Relations between Residential Electricity Consumption and Area

Yichen Wei
Carnegie Mellon University
401 Shady Ave
1-412-651-8574
yichenw1@andrew.cmu.edu

ABSTRACT
In this paper, we discuss some relations between electricity usage and residential household areas using 2009 RECS survey data from U.S. Energy Information Administration website. Linear regression analysis is applied to explore the relations and predict electricity consumption based on housing area.

1. INTRODUCTION
Residential electricity consumption is determined by various factors. Weather, building characteristics such as floor area, types of appliances, occupants' behaviors, energy efficiency techniques could all affect the building energy consumption. However, the total floor area is one of the most important determinants of residential electricity use. [1] By applying linear regression analysis, we're trying to validate the assumption that the usage is linear related to total floor area.

The data used to do the analysis is from 2009 Residential Energy Consumption Survey. The survey is a nationwide sample survey and collects both national and regional energy related data from 12,083 households which represent 113.6 million US households. The survey includes household questionnaire, which contains questions about housing unit characteristics, kitchen appliances, home appliances and electronics, space heating, water heating, air conditioning, fuels used, housing unit measurements, fuel bills, residential transportation, household characteristics, and so on.

2. METHOD
Linear regression is the most basic and commonly used predictive analysis. It is used for modeling the relationship between one dependent variable and one or multiple independent variables. The model has a form of:

$$y = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \varepsilon_i$$

It also has a vector form:

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$$

3. DATA SELECTION
The data selected as independent variables for X is Total Square Footage (includes all attached garages, all basements, and finished/heated/cooled attics). The data selected as dependent variables for Y is Total Site Electricity usage, in kilowatt-hours.

```
data = np.genfromtxt('recs2009_public.csv',delimiter=',',skip_header=1)
```

```
totalSF=data[:,827]
```

```
totalKWH=data[:,839]
```

The plotted figure is below:

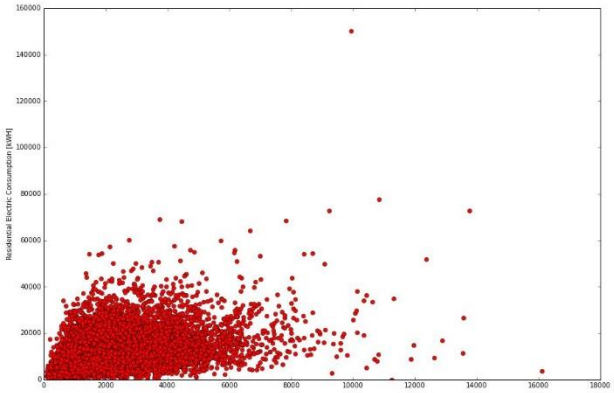


Figure.1 Scatter Plots of Building Floor Area and Electricity Consumption

4. PREDICTION
Separate the data as half for training and half for testing. Use the train data to calculate the linear regression model. Then use the model to predict electricity consumption based on test data of building floor area.

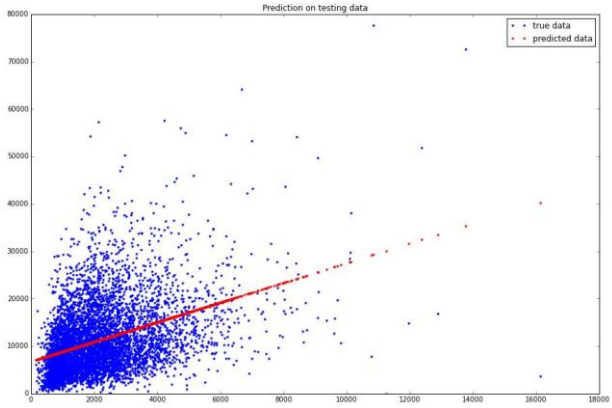


Figure.2 Comparison of Actual Electricity Consumption and Predicted Data

Noticing that there're other factors affecting the actual electricity usage. For example, there might be factor of how many rooms heated in the house that has influence on electricity consumption.

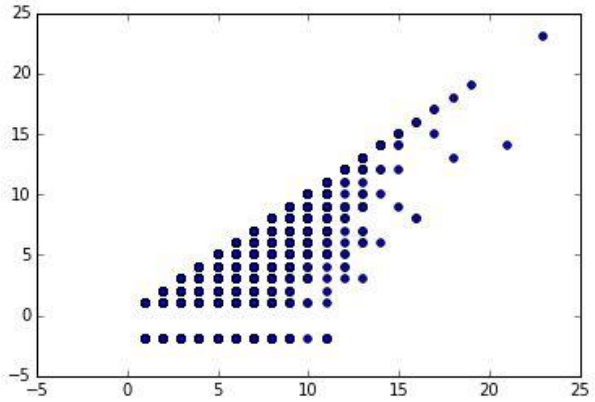
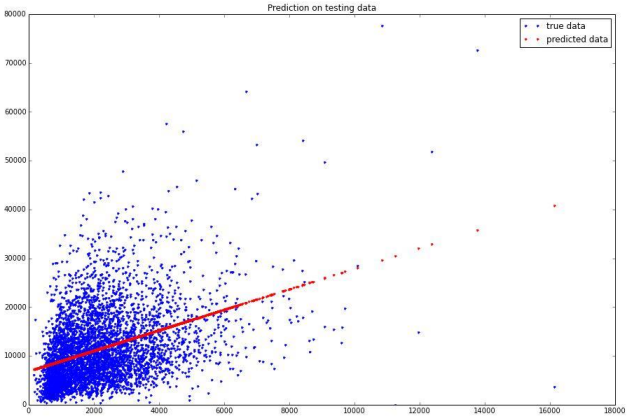


Figure.3 Total number of rooms in the housing unit and number of rooms heated.

Filter the data to use only when all the rooms are heated in the house. Re-train the linear model and predict again.



5. RESULTS & DISCUSSION

The predicted data seems not very fit to the actual electricity consumption data. However, it can roughly predict the trend. There might be several reasons. Nowadays, heating and cooling, of which electricity usage largely depend on areas, are no longer majority of US home energy use. Building floor area is not so linear related to energy consumption and other factors such as electronics, lighting and so on should be considered to get a more accurate prediction.

6. REFERENCES

[1] Kavousian, A., Rajagopal, R., and Fischer, M. 2013. Determinants of Residential Electricity Concumption: Using Smart Meter Data to Examine the Effect of Climate, Building Characteristics, Appliance Stock, and Occupants' Behavior. *Energy.* 55, (June. 2013), 184-194.

[2] Mathieu, J., Price, P., and Kiliccote, S., Piette, M. 2011. Quantifying Changes in Building Electricity Use, With Application to Demand Response. *IEEE Transactions on Smart Grid.* 2, (September. 2011), 507-518.