Energy Policy 69 (2014) 263–272

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

An analysis of monthly household energy consumption among single-family residences in Texas, 2010

Carlos Valenzuela [a], Alelhie Valencia [a], Steve White [a], Jeffrey A. Jordan [a], Stephanie Cano [a], Jerome Keating [a], John Nagorski [b], Lloyd B. Potter [a,*]

[a] The University of Texas, San Antonio, USA
[b] Rice University, USA

HIGHLIGHTS

- Data on energy use is combined with housing and demographic characteristics.
- Quantile regression is used to examine relationships among key variables.
- Less efficient homes have pools, no central HVAC, and pier/post foundations.
- Houses with persons working at home and renter occupied homes were less efficient.
- Energy conservation strategies are discussed and suggested for each element.

ARTICLE INFO

Article history:
Received 13 April 2013
Received in revised form
3 December 2013
Accepted 9 December 2013
Available online 31 January 2014

Keywords:
Residential
Demographic
Consumption

ABSTRACT

Demographic, socioeconomic, and housing characteristics influence variation in household energy consumption. By combining household-level utility, public, and proprietary data, we examine predictors of household energy consumption in a Texas urban area. Using quantile regression, this analysis assesses the relationship between energy consumption and predictors at the middle and both ends of the distribution (10th and 90th percentiles). Results indicate potential opportunities to lower consumption among the highest energy-consuming households including those with pools, with non-central cooling, with people working from home, those built on pier/post foundation, and those that are renter-occupied. These findings suggest significant opportunities to reduce consumption and demand as in the study area, almost 10% of housing units are renter-occupied, 18% percent are without central cooling, and 7% have pools. Capturing a significant portion of these homes for retrofit conservation efforts through marketing has potential to produce substantial results. Producing a better understanding of determinants of household energy consumption using the methods presented has potential to assist development and implementation of strategies to reduce consumption and increase efficiency.

1. Introduction

Increasing energy demand, rising energy prices, and concerns regarding impacts of fossil fuel emissions on the environment have promoted the interest of social scientists and policymakers to advance our understanding of determinants of energy consumption and to identify conservation strategies (Moore, 2010; Musti et al., 2011; Weber and Perrels, 2000). Ever increasing energy consumption demands come at a high cost, both environmentally as well as fiscally. Since 2007, Texas spent the most of any state in energy expenditures, totaling over $140 billion, or over $5899 per capita (U.S. Energy Information Administration, 2011b). During this same period, Texas residents spent about $123.41 per 1000-kilowatt hours (kWh) of electricity, compared to the U.S. average of $106.52. Moreover, Texas has been ranked between fifth and sixth in the country since 2008 with over 466.1 million British Thermal Units (BTUs) consumed per capita (U.S. Energy Information Administration, 2011a). Meanwhile, per capita electricity consumption increased 35% between 1980 and 2010 (U.S. Energy Information Administration, 2010). Since the 1970s, residential energy consumption studies have varied in terms of approach (conceptual, methodological, and/or unit of analysis) and purpose (estimation, energy reduction, and/or energy conservation). A majority of U.S. studies have analyzed energy consumption and trends among all residences in the country. Fewer energy consumption studies have focused on small geographic areas (Bernstein and Griffin, 2006; Chern and Just, 1980; Dagher, 2012), especially in Texas.

In the findings presented, we examine energy consumption from single-family households as a function of household demographic and housing unit characteristics in an urban area in Texas

* Corresponding author. Tel.: +1 210 458 6530.
E-mail address: Lloyd.Potter@UTSA.edu (L.B. Potter).

0301-4215/$ - see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.12.009

in 2010. An important facet of this project includes size and scope. With the collaboration of the local utility company, the research team combined utility, public, and proprietary data to assess determinants of monthly household energy consumption in a Texas county during 2010. This permitted a better understanding of household energy consumption that can allow energy providers and policymakers to develop strategies to reduce consumption and increase efficiency that are specific to their local area. Understanding the effects of demographic, socioeconomic, and housing unit characteristics on energy consumption has implications for groups interested in influencing other pro-environmental and/or conservation efforts, such as water use, in this county. We also believe that the results from this study can be useful in providing a broad and generalizable overview relating to household energy consumption that are specific to households with pools, as well as renter-occupied households, across the United States.

The following sections describe the theoretical framework and background literature that helped in conceptualizing, developing, and identifying significant predictors for this study. The data and methods articulate the collection and merging of energy consumption (from the local energy provider), housing unit physical characteristics (from county appraisal district), and demographic (from Infogroup) data. Then, we present quantile regression results to assess the relationship between energy consumption and predictors at the middle and both ends of the distribution (10th and 90th percentiles). Finally, we conclude with a discussion of policy implications of household energy consumption in this Texas county.

2. Literature review

Previous studies have shown that householder and housing unit characteristics, as well as shifts in temperature and/or type of climate all contribute to energy consumption. In order to frame our analysis and to identify relevant determinants we utilize the human ecosystem theoretical model of energy consumption which highlights four separate, but interconnected, components that include human, natural, social, and designed environments (Bubolz et al., 1980, 1979; Guerin et al., 2000; Morrison, 1974; Yust et al., 2002).[1] The human component of the model consists of individuals, families, or households. The natural environment includes geographical region, climate, and/or seasonal variation. The social environment incorporates economic, social, and psychological behaviors characteristics of the environment that surrounds the household, such as conservation efforts, cultural norms, and practices. Lastly, the designed environment includes anything constructed or built by humans – i.e. characteristics of the housing structure, such as year built, number of rooms, and appliances.

2.1. Indicators of energy consumption

Studies have used energy expenditure (or the dollar amount spent on energy) and unified metrics to measure energy consumption. Measuring energy consumption via perceived expenditures can provide inadequate measures. Surveys frequently ask respondents to recall the dollar amount spent on utilities at a particular point in time. Measuring energy consumption in this manner can provide inadequate measures of actual consumption because of recall or reporting biases and demonstrate modest correlations between perceived and actual energy use (Gatersleben et al., 2002). Most studies have used specific energy units, such as BTUs, kilowatt hours, “giga joules,” as indicators of energy consumption. These studies rely on meter readings given by energy providers. Direct measurements are more robust when compared to perceived consumption and expenditure measures.

2.2. Covariates of energy consumption

A number of studies have found relationships between energy consumption and household variables and the extent to which housing unit characteristics influence energy consumption. Characteristics that typically describe householders include age of the head of householder, sex, race/ethnicity, family type, number in the household, income, and level of education.

2.3. Demographic characteristics of householders and their households

The age of householder is an important demographic variable because it indicates the life-cycle/stage of a particular household. “[B]eing in a particular life-cycle stage can determine whether or not that family (or non-family) unit will consume more, or less, energy” (Schipper et al., 1989). Numerous studies have found that age of householder is significantly associated with household energy consumption (Baker et al., 1989; Cashin and McGranahan, 2006; O’Neill and Chen, 2002; Ritchie et al., 1981). Householder age is often used as a proxy for the amount of time people spend – and thereby the opportunity to consume energy – in the home (Baker et al., 1989), to observe cohort effects, and/or diverse preferences for the type of energy used by age group (Carlsson-Kanyama et al., 2005; Costa and Kahn, 2011). Baker and colleagues found that expenditures varied between the age groups based on the type of energy consumed. Among the senior-led (65+ years old) households, electricity demand increased, whereas the demand for gas increased and then decreased (a nonlinear relationship), but these relationships were moderated by the household income and the ownership of appliances. A more recent U.S. study found that senior households spent more money on energy than non-senior households, which the authors attributed to the elderly spending more time at home and having a higher share of home-ownership (Cashin and McGranahan, 2006); though, temperature preferences may also contribute to the observed differences (Guerra-Santin and Itard, 2010; Nesbakken, 2001). There could also be differences in energy consumption patterns attributed to generational differences. Senior-headed households may have distinct energy consumption patterns compared to non-senior-led households, which can be due to how individuals have acquired energy consumptive habits; it could be that older generations are more frugal because of economic experiences (Garabuau-Moussaoui, 2009).

Household type contributes to the number of people in the home and research suggests that household size, or the number of individuals in a household, is positively related to energy consumption (Gatersleben et al., 2002; Ndiaye and Gabriel, 2011). Two types of households include: (1) family households and (2) non-family households. Family households include at least two related people. These include married couples, married couples with children, female-headed households, male-headed households, and others. Patterns of energy consumption differ by family types (Hackett and Lutzenhiser, 1991). However, household level efficiency may actually have an inverse relationship with family type and household size. For example, larger households consume more energy than smaller households, albeit per capita consumption is lower for larger, rather than smaller, households, possibly because of “shared usage of equipment” (Fong et al., 2007; O’Neill and Chen, 2002). In other words, larger households consume more

[1] Adapted from Bubolz et al. (1979) and Morrison's (1974) human ecosystem theory.