Exploring The Factors Of Energy Efficiency

How do energy practices, smart grid technology adoption, dwelling characteristics, and demographics affect energy efficiency?

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INTRODUCTION

Because 85% of US energy production produces greenhouse gases, reducing energy consumption is an important part of reducing carbon emissions and slowing global warming (1). Furthermore, because residential and energy consumption accounts for 20% of US energy use, reducing residential energy consumption is, by extension, also very important (1). Understanding what factors affect energy efficiency is a key step in increasing it. This study examines how different types of factors influence residential energy efficiency.

METHODOLOGY

Survey: The US Energy Information Administration's Residential Energy Consumption Survey

Sample: 5,686 participants, of which the mean age was 52, ranging from 18 to 85. It was 56.1% female. The mode income was $20,000-$39,999 (22.2%), and 69.2% had some college or associate's degree or higher.

Linear regression was used to predict total natural gas and electricity consumption in Btu per square foot, which was used as an indicator of energy efficiency. The predictor variables were demographics, dwelling characteristics, smart grid technology adoption, and energy practices. The smart grid is a power grid that involves energy efficient appliances (Energy Star products/programmable thermostats/LEDs), as well as monitoring systems such as smart meters, which send energy consumption data to the utility provider.

RESULTS

Significant relationships:

- Older, higher-income, white, higher-educated participants and participants with more house members were associated with higher energy efficiency
- Colder outside temperatures were associated with higher energy efficiency, and hotter outside temperatures were associated with less energy efficiency
- Houses, newer residences, and larger residences were all associated with higher energy efficiency
- Programmable thermostats, smart meters, and energy star qualified products were all associated with higher energy efficiency
- Higher thermostat set temperatures during the summer and lower thermostat set temperatures during the winter, when someone is home, were associated with higher energy efficiency

Energy Efficiency Regression Results (Non-Hierarchical)

Variable	Model 1	Model 2	Model 3	Model 4
Demographics				
Income	-.176***			
Age	-.082***			
Gender	-.013			
Race	-.045***			
Number of house members	-.092***			
Education	-.074***			
Urban or rural	.035*			
Heating degree days in 2015	.066**			
Cooling degree days in 2015	-.082***			
Dwelling Characteristics				
House or non-house		-.148***		
Age of residence		.165***		
Total square footage		-.194***		
Level of insulation		.024		
Smart Grid Technology				
Programmable thermostat			-.189***	
Smart meter ownership			-.042**	
Number of Energy Star products			-.143***	
LED or CFL light ownership			.036**	
Solar PV Generation			.002	
Smart meter interval data access			.006	
Energy Practices				
Winter temp. when home				.017
Summer temp. when home				-.048*
Winter temp. when gone				-.073***
Summer temp. when gone				.041*
Winter set temp. at night				.010
Summer set temp. at night				-.080***
Clothes washer use				-.010
Dishwasher use				-.122***
Clothes dryer use				-.080*
Thermostat set strategy				-.025
Number of weekdays spent at home				.020
R^2	.084	.136	.069	.048
F	50.095	96.928	61.035	21.741
F Significance	.000	.000	.000	.000

*p≤.05 **p≤.01 ***p≤.001

CONCLUSION

While many of the relationships found have been identified in previous literature, this study has been able to show that smart grid technology and energy practices do have a significant influence on energy efficiency (2)(3). Furthermore, this study found that dwelling characteristics affected energy efficiency the most, accounting for 13.6% of the variance

To expand upon this research, future researchers could take the significant variables from these regression models and use them to work towards a hierarchical regression that could account for a larger amount of the influence. Future researchers could also investigate why variables that one would expect to have a negative relationship had a positive.

REFERENCES

1. Residential Energy Consumption Survey (RECS) - U.S. Energy Information Administration (EIA) [Online]. *Eia.gov* 2018. https://www.eia.gov/consumption/residential/about.php [23 Jul. 2018].

2. Baker K, Rylatt M. Improving the prediction of UK domestic energy-demand using annual consumption-data. *Applied Energy* 86: 475-482, 2018.

3. Kaza N. Understanding the spectrum of residential energy consumption: A quantile regression approach. *Energy Policy* 38: 6574-6585, 2010.

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