



IOT Analytics: Submeters and Smart Homes



Agenda

- Background
- Data Overview
- Submeters
- Issues with Dataset
- Useful Analytics
- Recommendations for Future Data Collection

Background

- IOT Analytics has been asked to create analytics and visualizations for Smart Home owners to provide greater understanding and control of their power usage
- Initial Exploration of Data:
 - Data location
 - Data Types and Variables
 - Interesting Trends from Descriptive Statistics
 - Useful Analytics

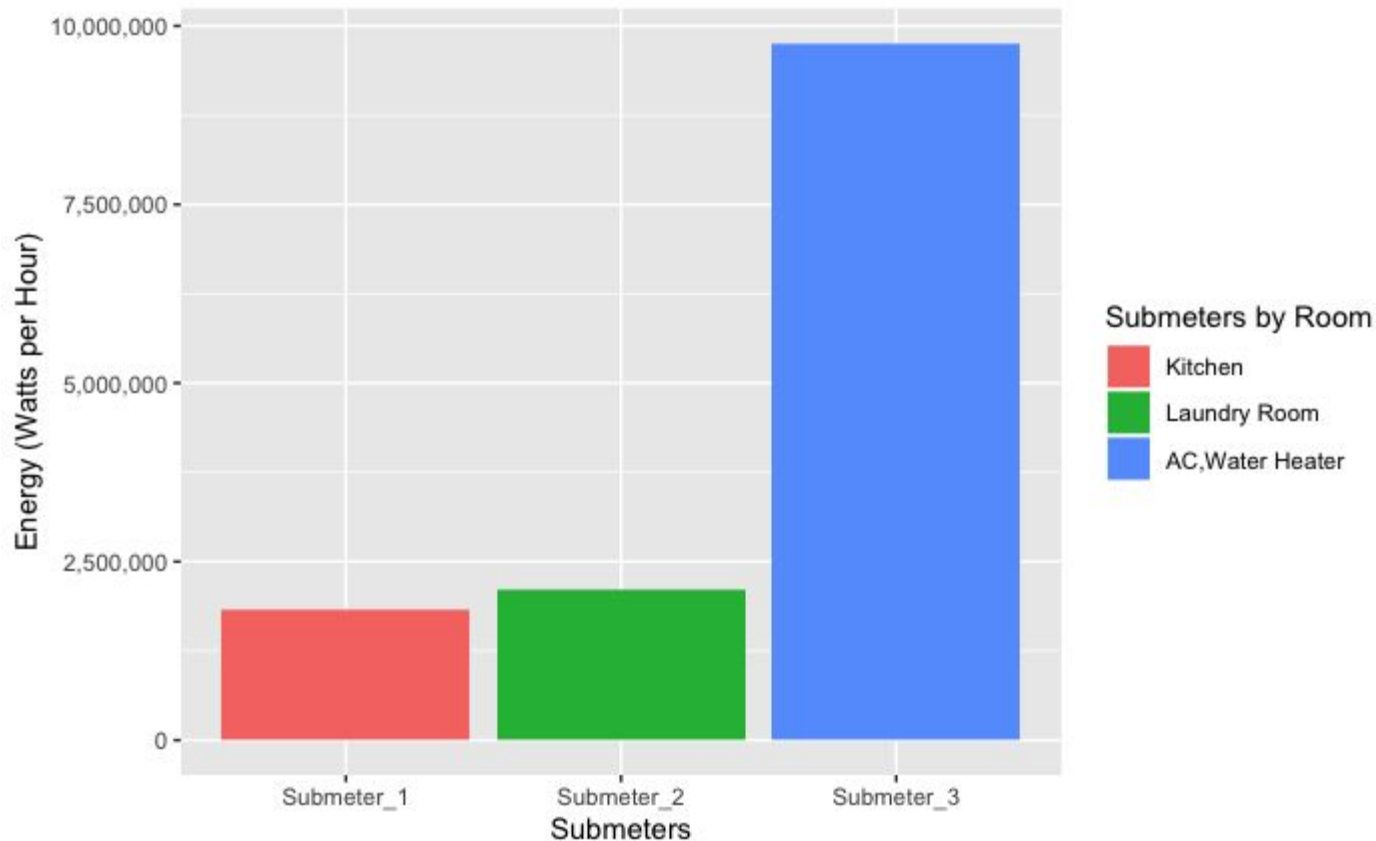
Data Overview

- Data: “Individual household electric power consumption Data Set”
- 2,075,259 measurements from a house in a Paris suburb between 12/2006 and 11/2010
- Measurements of electric power consumption in one household every minute in watt-hours
- Open source data with no data security responsibilities
- Located at Center for Machine Learning and Intelligent System repository (University of California, Irvine)
- Additional Data Sources
 - France National Holidays from timeanddate.com & publicholidays.fr

Submeters

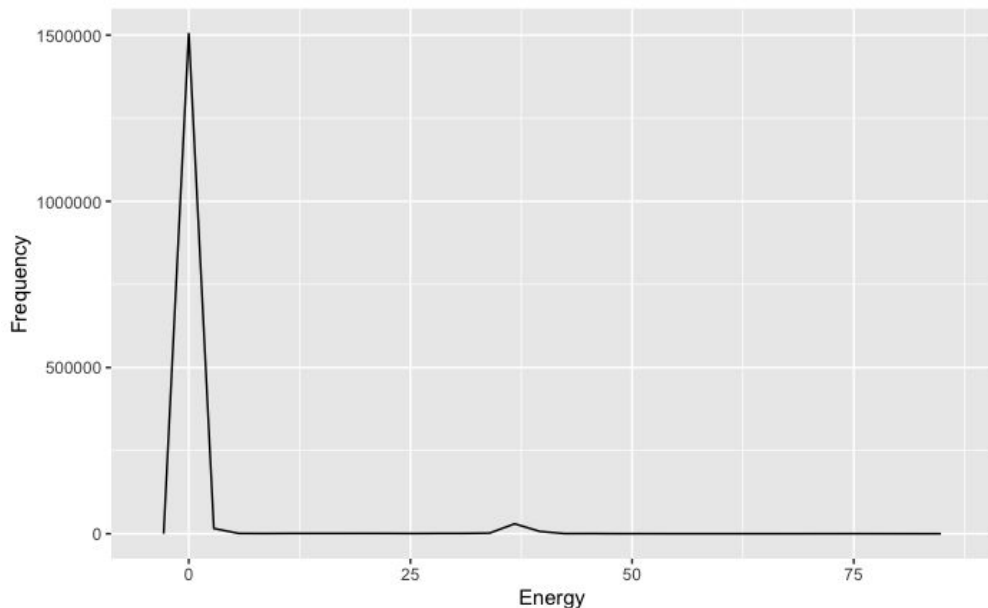
- Measures watt-hour of active energy, in minutes from 2006 to 2010
 - Refer to as “energy” or “wH” for watt-hours
- Accurate billing: renters can be billed for actual usage versus estimated splits, everyone can verify utility company bills
- Utility companies charge customers for reports on usage
- With submeters, homeowners can get data directly
- Three submeters in dataset:
 - Submeter 1: Kitchen: Dishwasher, Oven, Microwave
 - Submeter 2: Laundry room: Washing Machine, Drier, Fridge, Light
 - Submeter 3: Water Heater, Air-Conditioner

Total Energy Usage from 2007-2010



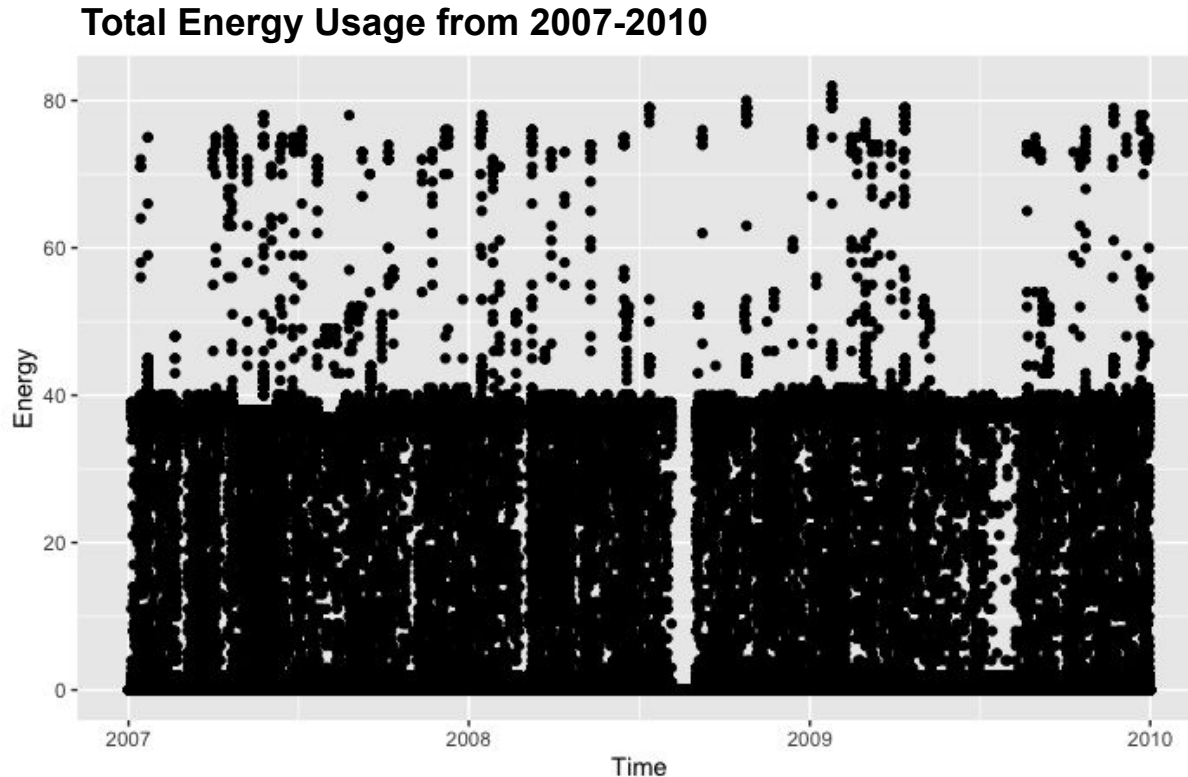
Submeter 1: Kitchen (Dishwasher, Oven, Microwave)

Frequency of Energy Usage from 2007-2010



- Average energy usage: 1.159 wH
- Maximum energy usage: 82 wH
- Appliances are not in constantly use
- Most frequency is 0
- Occasional spikes in usage
- Does not include fridge

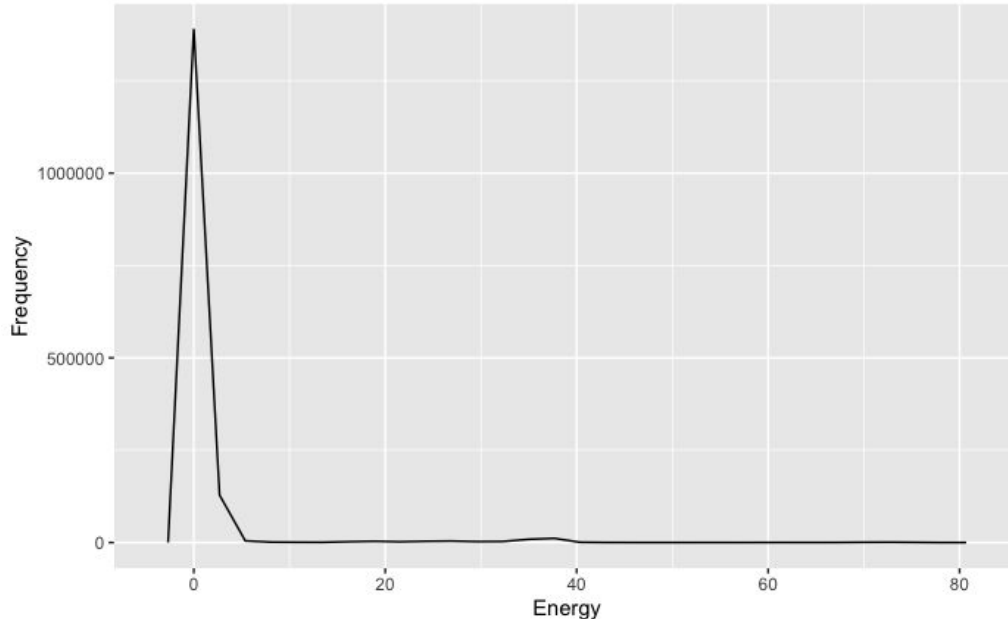
Submeter 1: Kitchen (Dishwasher, Oven, Microwave)



- Most energy between 0 and 40 wH
- Minimum usage during parts of 2008 and 2009. This gap indicates missing data
- Submeter may have been turned off during this time

Submeter 2: Laundry Room (Washer,Dryer, Fridge)

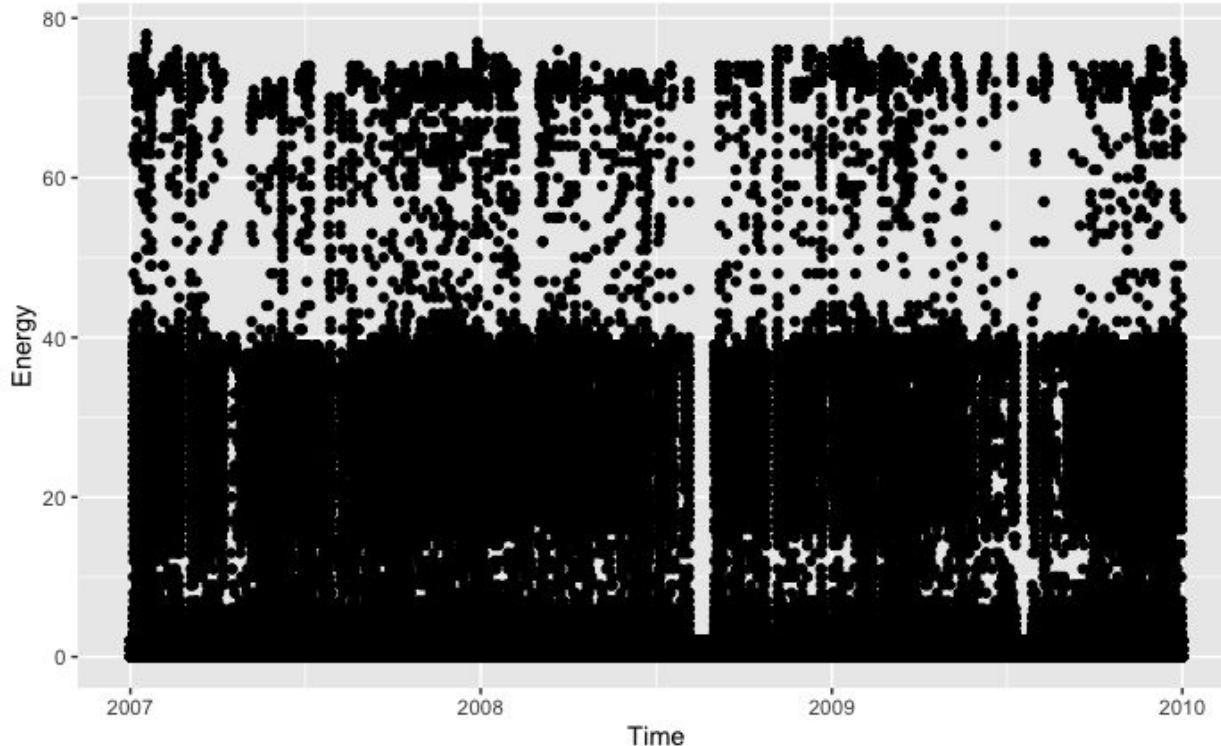
Frequency of Energy Usage from 2007-2010



- Average energy: 1.3 wH
- Maximum energy: 78 wH
- Similar to Submeter 1, appliances not in constant use
- Occasional spikes in usage to 40 wH

Submeter 2: Laundry Room (Washer,Dryer, Fridge)

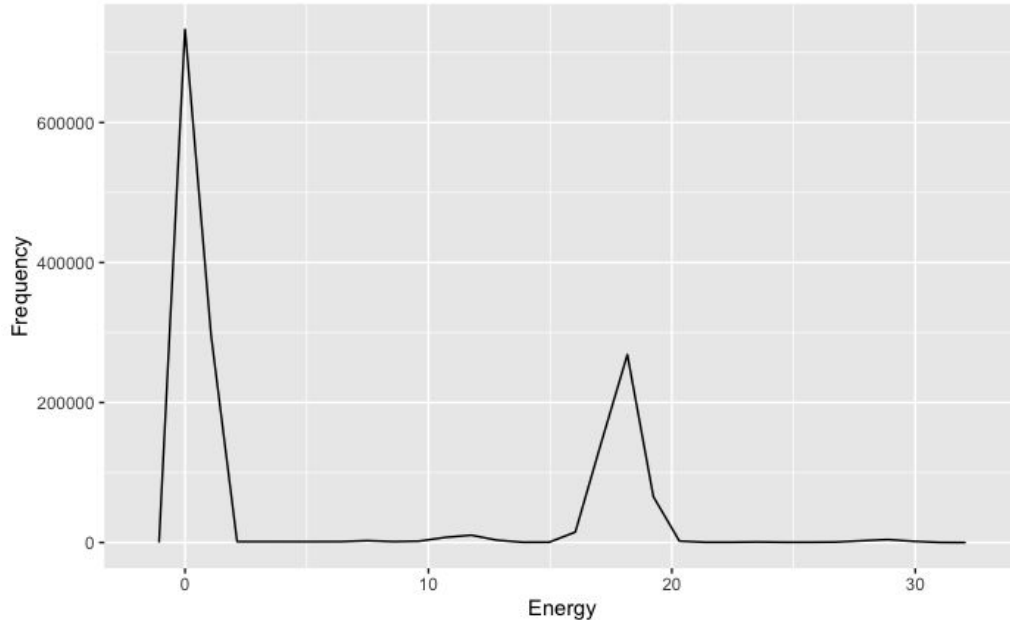
Total Energy Usage from 2007-2010



- Like Submeter 1, most energy between 0 and 40 wH with minimum usage period in 2008 and 2009, indicating possible time where submeters were turned off
- More spikes than Submeter 1. These appliances may consume more energy than kitchen appliances

Submeter 3: Water Heater, Air Conditioning

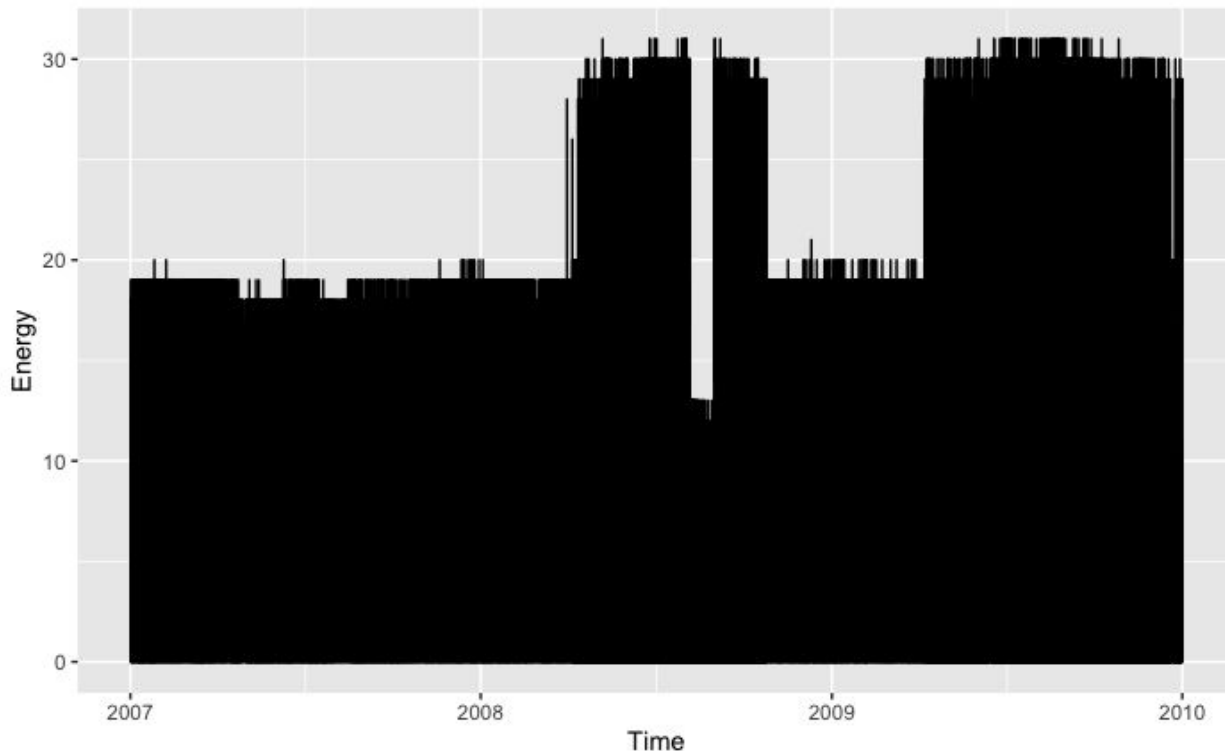
Frequency of Energy Usage from 2007-2010



- Average energy: 6.2 wH
- Maximum energy: 31 wH
- Submeter 1 had a tiny increment in frequencies of energy usage at 40wH whereas submeter 3 shows that the Water Heater and A/C consume more energy more often

Submeter 3: Water Heater, Air Conditioning

Frequency of Energy Usage from 2007-2010



- Energy from 0 to 30 wH
- From this data, homeowners could know:
 - How much energy is used when I leave the A/C continuously vs turning it off while at work?
- Unlike Submeters 1 and 2, there is no low energy period in either 2008 and 2009
- It would be helpful to know if the A/C also provides heat.

Issues with Data

- Granularity
 - We will condense data into hours, days, weeks, months, quarters, years, etc.
 - Per minute data is too dense
- 1.25% missing values, insignificant amount
- Submeter measurements are not specific to appliances or tasks. If they were, we could answer questions like:
 - How much energy was used for cooking? Using the dishwasher? Microwaving?
- We could provide estimates of energy use per device but more submeters would be the most accurate
- Formatting Issues:
 - Dates are strings
 - We can convert data formats appropriately for analysis

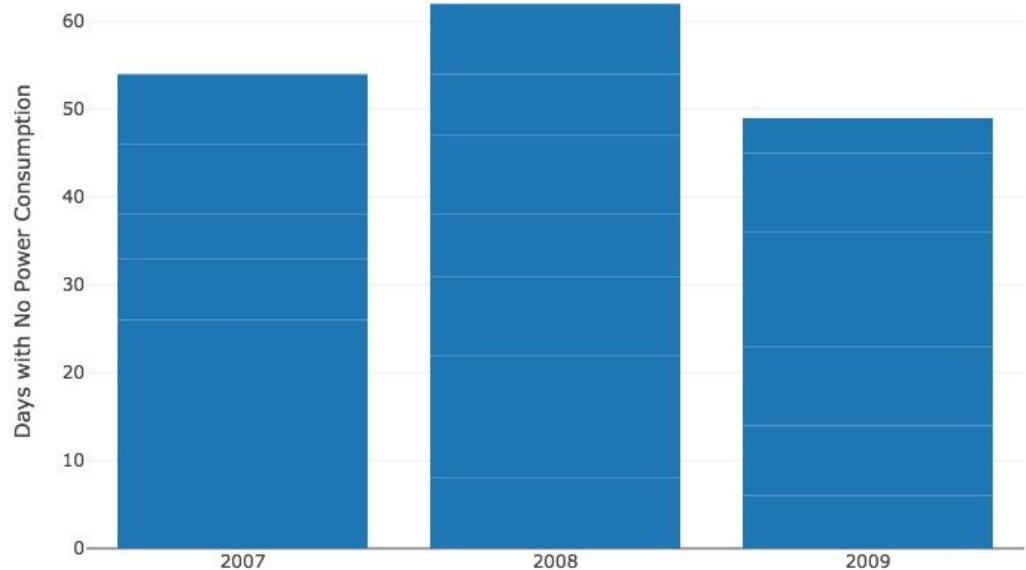
Issues with Data: Zero Watt-Hours

Most of the data consists of zero watt-hours. This could happen from:

- Power Outages
- Devices unplugged
- Broken submeters
- Submeters turned off

If this were accurate, this would mean that for **165** days in 3 years, the kitchen (for example) would have all devices unplugged, no power in the kitchen, or a broken submeter. Microwaves and ovens, for example, have clocks that are always using energy. This reflects a problem in how the energy usage is recorded.

Days with No Power Consumption in Kitchen



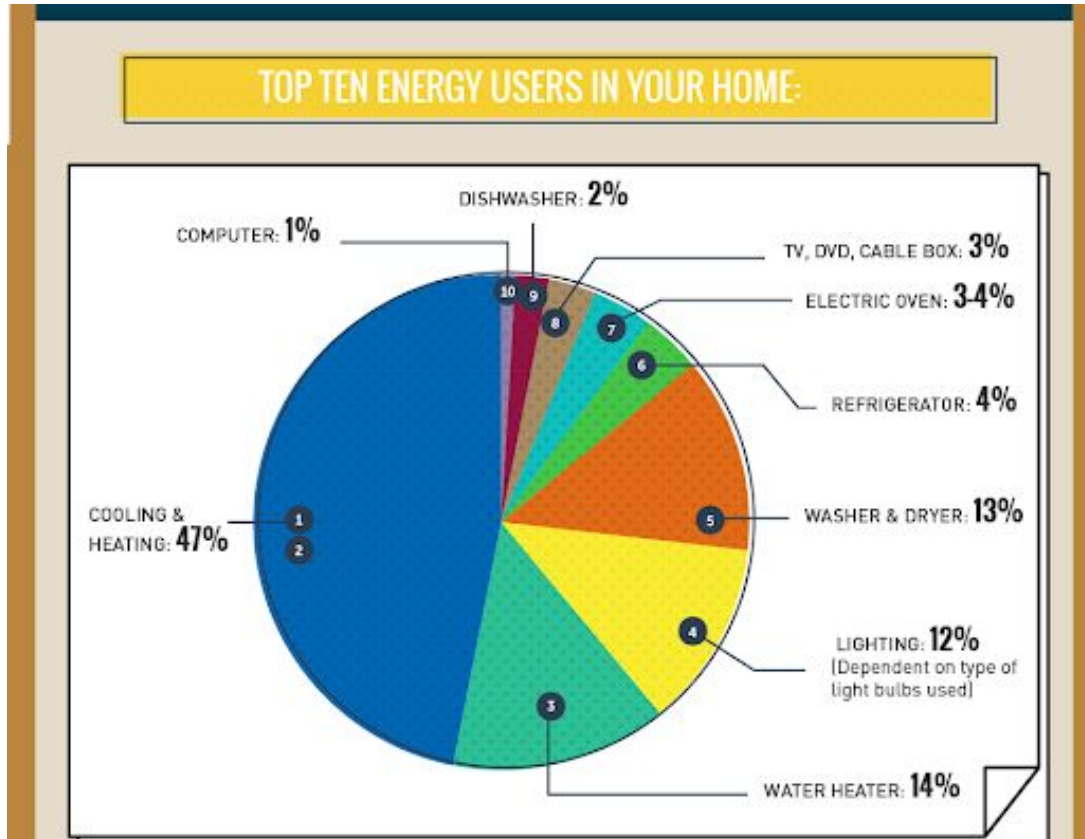
Issues with Data: Zero Watt-Hours

- No power consumption at all in Laundry Room from 7/29/2007 to 08/03/2007 and from 08/05/2008 to 08/18/2008.
 - This implies that the fridge was not working, was unplugged, or that submeter was off or broken.
- However, Water Heater and A/C unit were in use every single day per the Submeter 3. This indicates that there was no power outage.
- We need to know what happens when a sensor is faulty and what protocols are in place to detect when this happens.
- It would also be helpful to know if there is a minimum set threshold where the submeters do not record energy consumption if it is less than a set amount.

Questions than can be Answered from Submeter Data

- Energy Consumption Patterns
 - When are peak demand times? Off-peak times?
 - What time periods (by hour, days, weekdays, month) did the residents use more energy on?
 - When are certain rooms, like the kitchen, usually in use?
 - How often did the residents do laundry?
- What is a 'normal' rate of energy consumption for the residents?
- Are appliances still efficient?
 - Once normal usage is defined, were there certain rooms that started consuming more energy over time?
- Were there power outages?
- Do the residents use more or less energy on holidays?

Recommendations for Future Data Collection:



- Include energy consumption per appliance (like graphic on left)
- Energy per task (cooking, laundry, cooling home)
 - User would be able to map appliances with self-defined tasks
 - Fridge included with kitchen submeter
 - Water heater use for dishwasher separate from washing machine

Recommendation on Applying Submeter Data to Benefit Homeowners

- Cost Saving Measures
 - Recommend when to use high energy appliances, based on local utility rate schedules and show extent of cost savings to homeowners
 - Notify when appliances are consuming energy at inefficient rates
- Security measures:
 - Vacation mode: notify when application usage exceeds a set amount OR
 - Notify when specific applications are in use that shouldn't be, like accidentally leaving the oven for hours (overnight)

