in California than nationally (by 81 per cent compared to 34 per cent). In

[16] Most of these industries are also characterized by high usage of electricity (see MECS, 2002, Table 1.2).

[17] Comparable data for the same period were not readily available for value added because of changes to the industrial classification system. Employment by industry data have been reanalyzed back to 1990 to create an historical series for the NAICS. For value added these data are available only from 1997 at the state level.

addition, the energy intensity of one of California's most important industries, computer and electronic product manufacturing (which accounts for over one-fifth of both manufacturing employment and manufacturing value added in the state, compared to 10 per cent nationally), has declined substantially over the past 20 years. Not only is this industry a relatively low user of energy, but its use of energy per $ value added has also declined (Indicators of Energy Intensity in the U.S, 2007). If one of California's most important industries is a relatively low user of energy, and that industry's energy intensity has declined over the past two decades, this could have implications for total per capita electricity consumption levels in the state (helping to keep it stable), as well as the pattern of divergence between California and the United States.

This analysis indicates that the manufacturing sector may have contributed both to the relatively low levels of per capita consumption of electricity in California and the divergence between trends in consumption in the state and those in the rest of the U.S. The California manufacturing economy is more heavily dominated by non-energy intensive industries than is the case nationally and between 1990 and 2005 employment in energy-intensive industries declined more in California than was the case for the rest of the U.S.

California's Thirty Years of Utility Program Energy Efficiency Savings

Interestingly, our per capita analysis provides additional insight to our earlier separate analysis concerning the utility EE program savings portion of California's cumulative energy savings per Figure 2.[18]

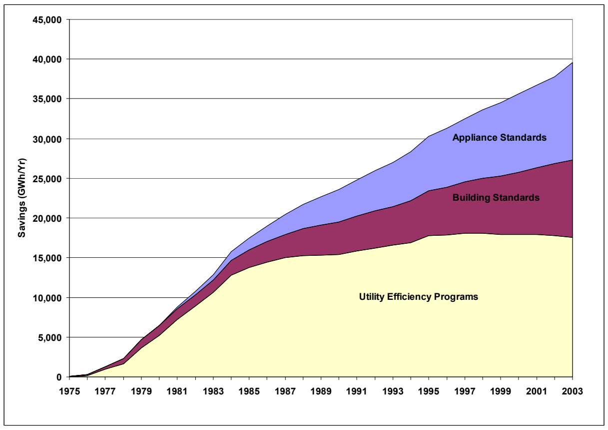
Our findings from our earlier work on California utilities' EE program savings are summarized as follows:

- Since the late 1980's California utility EE programs have contributed to only a modest growth in new or incremental savings; state building and appliance standards apparently register the lion's share of continued EE savings growth.[19] This is illustrated per Figure 10 below which reorders or restacks the CEC's forecast of California's historical cumulative EE savings shown in Figure 1 so that the utility EE program savings are layered in first, followed by state building and appliance standard savings.

[18] Work of Energy Economics Inc. as consultant to TURN in R.06-04-010 2nd and 3rd quarters 2007. EE Inc. per capita analysis separate from the TURN work. http://www.cpuc.ca.gov/Published/proceedings/R0604010_doc.htm This analysis uses the CEC's earlier version of the savings data for the following reasons (1) per Figures 1 and 2 and footnote 2, it is the data used by the CEC and CPUC in its representation that CA EE policies have in whole or large part resulted in CA's relatively stable and lower per capita consumption, and (2) the CEC's newer data set has not in total been made available. To the extent that the CEC's newer data set reflects lower cumulative utility EE savings merely reinforces the analysis discussed in this section.

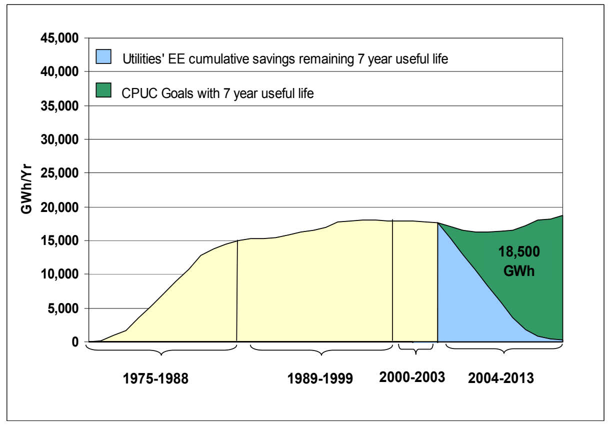
[19] The characterization of California's historical building and appliance standard EE savings is an entirely separate matter worthy of additional detailed analysis, given the fact that the savings are highly dependent on assumed levels of compliance rates. Appliance standard compliance rates are easier to estimate because (1) appliance standards set dates for changes in appliance manufacturing and stocking, and (2) appliance turnover rates can be tracked through retail sales data (with additional consideration needed on whether the replaced appliance enters a secondary market).

Figure 10. Re-ordered California Cumulative Energy GWh Savings: Utility EE Programs and State Building and Appliance Standards



Source: Data supplied by California Energy Commission

Figure 11. Forecast of California Cumulative GWh Savings 2004-2013 Based on Utilities' Projected 2006-08 EE Program Savings



Source: Analysis of savings data supplied by the CEC and goals in CPUC, 2004, Table 1E

- This is in part because the utilities have relied on EE measures that are short-lived, such as compact fluorescent lamps, (CFL). In essence what this means is the California utilities are "treading water" when it comes to growing cumulative long-term EE savings by in large part saving the same kilowatthours over again and again.
- The historical California utility EE program savings data used by the CEC in its DSM forecasting model is as reported by the utilities' on an *ex ante* -- or prior to measurement and verification (M&V). It was not until 1989 that utility reported savings were adjusted for freeridership. From 1989 – 1999, some billing analysis was also used to adjust reported savings on an ex post basis. Since that time, the EE savings data has reverted to utility reported ex ante savings. Also, for the first decade (1975- 1984) of run-up in claimed EE savings from zero to slightly over 15,000 GWhs, the utility EE programs were largely home audits and education and information programs, with the first cash rebate in 1982. Thus, to represent those EE savings as equivalent "steel in the ground" supply-side resources is at best extremely far-fetched. Further, about 10% of the GWh and MW savings are ascribed to utility T&D CVR (conservation voltage reduction) implemented during 1975-1980. Such utility system efficiency savings, while beneficial, are not generally classified as consumer EE.
- If the current trend (2006-2008) in utility reliance on relatively short-lived EE measures such as CFLs continues, there will be little if any new or incremental utility EE savings towards the CPUC's aggressive EE saving targets.[20] Figure 11 shows our forecast of California's cumulative utility EE program savings from 2004 to 2013[21], based on PG&E, SCE, and SDG&E's projected 2006-2008 EE savings. It indicates a "treading

[20] The California investor-owned electric utilities assumed very low levels of freeridership in their projected savings from CFLs, generally 0.80 and 0.96 residential and nonresidential respectively. We did not adjust this factor to reflect the recent market transformation of CFLs nationally.
[21] CPUC Decision 04-09-060 September 23, 2004 adopted electric and natural gas energy savings goals for 2004-2013 (CPUC, 2004).

water" syndrome that by 2013 will result in little if any gains in new or incremental GWh savings.[22]

Conclusion

Over the past 20 years here has been a strong divergence between California and the U.S. with regard to per capita electricity consumption, both in the residential sector and total consumption. This divergence has been attributed to California's ambitious and far reaching EE programs and standards. While recognizing that these programs and standards have saved a considerable amount of electricity, in this paper we have sought to raise the issue of whether there are additional characteristics which may influence patterns of electricity consumption in California, and which could have played a role in the divergence between per capita electricity consumption in California and the rest of the United States. Focusing on the residential sector, we have identified a number of factors that distinguish California from the rest of the United States, and which may have contributed to keeping the state's electricity consumption relatively stable. Understanding the role of these factors, as well as savings from utility EE programs and state building and appliance standards, will allow for an assessment of the extent to which the 'California model' can be successfully transplanted to other states, regions, or countries.

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[22] CPUC Decision 07-10-032 October 18, 2007, Section 6.3.1. Cumulative Savings, recognized this problem of non-persistence in energy savings when the EE savings from a particular year diminish through time as the EE measures installed in earlier years decay in performance or reach the end of their useful lives (CPUC, 2007).

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