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Article

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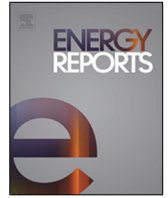
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Roles of income, price and household size on residential electricity consumption: Comparison of Hawaii with similar climate zone states

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ABSTRACT

In general, it is expected that residential electricity consumption decreases due to price increase. However, electricity consumption can also increase while electricity price increases, provided that income increases at the same rate or higher. Thus, we investigated the factors affecting residential electricity consumption in Hawaii; particular emphasis was placed on the Island of Oahu, most populated and an urban island. We determined that the average residential electricity consumption decreased by over 25% between the peak usage of 2004 and 2012. Despite a decrease in residential electricity consumption, the ratio of the average electricity bill to per capita income increased from 3% to 5%. A comparison of the islands' residential energy usage suggests that each island has its own electricity consumption behavior, suggesting the importance of dwelling type, life style and household size. Further comparison of the residential electricity consumption of Hawaii with Arizona, California, Florida and Texas suggests that there is a general decrease in residential electricity consumption. However, unlike Hawaii, reduction in residential electricity usage translates into cost savings in other states. The results suggest that the decrease in residential electricity consumption in Hawaii is simply because people cannot afford it.

Linear regression analysis indicates that household size is an important variable in determining the residential electricity consumption in Oahu, however is not a determining factor in other islands. It was also observed that unlike Oahu, income and price alone are not good indicators of residential electricity consumption for the islands of Hawaii, Maui and Kauai.

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1. Introduction

Generally, residential electricity usage varies with the household size (HHS), type and size of the residential dwelling, climate, ownership of appliances and other factors (Yohanis, 2012). Furthermore, researchers have shown that residential electricity consumption varies with income and electricity price. For example, some researchers (Dergiades and Tsoulfidis, 2008) reported that consumption is very sensitive to price in the long run, whereas other studies based on State level panel data (Sanquist et al., 2012; Alberini and Filippini, 2011) reported that consumption is relatively insensitive to price, especially in the short term.

Recently, the interest in residential electricity consumption has been renewed because of introduced energy efficiency and conservation incentives with an increased awareness of global warming. The intent of all energy incentives is to reduce electricity consumption, which in turn reduces associated carbon emissions.

Reduction of energy consumption can be organized into four different categories:

- (i) **Increased Efficiency:** Energy consumption is reduced due to the adoption of energy efficiency technologies such as LED bulbs or a refrigerator with a higher coefficient of performance. Installation of efficient appliances and lighting do not require residents' active participation to reduce energy consumption. However, without active participation of residents in energy conservation activities, new energy efficient technologies may increase the overall usage of these appliances and lighting because they are now less expensive to operate. Economists call this the "rebound effect"; when electricity consumption increases with energy efficiency improvements or increased income. The rebound occurs because of increased purchasing power. Based on historical data, Tsao et al. (2010) stated that a net increase of electricity prices by 12% will cause a reduction in electricity usage for lighting by 2030. Furthermore, Ghosh and Blackhurst (2014) found a negative correlation between energy efficiency and energy savings.
- (ii) **Building Codes:** States mandate strict energy codes for newly built or renovated dwellings to meet certain energy

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requirements. Several researchers studied the effect of introducing building codes on residential electricity demand. For example, [Aroonruengsawat et al. \(2009\)](#) reported that the introduction of building codes decreased energy consumption from 0.3% to 5% per capita depending on the state. Similarly, [Jacobsen and Kitchen \(2013\)](#) reported that building codes reduced electricity consumption by 4% in Florida. Furthermore, [Koirala et al. \(2013\)](#) stated that the application of energy efficiency building codes IECC 2003 and IECC 2006 can save about 1.8% on residential electricity consumption. [Levinson \(2014\)](#) used energy usage data from buildings in California and reported that “*there is very little evidence that buildings constructed more recently in California are using less electricity*”. [Chong \(2012\)](#) reported that new buildings use more electricity than vintage buildings. He further reported that new buildings are more responsive to high temperatures in Southern California. [Chong \(2012\)](#) predicted that residential electricity consumption will increase in new buildings.

The cited studies suggest that the effect of the building energy codes on residential electricity demand is inconclusive. Many factors can be attributed to the inconclusive results. For example, new buildings are larger in size and have several accessories such as air conditioning, pools and other equipment. Older buildings might not have such amenities and therefore may have a lower rate of energy consumption. At the same time, new houses may be occupied by a younger generation that is less susceptible or willing to take measures to reduce electricity consumption ([Jones et al., 2015](#); [Mc Loughlin et al., 2012](#); [Yohanis et al., 2008](#)).

- (iii) **Implementation of Energy Conservation Measures:** Energy demand reduction is realized by eliminating the “waste”, such as turning off the lights in an unoccupied rooms, placing the water heating pump on a timer so that it will not respond unnecessarily to temperature fluctuations during the day when no one is at home, or placing the air conditioning on a timer. Implementation of these types of energy conservation measures requires behavior changes. Researchers report that feedback on household electricity consumption leads to a decrease in electricity consumption ([Fischer, 2008](#); [Allcott, 2011](#); [Ayers et al., 2009](#)). However, [Allcott and Rogers \(2012\)](#) report that feedback related energy conservation leads to “quick action with fast slide back” behavior. Thus, the long term or residual feedback associated with energy conservation measure related energy savings needs to be further investigated.
- (iv) **Eliminating Energy Usage:** This type of energy reduction is realized by residents’ active participation. For example, if residents stop using the pool, spa or the clothes dryer at home, they will reduce their electricity consumption. [Brown and Koomey \(2003\)](#) reported that the electricity consumption of pools and spas contributed to 2% of residential electricity usage. They also reported that dryers account for 2% of the residential electricity usage in California. Thus, the preference of air drying washed clothes would surely reduce residential electricity consumption.

With rises in oil prices and a recession in 2008, almost all States in the US introduced/enhanced energy incentives programs to reduce energy consumption. Similarly, the State of Hawaii introduced the Hawaii Clean Energy Initiative (HCEI) program in 2008. The introduced HCEI program originally called for 70% renewable energy generation by 2030. After publication of our paper entitled “Conservation vs. renewable energy: Case studies from Hawaii” in 2009 ([Yalcintas and Kaya, 2009](#)), HCEI revised its goal of 40% renewable energy and a 30% reduction in energy usage due to energy efficiency by 2030.

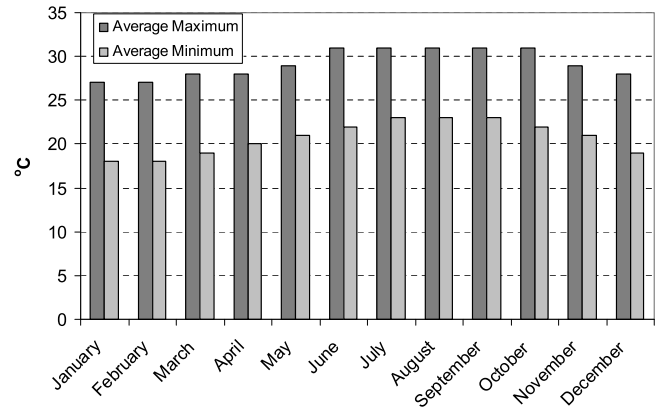


Fig. 1. Typical average monthly maximum and minimum temperatures in Oahu, Hawaii.

Numerous researchers have investigated the effect of price and income on residential electricity consumption. However, as expected, the results vary with data types as well as geographic locations and house stocking. Intuitively, it is expected that consumption decreases with price increase. However, consumption can increase with price increase as well, provided that income increases at the same rate or higher than the price increase. We believe the State of Hawaii, particularly the island of Oahu, presents a unique opportunity to examine the factors affecting residential electricity consumption, especially those of price, income and household size since year round temperatures do not vary much. In subsequent sections, we will examine the effect of each factor on residential electricity consumption and compare it with those of Arizona, California, Florida and Texas. We selected these states for comparison because these States are largely located in USA Climate Zones I, II, and III.

2. Hawaii residential electricity consumption

The State of Hawaii is comprised of several islands. The island of Oahu with a population of over 950,000 makes up 70% of the entire population of the State of Hawaii. 98.6% of the population on Oahu resides in urban areas. The island of Maui and the island of Hawaii (also known as the Big Island) are two other large islands with sizable populations.

The State of Hawaii publishes Hawaii State Data Book annually. The Data Book lists electricity usage as well as the income and other relevant information about the islands. Thus, one can easily deduce the electricity production, residential electricity consumption and its prices from the Hawaii Data Book ([DBEDT, 2015](#)).

2.1. The Island of Oahu

There are only two seasons on Oahu: Summer and Winter. Winter months are slightly cooler with a few degree Celsius differences. [Fig. 1](#) shows the average maximum and minimum monthly temperatures in Honolulu, Oahu. Due to these mild temperatures, no heating is necessary on Oahu and year round trade winds make it comfortable for most of the islanders. Therefore, variations in cooling days have a minimal, if any effect on the residential annual electricity consumption on Oahu.

It should be noted that all data in this section is extracted from the State of Hawaii Data Book ([DBEDT, 2015](#)), except when otherwise stated. Also, income per capita and residential electricity usages for other states’ data were obtained from the US DOE.

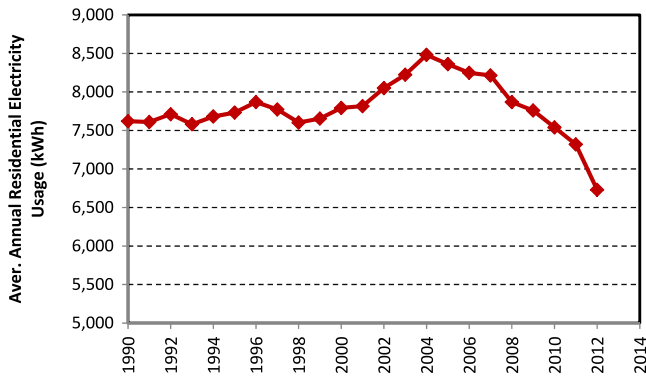


Fig. 2. Average annual residential electricity consumption in Oahu between 1990 and 2013. Note that the consumption started to decrease continuously before energy conservation initiatives were introduced in 2008.

2.2. Residential electricity consumption of Oahu

Fig. 2 shows the residential average annual electricity consumption per residential customer between 1990 and 2013. A quick review of Fig. 2 reveals that residential electricity consumption continuously increased between 1998 and 2004. After 2004, annual electricity consumption decreased and reached 1990 levels in 2010. The average residential electricity consumption in 1990 and 2010 were almost equal. The average electricity consumption in 2013 was 17.5% lower than that of 1990. Furthermore, Fig. 2 indicates that from the peak consumption in 2004–2013, the average annual residential electricity consumption decreased by 26%.

From Fig. 2, environmentalists can claim that the decrease in electricity usage contributes to a reduction in CO₂ emissions in Hawaii, since 90% of electricity is produced from fossil fuels. Policy makers can claim that adopted policies have been successful and residents are spending less money for electricity and have more money for pleasurable spending. The shareholders of the utility company can claim the reduction in energy usage reduces profits because of lower electricity sales. In other words, attributed reasons and consequences for decreased residential electricity usage can vary. Nonetheless, it is important to ask why average residential electricity consumption started to decrease years before the introduction of the Hawaii Clean Energy Initiative and economic recession in 2008. Specifically, what drove residential electricity consumption down in the State of Hawaii?

To answer the stated questions, we studied the effect of income and price on residential electricity consumption and number of persons per household.

2.2.1. Income and price effect on residential electricity consumption

To determine the average residential customer's purchasing power, we divided per capita income by annual average electricity. See Fig. 3. As noted from Fig. 3, the purchasing power decreased from 215,500 kWh in 2004 to 127,000 kWh of electricity in 2012. In other words, purchasing power decreased 40% between 2004 and 2012.

Fig. 4 is the ratio of the average residential electricity bill to income per capita of Oahu. As noted from Fig. 4, the ratio of electricity bills to per capita was about 3.5% in early 2000s; however, it was about 5% percent in the early 2010s. In other words, despite a reduction in real electricity consumption, the average electricity bill eats up an additional one and half percent of per capita income.

Another way of illustrating the effect of income on electricity consumption is by comparing the residential electricity demand with median income. To do so, we compared the median income equalized to constant 2012 dollars with annual average residential

electricity usage. See Fig. 5. As noted from Fig. 5, there is a good qualitative match between median income and residential electricity consumption.

2.2.2. Residential electricity consumption vs. number of people per customer account

Household size (HHS) is an important factor for evaluating residential electricity consumption. This is because HHS is positively related to the electricity consumed. Residences with large HHS consume more electricity; however, they may be more energy efficient (Lanjouw and Ravallion, 1995).

HHS is determined by dividing de facto population by number of residential customers. Then, we plotted average HHS with average residential electricity consumption; see Fig. 6. As noted in Fig. 6, average HHS is indeed dynamic and shows significant variation over the years. Fig. 6 shows that HHS roughly corresponds to both residential electricity increase and decrease depending on income. For example, HHS decreased from about 3.8 to 3.55 between 1990 and 2003 corresponding about 7% decrease in HHS; then it begins to increase gradually. A decrease in HHS contributed to an increase in electricity demand prior to 2004; then residential electricity demand decreased with an increase in HHS. Currently, the average HHS is about 3.70 per residential customer. This corresponds to a 5% increase since 2004 and a 26% decrease in electricity consumption for the same period.

2.3. Regression analysis

There are several regression methods available to determine the effect of variables such as income, price and household size, etc. Fumon and Biswas (2015) report that linear regression produces promising results when used to determine the factors affecting residential electricity consumption. They attribute to reasonable accuracy and relatively simple implementation of linear regression when compared to other methods. Thus, we conducted linear regression analyses on the variables controlling the residential electricity demand. Based on the discussion presented above, we identified income, price and HHS as variables determining the residential electricity consumption. We conducted two regression analyses: (i) two variables: price and income and (ii) three variables: price, income and HHS.

We also conducted regression analyses for other islands, namely: Big Island (Hawaii), Maui, and Kauai.

The linear regression model is linear and in the form of (Costa and Kahn, 2010):

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + e \quad (1)$$

where Y represents the annual electrical energy consumption, b values are regression coefficients, x values are the variables and e is the unknown disturbance term (i.e., error or residuals).

Table 1 lists the correlation coefficient, r^2 , for each island. It is noted that all p -values were less than 0.05, indicating that it is statistically significant. The results of the regression analysis indicate that the correlation between income and price on residential electricity consumption is poor for Oahu and is poorer for the other islands. The differences between Oahu and other islands are that r^2 increases from 0.42 to 0.85 when the HHS is introduced as a variable. The average HHS has a significant increase not because it changes from 3.5 to 3.8, but because r^2 increase from 0.42 to 0.85 if HHS is taken into account in Oahu.

Furthermore, it should be noted that the lowest r^2 was observed for the island of Kauai, where electricity consumption is practically flat (see Fig. 7). For example, the decrease in the residential electricity consumption per customer was only nine percent from peak 2004 to 2013, while the decrease was 26%, 23% and 19%, for Oahu, Maui and Big Island, respectively.

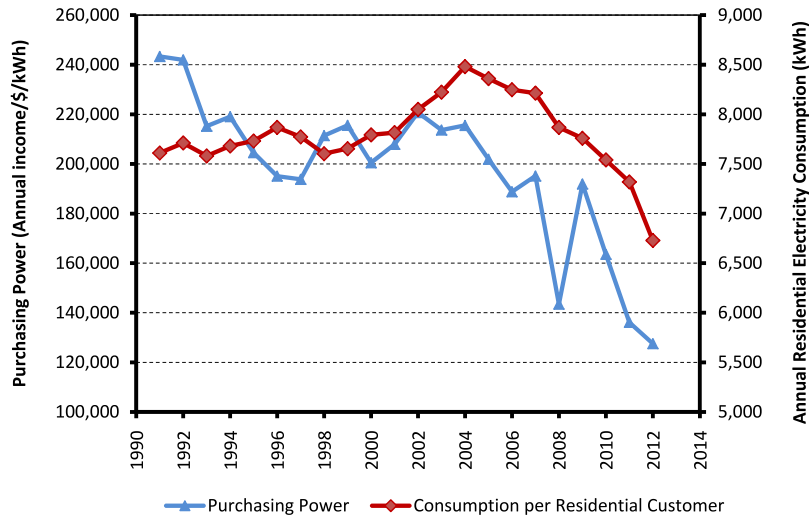


Fig. 3. Residential electricity purchasing power of Oahu in Oahu. Note that decrease in purchasing power is much greater than decrease in electricity consumption.

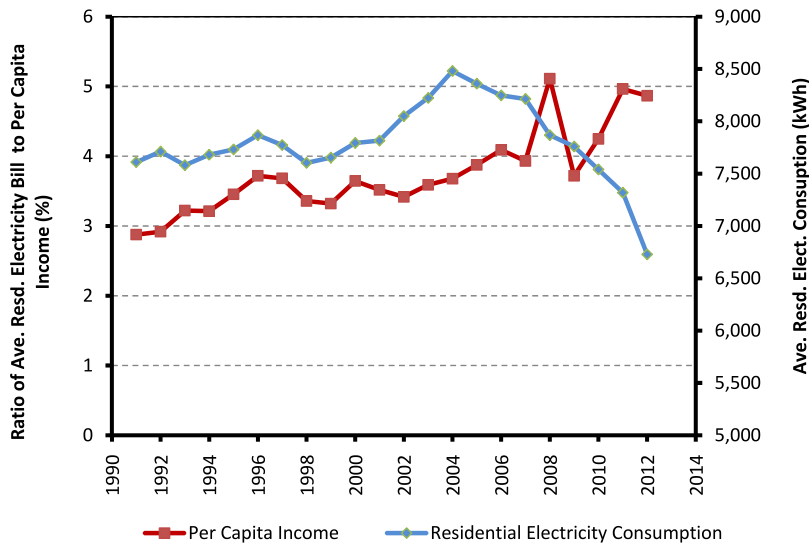


Fig. 4. Comparison of per capita annual residential electricity bill to per capita income. Note that the ratio of average electricity bill to per capita income increased from about 3.5% to almost 5% even though consumption decreased by 25% between 2004 and 2012.

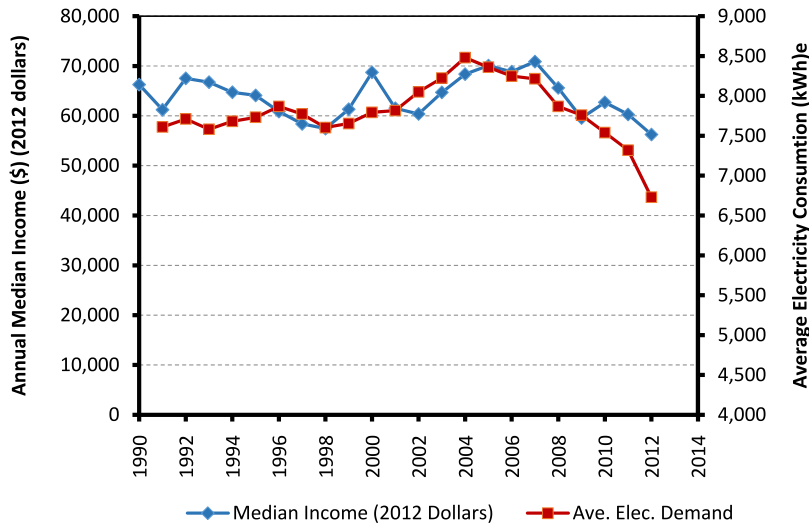


Fig. 5. Comparison of median income and electricity consumption in Oahu. Note that annual income and residual electricity consumption shows general patterns.

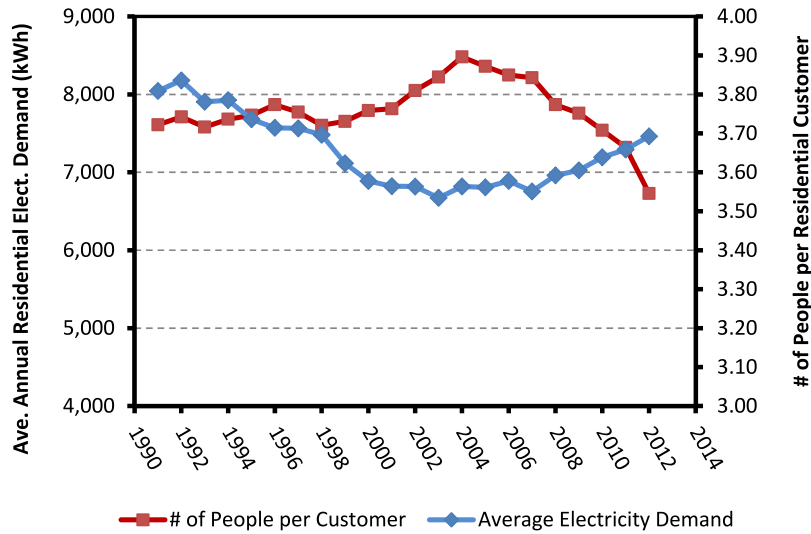


Fig. 6. Variation of household size and annual electricity consumption per household. Note that #of people per customer decrease prior to 2004 but it increases after 2004.

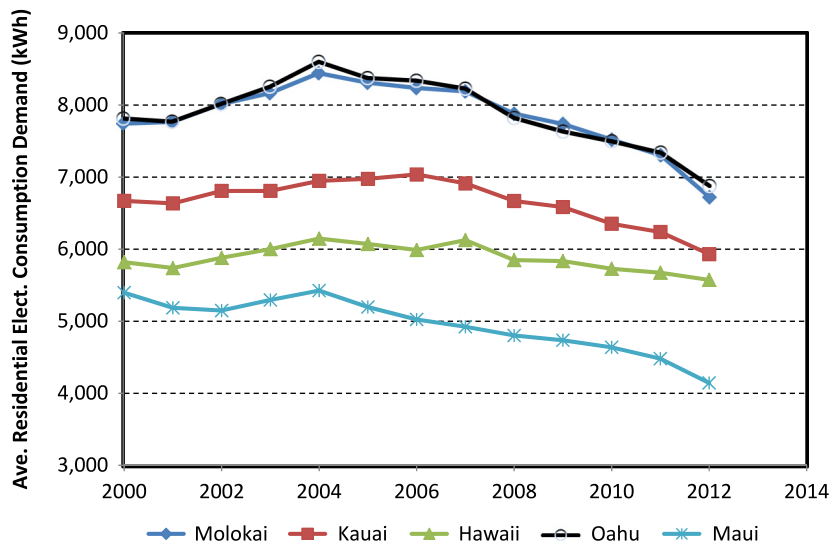


Fig. 7. Comparison of islands average annual electricity consumption. Note that the residential electricity consumption gradually decreases starting 2004.

Table 1

List of coefficient correlations, r^2 , obtained from regression analysis for Islands of Hawaii.

	r^2	
	Two parameters (Income and price)	Three parameters (Income, price, household size)
Oahu	0.42	0.85
Big Island	0.56	0.60
Maui	0.33	0.35
Kauai	0.22	0.42

The use of linear regression could be one of the reasons for the observed poor r^2 between residential electricity consumption, income and price. However, it should be noted that several researchers have already reported that the residential electricity consumptions of residents that have relatively low income are insensitive to price increase. For example, Reiss and White (2005) reported that 44% of households in California are price insensitive. Similarly, Huang (2015) reached the same conclusion that residents with lower incomes are insensitive to price increases in Taiwan. (Nesbakken, 1999) showed that energy price sensitivity is higher for high-income households than for low-income households. The obtained poor r^2 between income and price in our

analyses are in good agreement with several studies (Atamturk and Zafar, 2012; Fell et al., 2010).

2.4. Comparison of residential electricity consumption with other Islands in Hawaii

Researchers have shown that lifestyle has a significant effect on residential electricity consumption (Sanquist et al., 2012). Thus, we intended to determine if there is an island demographic that has an effect on the residential electricity demand of other islands. We compared the observed residential electricity consumption of Oahu with the other islands of Hawaii, including the Big Island,

Maui, and Kauai. These islands are less urban than Oahu and have significant demographic differences. For example, Big Island has the lowest income per capita and the highest electricity price. Fig. 7 shows the residential electricity consumption of these islands between 2000 and 2014. Fig. 7 shows all islands show the same trend of a decrease in electricity consumption in recent years. It should be noted that the residential electricity consumption of Maui and Oahu are almost the same and that the residential electricity consumption of Big Island and Kauai are considerably lower than those of Maui and Oahu. Nonetheless, the electricity consumption of all islands (excluding Molokai) is currently trending to just about 6000 kWh per year per residential unit. Reduction in electricity consumption between 2004 and 2013 is 26%, 9%, 23% and 19% for Oahu, Kauai and Big Island, respectively.

Similarly, we compared the HHS of the islands in Fig. 8. As noted in Fig. 8, the average HHS of Big Island, Maui and Kauai slightly decreased before the mid-2000s; then more or less remained the same. On the other hand, as stated above, the HHS of Oahu increases after the mid-2000s. Fig. 8 also shows that Oahu has the largest HHS while Kauai has the lowest. The household size of Maui and Big Island are similar.

We determined the percentage of electricity bill per capita income in order to demonstrate the effect of income on residential electricity consumption. Fig. 9 shows that the percentage of electricity bill in per capita income increases since 2002 with the exception of a sharp peak of 2008 and 2009. Furthermore, we compared the residential electricity consumption per HHS for each island (Fig. 10). Figs. 9 and 10 reveal several important points:

- (i) Fig. 9 indicates that although average residential electricity consumption decreased in the islands of Hawaii, the percentage of the annual residential electricity bill to income per capita increased. A decrease in residential electricity consumption does not release the burden of electricity bill on the average income. The burden has increased due to higher electricity prices.
- (ii) Even though Maui and Oahu have almost identical average residential electricity consumption, the percentage of annual electricity bill to per capita income of Maui is almost twice of that of Oahu. Furthermore, the HHS of Oahu is almost 40% higher than that of Maui. Nonetheless, the average electricity consumptions of both islands are the same. Moreover, HHS of Maui and Big Island are almost the same. However, the average electricity consumption of Big Island was almost 16% lower than that of Maui in 2012.
- (iii) Residential electricity consumption per capita is the lowest in Oahu. Low per capita residential electricity consumption of Oahu can be partially attributed to their large HHS.
- (iv) The results show that the residents with larger HHS are more energy efficient per capita, excluding Maui. Maui and Big Island have almost identical HHS (~ 2.8) but Maui's residential electricity demand is more than 10% higher than that of Big Island. Furthermore, Kauai's HHS is 15% smaller than that of the Big Island; however, the residential electricity consumption is almost the same for both islands (Fig. 9). Perhaps, large variations in electricity consumption with the same HHS may be explained by the type of housing and household behavior, which require further research and analysis. Nonetheless, the obtained results are in good agreement with those of Huang (2015): The larger the HHS, the less energy consumption per capita.

2.5. Comparison of Hawaiian residential electricity consumption to states with similar climates

We compared the observed residential electricity consumption behavior of Hawaii to those of States with similar climates.

We choose to compare the residential electricity consumption of Hawaii with those of California, Arizona, Texas and Florida. We selected these states because they are mostly located in USA Climate zones of I, II and II.

Fig. 11 shows the residential electricity consumption rates of Arizona, California, Florida, Hawaii and Texas (The data was obtained from EERE, 2016). Fig. 11 indicates that the residential electricity consumption of Hawaii is comparable with that of California. The per capita residential electricity consumption in Hawaii was lower than that of California until 1995. Between 2001 and 2005, consumption in Hawaii surpassed that of California. Then, the residential electricity consumption of Hawaii starts to drop below that of California once more. It is interesting to note that the residential electricity usage of Hawaii decreases below that of California even though California has many regulatory requirements and more lucrative incentives to decrease electricity usage.

Even though it is redundant, it is important to ask what drives residential electricity consumption and what the role of income and electricity price are on electricity demand. To answer this question, we normalized the average annual electricity bill (average electricity consumption multiplied by electricity price) to per capita income of the State. Fig. 12 provides explanations for residential electricity demand behavior of the studied States. It should be noted that the ratio of residential electricity bill over per capita income of Hawaii increases continuously. It should be also noted that the ratio of the residential electricity bill to per capita income was less than one percent in 1990; however, it was 1.75% in 2011. The residential electricity bill increased 75% more than that of income per capita. On the other hand, the percentage of electricity bill of California is almost 0.75% since 2000. Increased regulations and electricity conservation incentives did not alter the electricity consumption behavior much because the increase in electricity prices and income are compatible.

The percentage of income spent on residential electricity consumption of Arizona, Florida and Texas decrease prior to 2000, stabilizes between years 2000 and 2006, and then begins to decrease again. Note that residential electricity consumption increased between 1980 and 2000 with different rates. However, it should be noted that the percentage of electricity bill per capita income of these states are lower in 2012 than those of 1990 even though electricity consumption remain high.

A comparison of Figs. 11 and 12 indicates that the reduction in residential electricity consumption of Arizona, Florida and Texas translate into savings for the residents. On the other hand, reduction in residential electricity consumption does not translate into savings for the residents of Hawaii. The residents of Hawaii are forced to conserve and eliminate electricity usage in order to balance the household budget, not because of introduced conservation initiatives. Furthermore, Fig. 12 indicates that residents in Arizona, California and Texas try to keep the electricity consumption at a certain level so that the monthly electricity bill is only a certain percentage of their income. The residents control the percentage of the electricity cost on a household budget by reducing their electricity consumption.

2.6. Regression analysis on the states' residential electricity consumption

Similar to Islands of Hawaii, we ran regression analysis on the States whose electricity consumptions are comparable with those of Hawaii. Table 2 shows obtained correlation coefficients with two independent variables, income and price and three variables, income, price and HHS. We noted that the whole State of Hawaii data were used for a uniform comparison of the regression analysis. The obtained correlation coefficients are listed in Table 2.

As noted in Table 2, r^2 , for income and price for the entire state of Hawaii is 0.39, which is slightly less than that of Oahu. However,

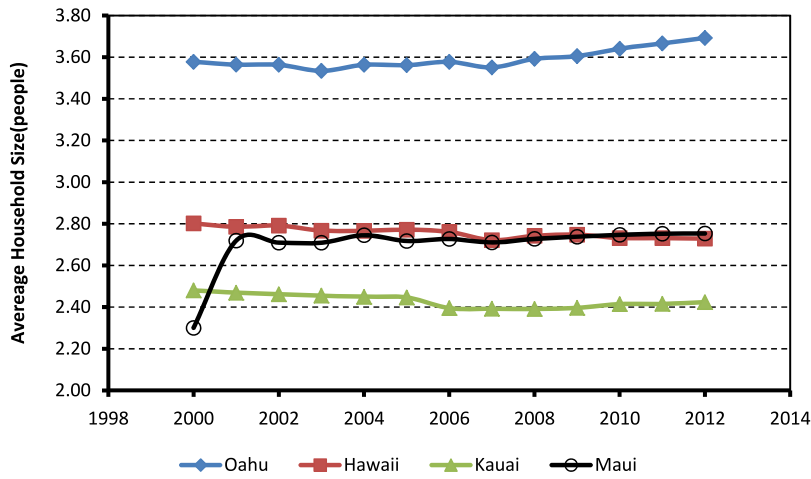


Fig. 8. Comparison of islands' average household sizes. The data for Maui for 2000 appears to be in error. We plotted the data to be consistent with others.



Fig. 9. Average residential electricity bill per capita income.

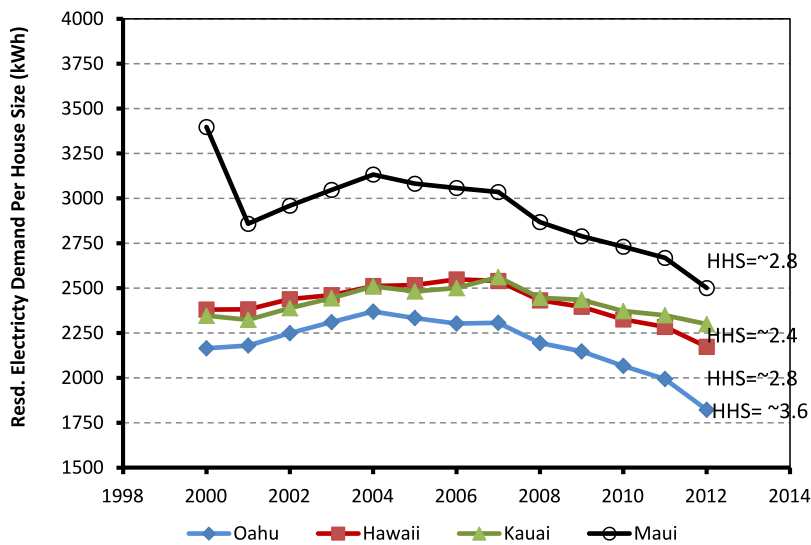


Fig. 10. Comparison of electricity consumption per household size (HHS). Note that Oahu has the highest HHS but lowest electricity consumption.

when the HHS is incorporated as a variable, the r^2 increases to 0.59, which is much less than that of island of Oahu. Insensitivity of the

residential electricity consumption of Maui and Kauai is observed on the obtained r^2 for the entire state of Hawaii. Note that the

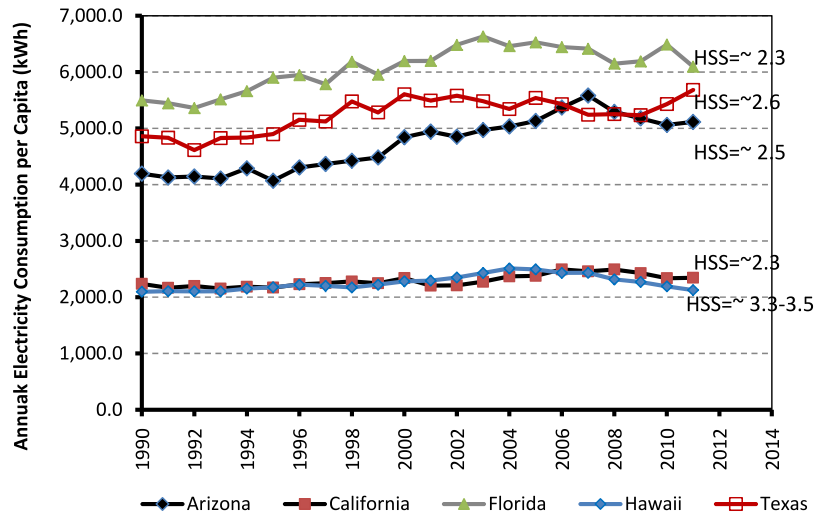


Fig. 11. Comparison of Arizona, California, Florida, Hawaii and Texas' annual electricity bill. Note that electricity bills in each states prior to 2000 increases. Then after, it starts to decrease.

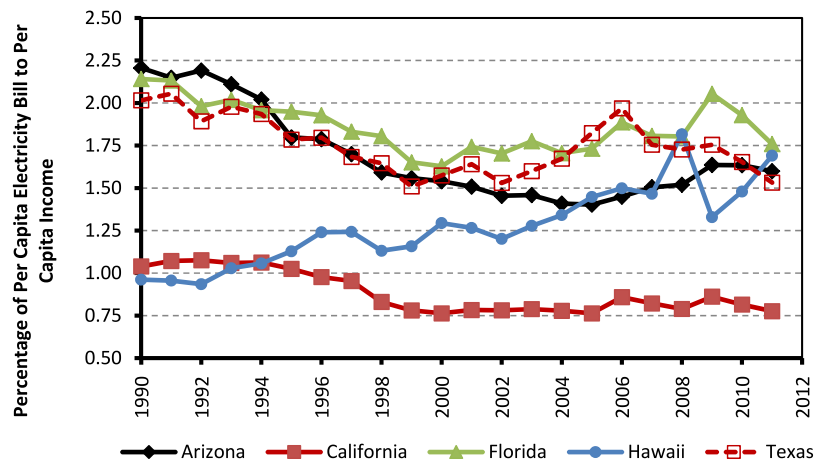


Fig. 12. Comparison of annual per capita electricity bill to per capita in income of Arizona, California, Florida, Hawaii and Texas. Note that the ratio of electricity bill per capita to per capita income decreased gradually and stabilized for other states whereas it continuously increased for Hawaii.

Table 2
List of coefficient correlations, r^2 , obtained from regression analysis for Southern States.

	r^2	
	Two parameters (<i>Income and price</i>)	Two parameters (<i>Income and price</i>)
Arizona	0.94	0.96
California	0.74	0.75
Florida	0.85	0.85
Texas	0.81	0.85
Hawaii	0.39	0.59

observed r^2 is 0.85 for Oahu when the HHS is introduced as a variable.

The observed high r^2 between income and price are in good agreement with the results published by previous researchers. For example, Fell et al. (2010) estimate the residential electricity demand for different regions in the US. They reported that price elasticity estimates vary across the regions, the South being the most price-elastic region and the Northeast being the least elastic region. Since all of the states in this study are located in the South, the reported high r^2 between residential electricity usage for Arizona, California, Florida and Texas are in good agreement with previous studies.

As noted in Table 2, the household size is not a significant variable determining the residential electricity consumption of Arizona, California, Florida and Texas. This is probably because of

the fact that the HHS of these states did not show a variation as much as Hawaii during the study period (Fig. 13).

3. Conclusions and policy implications

It is expected that residential electricity consumption decreases as the prices increases. However, electricity consumption can increase while price increases, provided that income increases at the same rate or higher. We provided evidence that the residential electricity consumption in Oahu and other islands of Hawaii steadily decreasing both per customer and per capita. The decrease in residential electricity consumption started after peak use in 2004, which is prior to enacting energy conservation initiatives in 2008. The residential electricity consumption in Oahu decrease

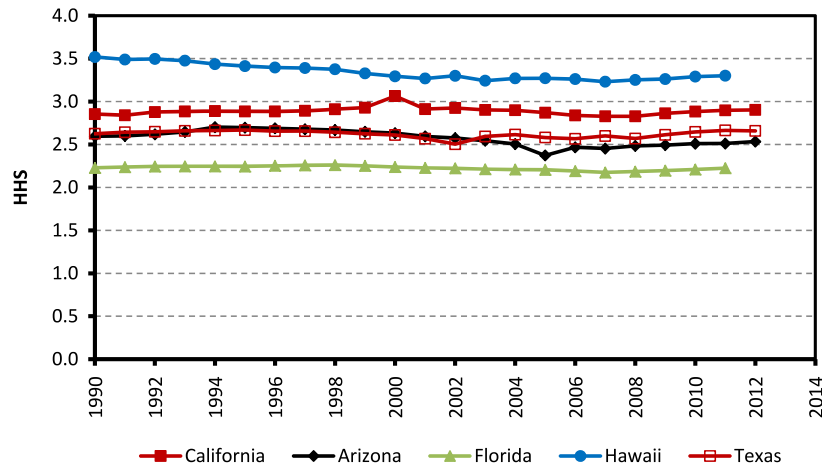


Fig. 13. Variation of household size, obtained by dividing the state population by the number of residential customer for Arizona, California, Florida, Hawaii and Texas.

about 25% between 2004 and 2012 per customer. Similarly, residential electricity consumption per customer decreased in Big Island, Kauai and Maui with varying degrees.

Despite an over 25% decrease in residential electricity consumption between 2004 and 2012, the percentage of income spent on electrical bills per capita increased from 1.0% to 1.75% in the island of Oahu. The average annual electricity bill per capita was about \$350 in 2004, whereas it was about \$850 in 2012. Therefore, the ratio of per capita electricity bill to per capita income is very important factor on residential electricity demand. This is because a decrease in purchasing power of residential electricity overshadows the effect of implemented energy efficient technologies and policies.

As discussed in early sections of the study, reduction in energy consumption in addition to variations in income and price variables can be realized in different forms i.e., adaption of energy efficient technologies, energy efficient building codes, turning off lights when not used, etc. Therefore, the effect of each variable has to be determined. As demonstrated in this study, the effects of HHS and, income and price per capita have to be taken into account. The results of this study suggest that HHS has significant effect on residential electricity consumption in Oahu.

Realized decrease in energy consumption should not be attributed solely to adopted energy efficiency programs as the Hawaii Energy electric utility company does. Hawaii Energy attributes decrease in residential electricity consumption to energy efficiency improvements in its FY 2013 report (Hawaii Energy, 2016).

The results further indicate that decreased residential electricity consumption did not translate into savings in the State of Hawaii while it did in other States. The reduction in electricity consumption partially occurred because the residents were forced to contain the electricity bill within their household budgets.

Linear regression analyses indicate that use of price and income as variables does not yield any significant correlation with the residential electricity consumption for all islands. However, when HHS is introduced as a variable in addition to price and income, a significant correlation of coefficient is observed in Oahu. We observed a very strong correlation between residential electricity consumption, income and price relation for Arizona, California, Florida and Texas.

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