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# A zip code study of socioeconomic, demographic, and household gendered influence on the residential energy sector

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## HIGHLIGHTS

- Influence of socio-demographics on household energy utilization is evident.
- Gender influence is significant in understanding residential energy consumption.
- Energy consumption increases significantly around the median age of 40–55.
- Owner occupied single-family dwellings use more total energy than renter units.
- Predictive analyses of social variables for good energy policy are prescribed.

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## ABSTRACT

This study investigates the influence of socioeconomic and demographic characteristics of the population on residential energy utilization patterns at the ZIP code level in San Antonio, Bexar County, Texas. The City of San Antonio, Texas is the seventh most populous city in the United States and second in the State. Variables analyzed include gender, median age, median income, educational attainment, occupancy, population density, total energy, per capita energy and per home energy. Statistically significant relationships between variables are discovered and highlighted in support of public policy development to ensure long-term, and cost-effective energy management.



## 1. Introduction

With the influx of smart energy systems, intelligent appliances, connected devices, sensors and meters, now more than ever the influence of socio-demographic and gendered energy utilization is manifested. For the most part, human social behavior and the role it plays in household energy consumption has been largely overlooked in past energy research despite the fact that behavior significantly dampens and amplifies the effects of technology-based efficiency measures (Lutzenhiser, 1993). Behavior is often driven by the socio-economic and geographical culture and can directly influence energy consumption and conservation. Understanding important determinants of residential energy consumption is key to the design and implementation of energy conservative policies that pursue sustainability (Brounen et al., 2012).

Over the next two decades the US Department of Energy's Energy Information Administration estimates that US energy consumption will increase by about 40% (Wiggins et al., 2009). Households contribute approximately 15%–20% of the total energy consumption in the United States. Within a household there are many factors that influence energy conservation ranging from socio-demographic to behavioral practices (Steg, 2008). In addition to their growing size and significant contribution to national energy consumption and green house gas production, residential households represent an important target group for energy conservation. Abrahamse and Steg (2009) note that household energy is significantly related to socio-demographic variables. For example, in San Antonio, it is found that households with higher incomes living in larger homes tend to use more energy even though they are more efficient in a per square foot basis due to their newer and better building envelope (see Elnakat et al., 2015 and Gomez et al., 2014).

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Beyond academic curiosity, the results of the marriage of demographic and socioeconomic data with housing characteristics and energy consumption data have practical demand side management applications for electric utilities, city planning officials and the public at large. Such energy analytics can provide a more targeted approach to developing energy efficiency and conservation programs, utility rebate programs, comparative billing, and a more customer-centric and eco-centric approach for optimizing residential energy consumption.

## 2. Background

### 2.1. The city of San Antonio: A microcosm for the future US populous

Texas is one of the fastest growing states in the nation with three of its major cities on the Top-10 list of most populous cities in the country (US Census Bureau, 2010). San Antonio is the second largest city in Texas and a dominant city in the south Texas and Mexico border region and a modern metropolis home to approximately 1.3 million people in 2010 (US Census Bureau, 2015). While the national population growth rate is 9%, San Antonio is growing much faster at a rate of 16% per year. As the city continues to grow as a melting pot of heritage, history, and employment opportunities, the city represents a growing economy and can be seen as a microcosm of America's future with regards to demographic and economic diversity and the many infrastructure challenges faced by rapidly growing communities. The importance of highlighting the area's rich heritage is to emphasize the influence of the city's history on socio-demographics transcending to education, income, and as consequence, the built environment, and resulting energy utilization patterns.

### 2.2. Energy and demographics

Energy efficiency is influenced by many important factors including vintage of home, size of home, socio-economic, demographics, and composition of household family. Many of these factors, to include building stock, can be linked back to neighborhood characteristics unique to that area of town. Lower income neighborhoods will typically have older and smaller homes that are normally less efficient as evidenced by their higher electric intensity and higher energy use intensity, energy utilized per square foot of conditioned space. Bingham and Zhang (2001) equate Zone Improvement Plan (ZIP) codes to central-city neighborhoods in Ohio and studied the effects of neighborhood characteristics, business location, and neighborhood health. "Economically disadvantaged neighborhoods in the US often have a large fraction of minority and female headed households" (Arora and Cason, 1999). Elnakat and Gomez (2015) highlight the role that women's participation in energy can have on residential energy intensity. Study conclusions show that female dominant households have approximately 80% higher per capita energy consumption driven by around double the gas consumption and about 54% more electric usage. Lower income neighborhoods are likely to have higher energy consumption per square foot of living space due to older less efficient homes combined with a higher percentage of female dominant households, both of which have been statistically shown to have a higher energy use intensity.

Furthermore, women and residents that spend a majority of their time at home (such as retirees and the elderly) tend to use more water for personal hygiene and cooking and therefore tend to use more energy required for water heating (Domene and Sauri, 2006). In another example, there is a tendency for electric consumption to be higher during the stage of life when children have moved out and residents are over 55 years old than in the stages where children and teenagers still live at home. The elderly tend to use less energy on washing/drying clothes and washing dishes but more energy on lighting and conditioning their space compared to younger citizens (Gram-Hanssen et al., 2004).

The occupancy hypothesis explains that renter-occupied buildings contain fewer energy efficiency investments than owner-occupied buildings. The renter will not invest in energy efficiency fixtures for a rented unit due to the inability to fully capitalize on the value of the investment. Reversely, the owner will not invest in energy efficiency since the renter pays the electric bill and therefore the owner has no incentive (Sutherland, 1991). However, data has shown that size of home is a significant variable and most renter-occupied buildings tend to be smaller, this could lead to a trend of more energy consumption in the owner-occupied larger homes as presented in the results section of this study. As square footage increases so does the need for heating and cooling, additional lighting, and the likelihood of extra appliances (The News, 2012). In San Antonio newer homes with larger square footage tend to have a lower energy intensity due to the presence of more efficient heating and cooling systems, better building envelopes and improved overall efficiency but a higher total energy consumption per home when compared to smaller, older homes (Elnakat et al., 2015; Gomez et al., 2014).

Tenants residing in apartments that advertise utilities included with rent tend to use more energy than tenants who pay a separate energy bill. It is estimated that utility included apartments comprise 30% of rented apartments in the US (Levinson and Niemann, 2004). The Residential Energy Consumption Survey conducted by the US Energy Information Administration in 2009 estimates that approximately 31.5% of housing units in the US are renter-occupied. Low-income households tend to rent their homes, which can be characterized as low-income, small rental units. High density living doubled up with relatives or friends, voluntarily or involuntarily, is a common strategy for people to afford a rental unit (Skobba et al., 2013).

### 2.3. ZIP Codes

The US Postal Service created ZIP codes as a way to classify street segments, address ranges, and delivery points to expedite the delivery of mail. Since US Postal Service ZIP codes are not technically geographical areas, but rather a collection of mailing routes, ZIP Code Tabulation Areas (ZCTAs) – which are generalized area representations of ZIP code service routes – are created by the US Census Bureau to segment data. These ZCTAs are what the Census Bureau uses to segment their socioeconomic and demographic data and thereby what this study uses to correlate household and housing characteristics with energy consumption.

The use of ZIP codes for purposes outside of delivering mail is quickly becoming commonplace. As of 2005, around 193 articles are indexed by "ZIP code" in the Social Sciences Citation Index, and 386 are indexed in PubMed. Since ZIP codes are usually seen in a geographic context, they are utilized in socioeconomic planning, epidemiology, and retailing. For example, retail stores request ZIP codes from their customers after purchases in order to identify the geographical extent of the store's trade area. In epidemiologic research, ZIP codes are used to categorize access to health care (Fourtney et al., 2000), map prostate cancer (Johnson, 2004), track unmarried teen births (Blake and Bentov, 2001), and establish local/regional differences in radon levels (Steck et al., 1996; Grubesic, 2008). Researchers should be diligent in their awareness that ZIP codes are created by the US Postal Service to expedite mail delivery and account for the variations when comparing ZIP codes or ZCTAs (Misra et al., 2014).