Smart Sensing and Control for More Energy-Efficient Homes

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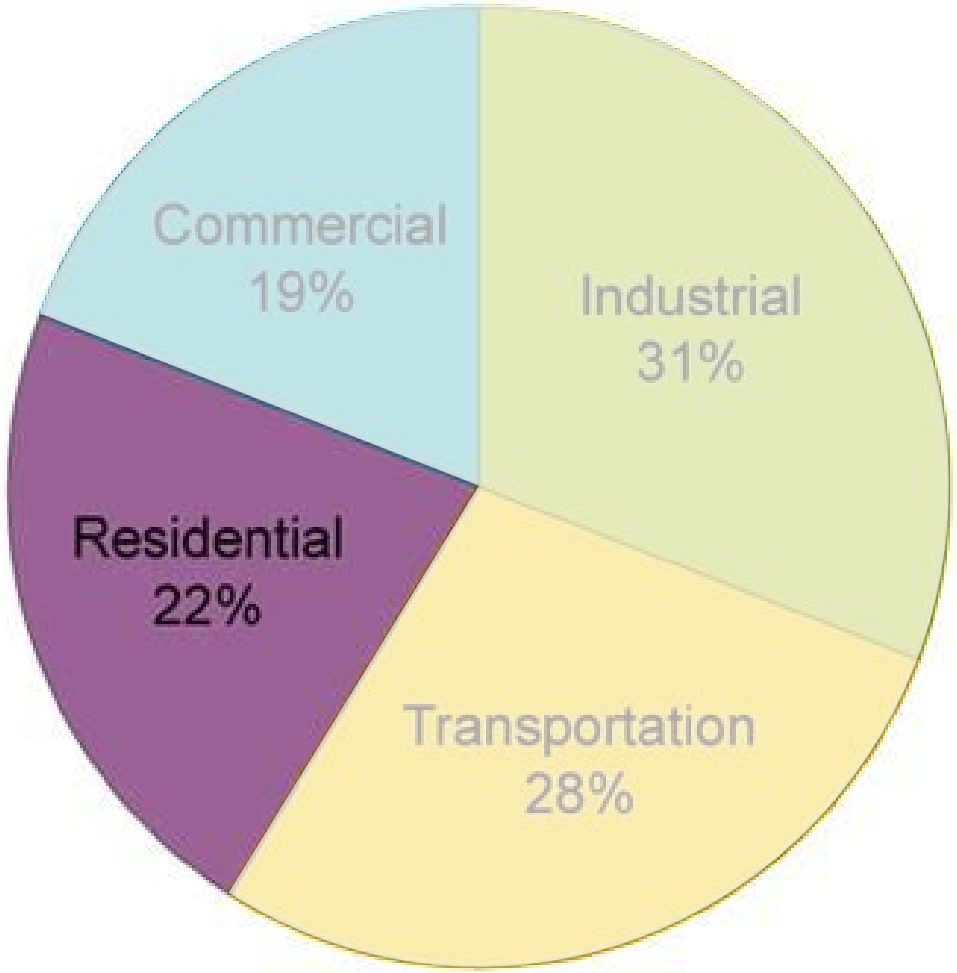
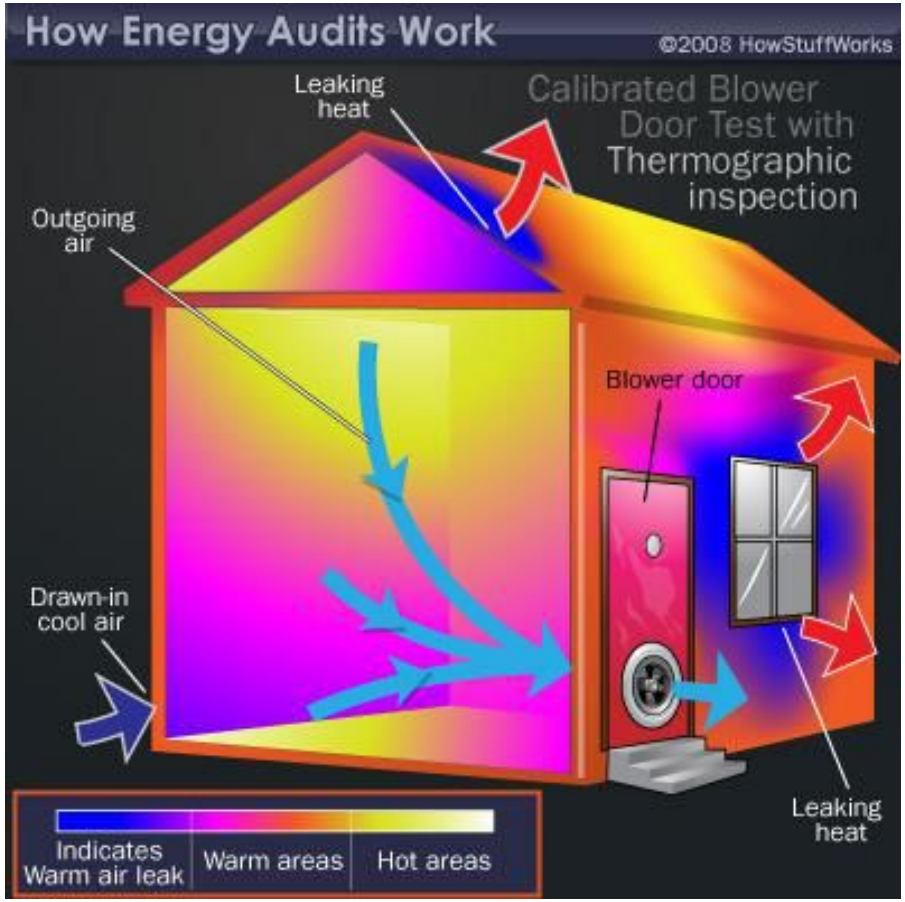


Source: U.S. Energy Information Administration, *Annual Energy Review 2008*.

Weatherization



$5,000 - $25,000

Hypothesis

Computerization

can save as much energy in homes

as weatherization

at 10x to 100x lower cost

Target: $300 + controllers

Occupancy Sensing Today

No sensors give occupancy and identity today!

Motion

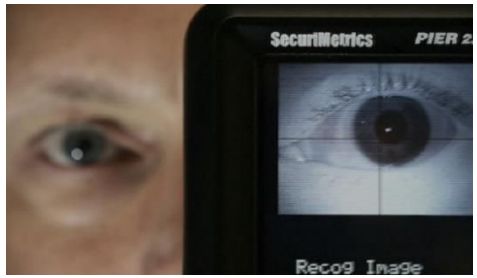
Optical Counter

CO2

Thermal

Vision

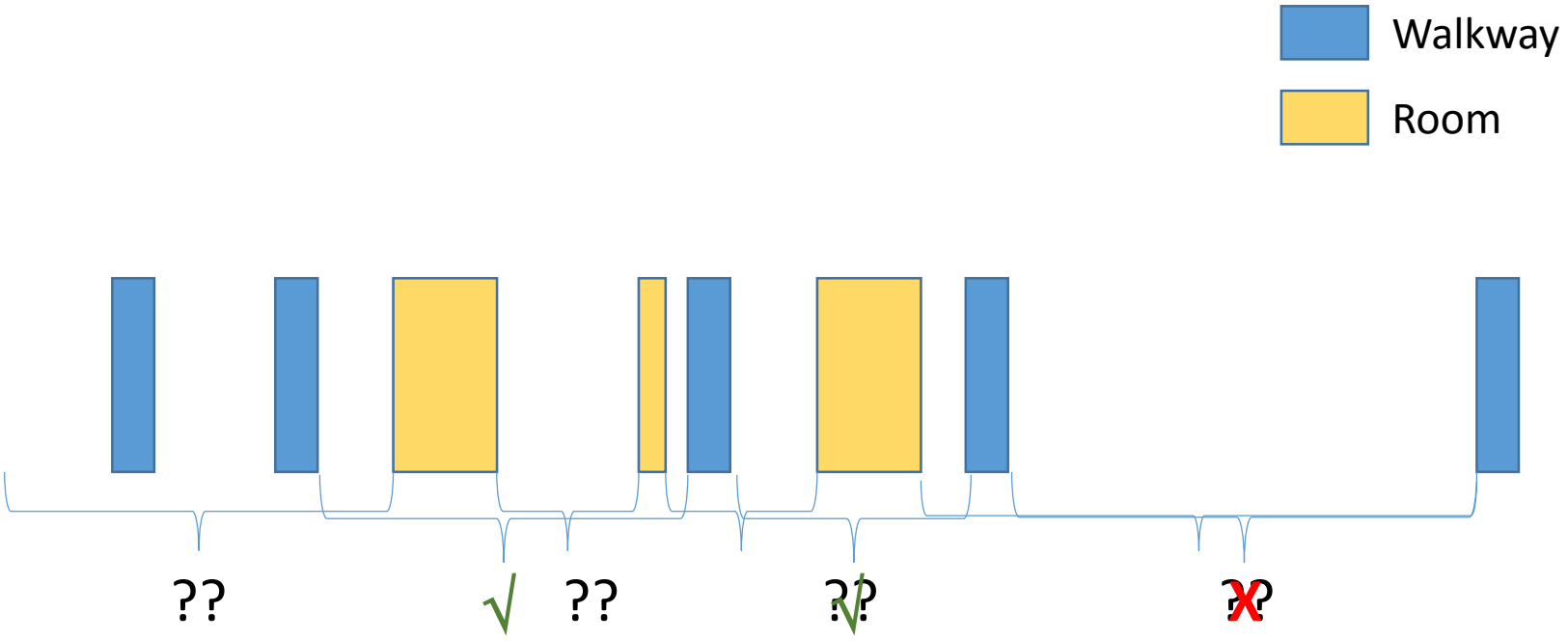
Eye Scan




Ultrasound

Walkway Sensing

Walkway Sensing



Wearables

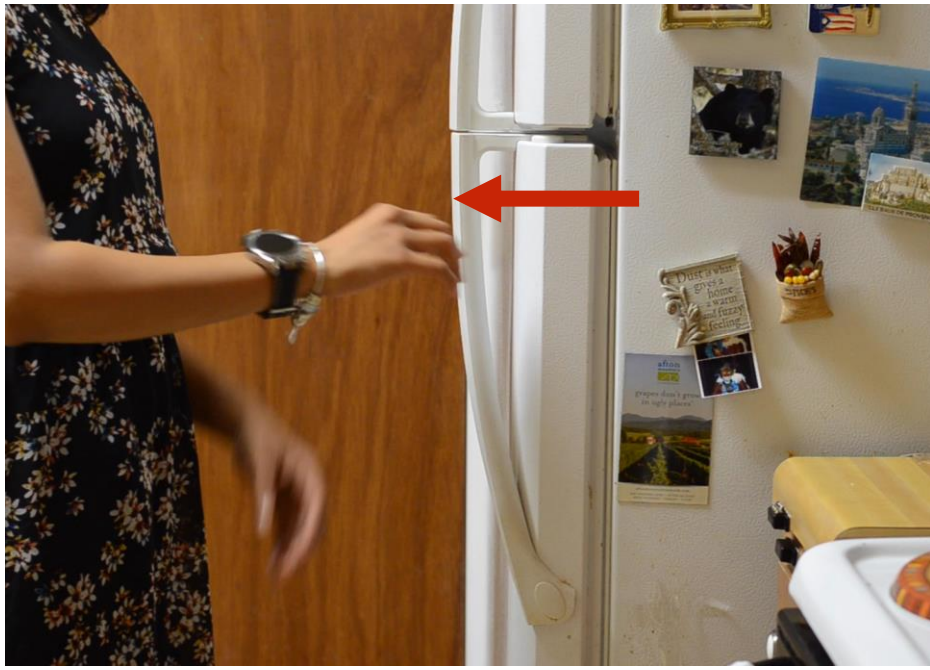
- Location
- Identity
- Can we get object usage?

Wearables

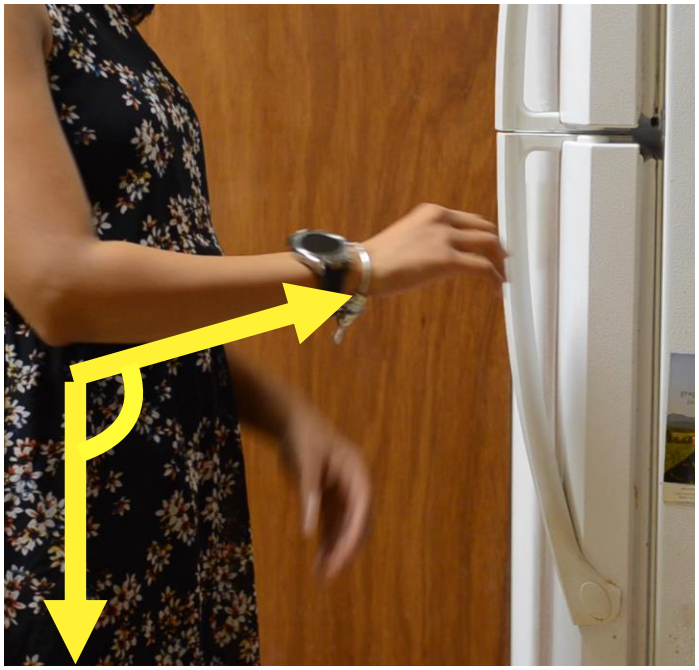
Electric Meter

Water Meter

Object Interactions: Action



Object Interactions: Angle

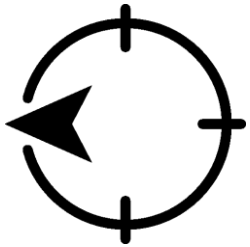


Object Interactions: Direction

Object Hallmarks

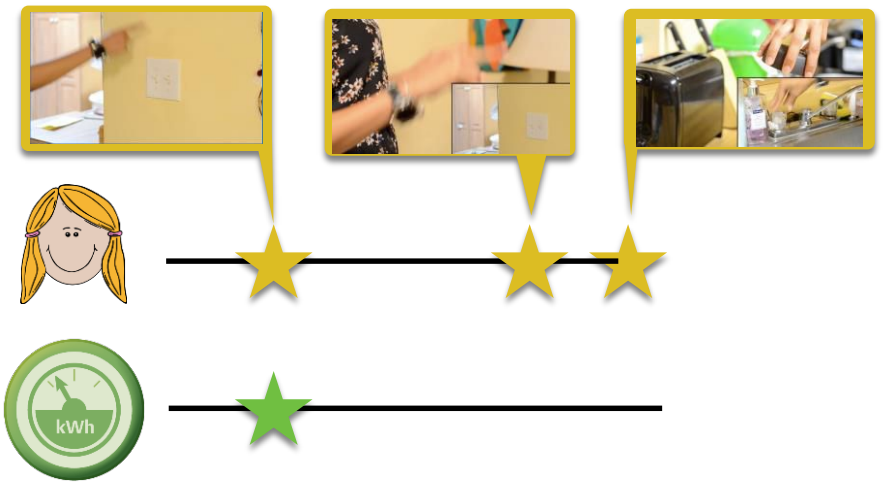
Action

Angle

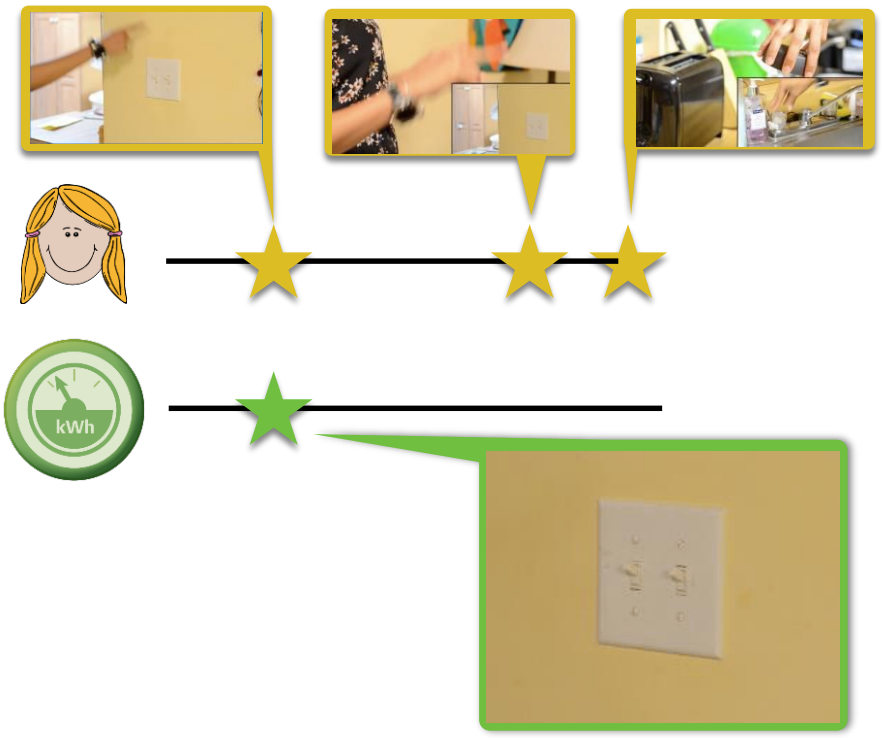


Direction

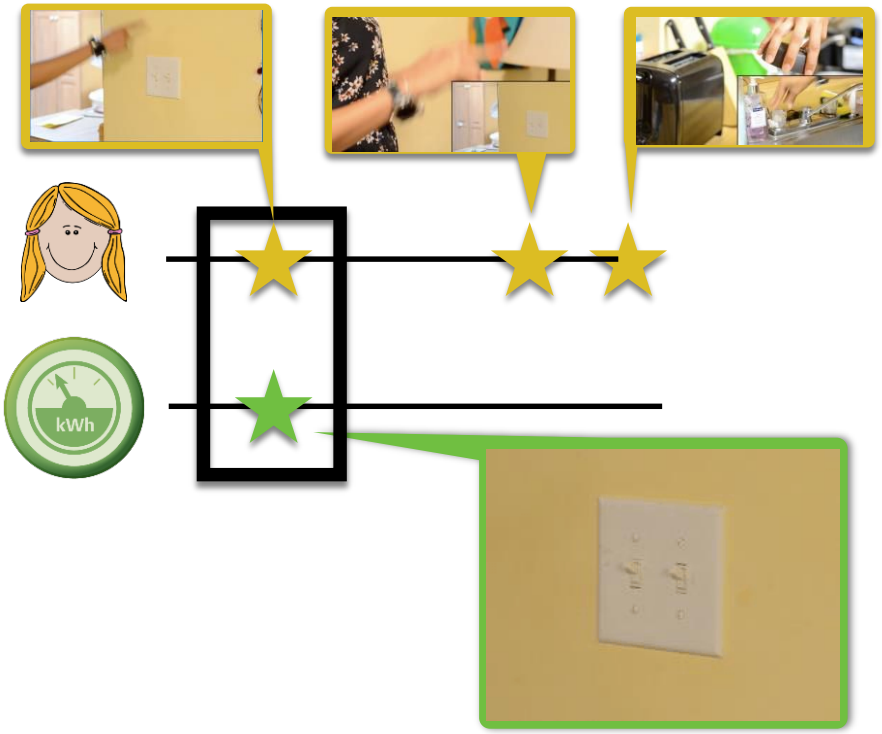
Object Hallmarks Fusion



Object Hallmarks Fusion

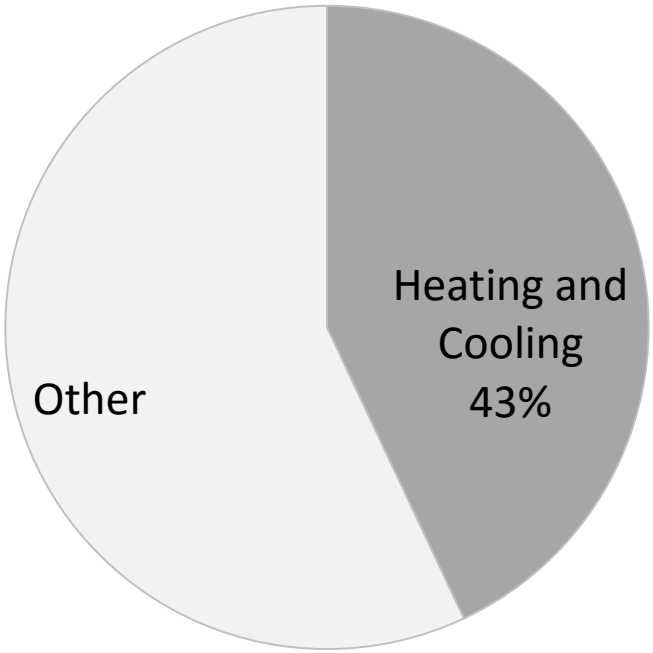


Object Hallmarks Fusion

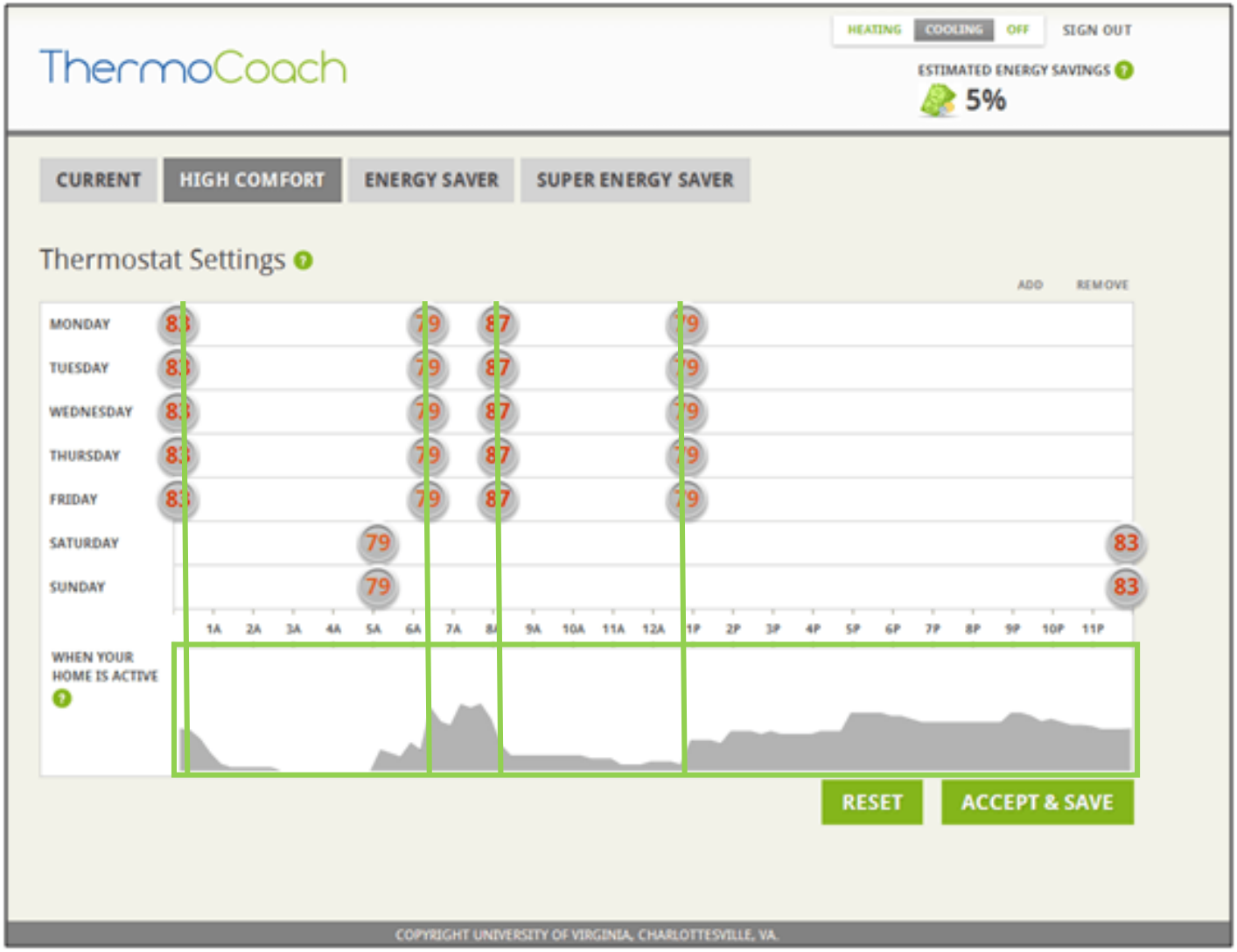


Using Occupancy

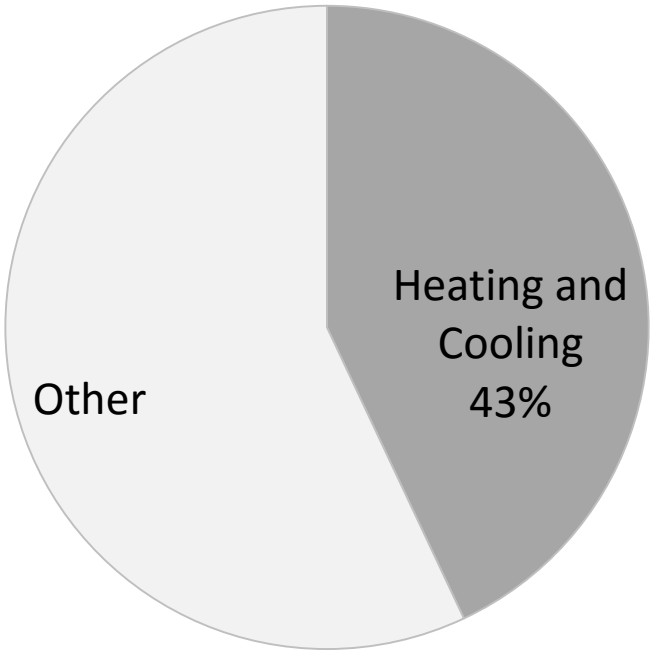
US Residential Energy Use*



* National Academy of Science, 2006


ThermoCoach
HEATING
COOLING
OFF
SIGN OUT
ESTIMATED ENERGY SAVINGS
5%
CURRENT
HIGH COMFORT
ENERGY SAVER
SUPER ENERGY SAVER
Thermostat Settings
ADD
REMOVE
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
79
87
83
1A 2A 3A 4A 5A 6A 7A 8A 9A 10A 11A 12A 1P 2P 3P 4P 5P 6P 7P 8P 9P 10P 11P
WHEN YOUR HOME IS ACTIVE
RESET
ACCEPT & SAVE
COPYRIGHT UNIVERSITY OF VIRGINIA, CHARLOTTESVILLE, VA.

US Residential Energy Use*



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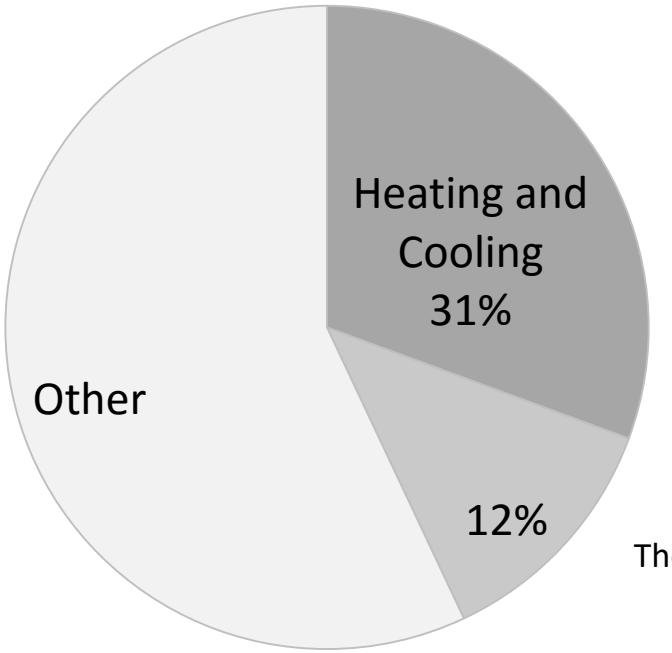
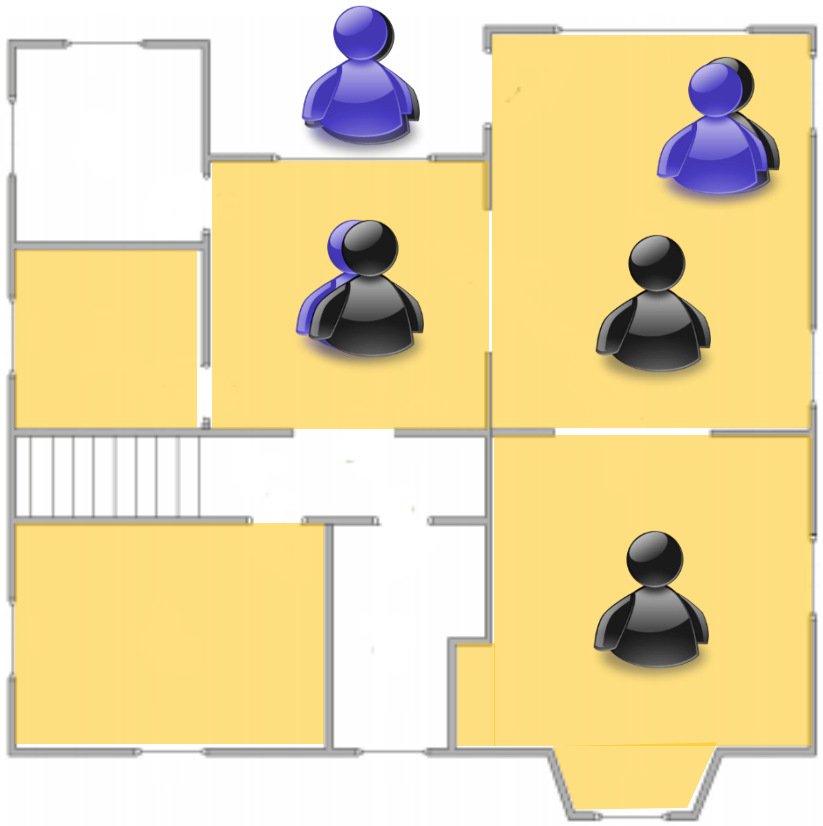
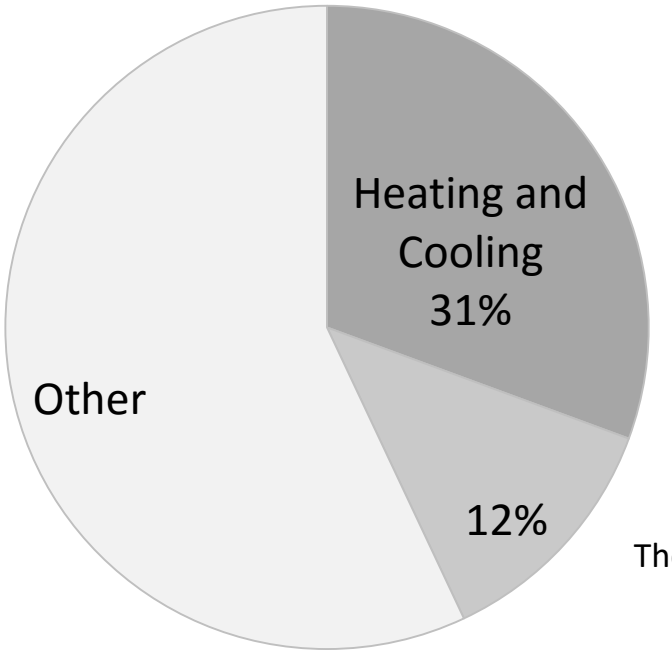


The Smart Thermostat

* National Academy of Science, 2006



US Residential Energy Use*



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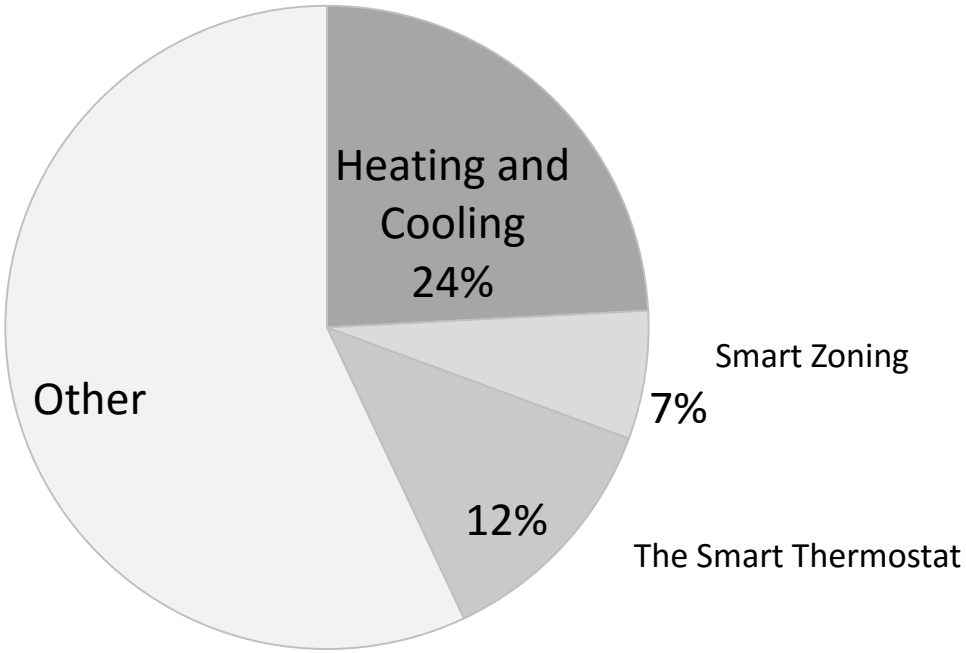

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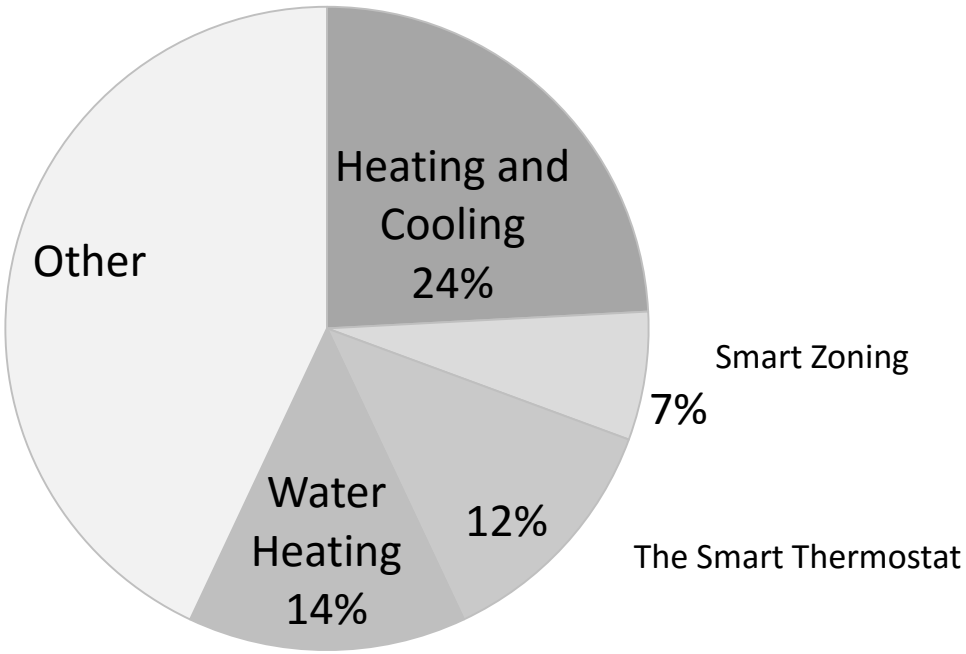
US Residential Energy Use*



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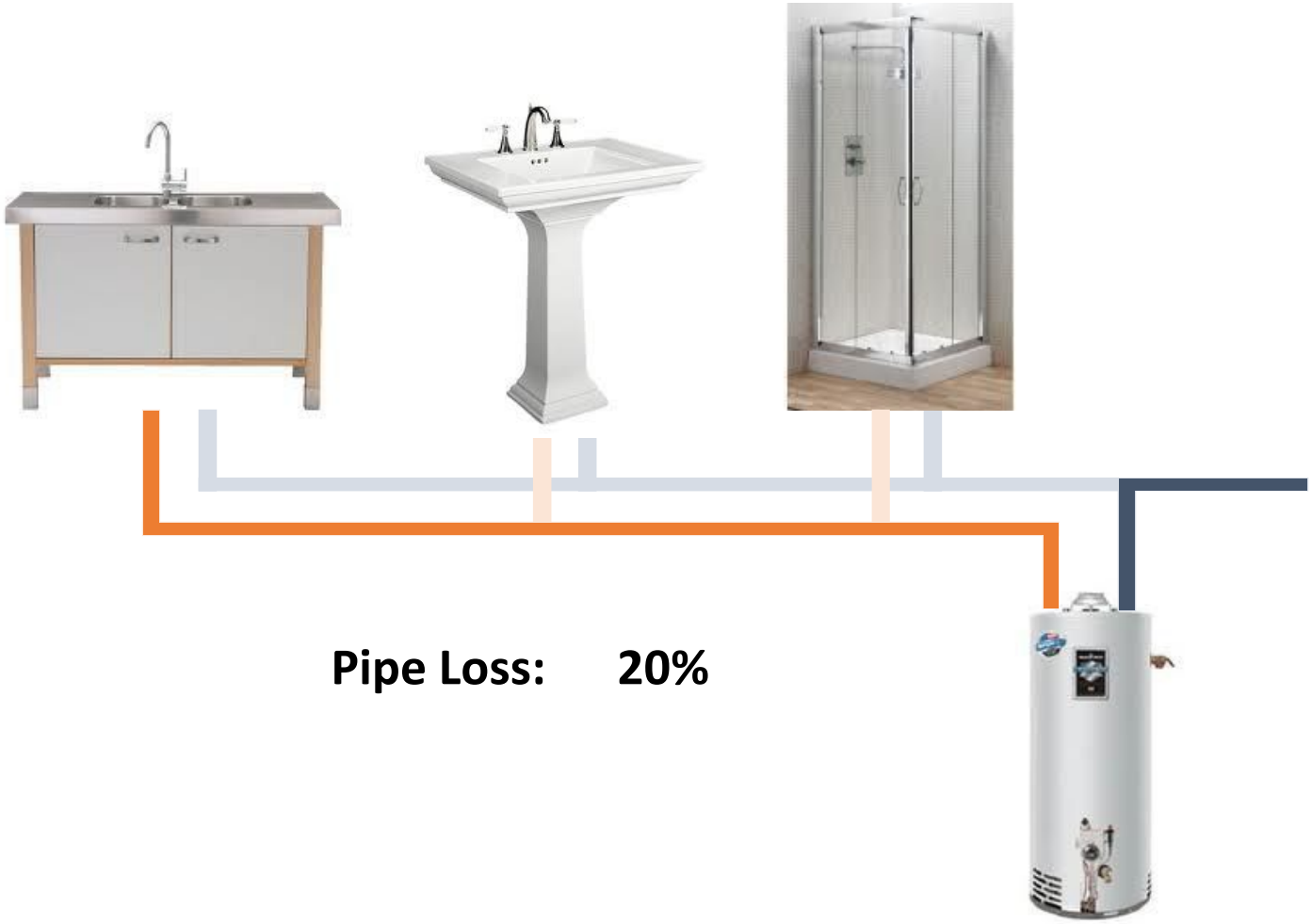
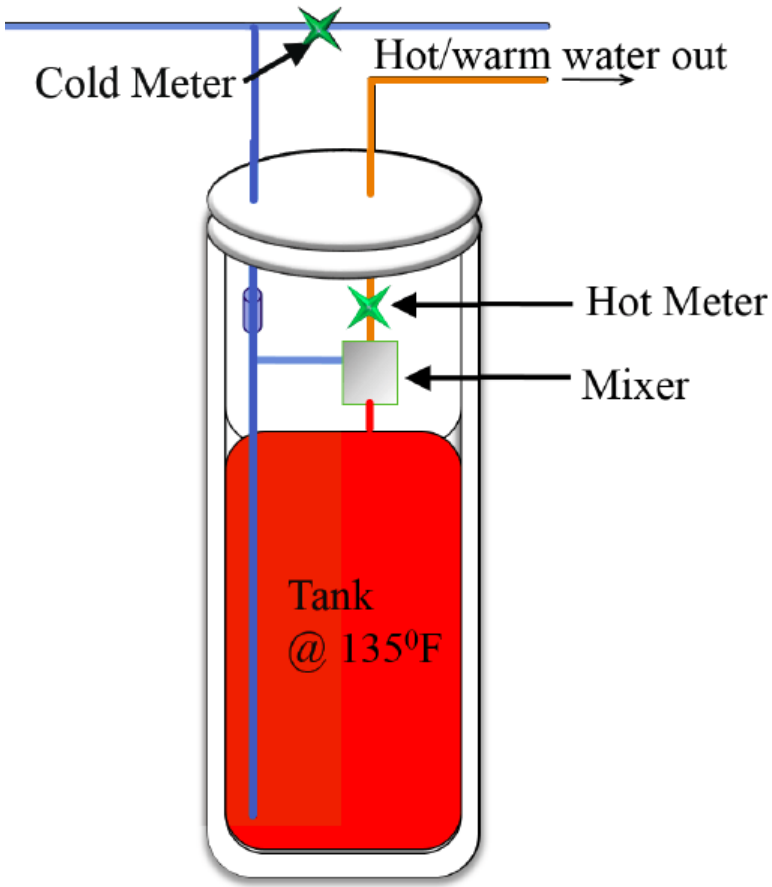
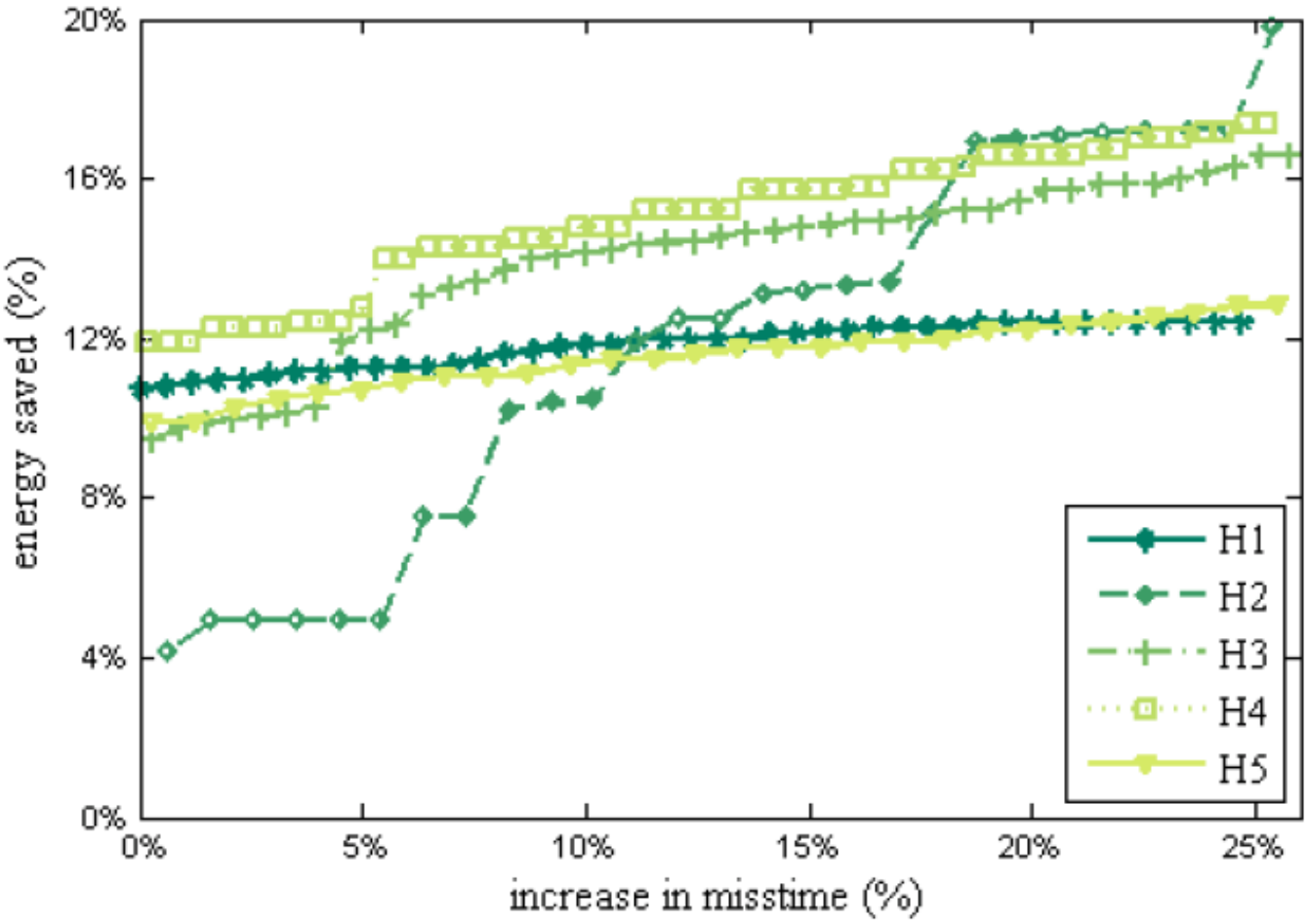


Pipe Loss: **20%**

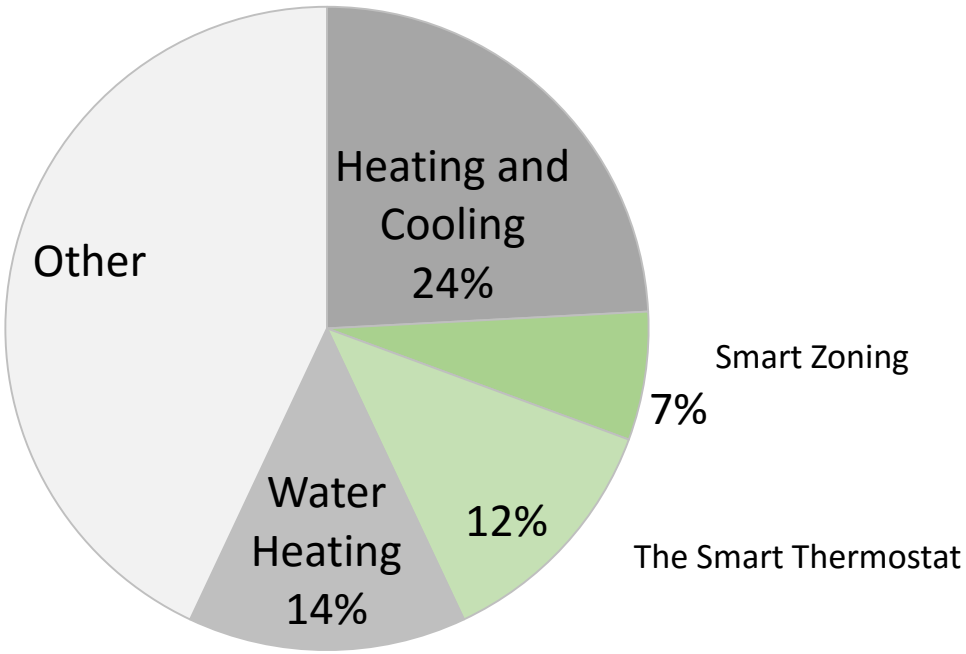
Pipe Loss: **20%**

Short Events: **4%**


Cold Meter
Hot/warm water out
Hot Meter
Mixer
Tank
@ 135^{0}F


20%
16%
12%
8%
4%
0%
energy saved (%)
0%
5%
10%
15%
20%
25%
increase in misstime (%)
H1
H2
H3
H4
H5

US Residential Energy Use*



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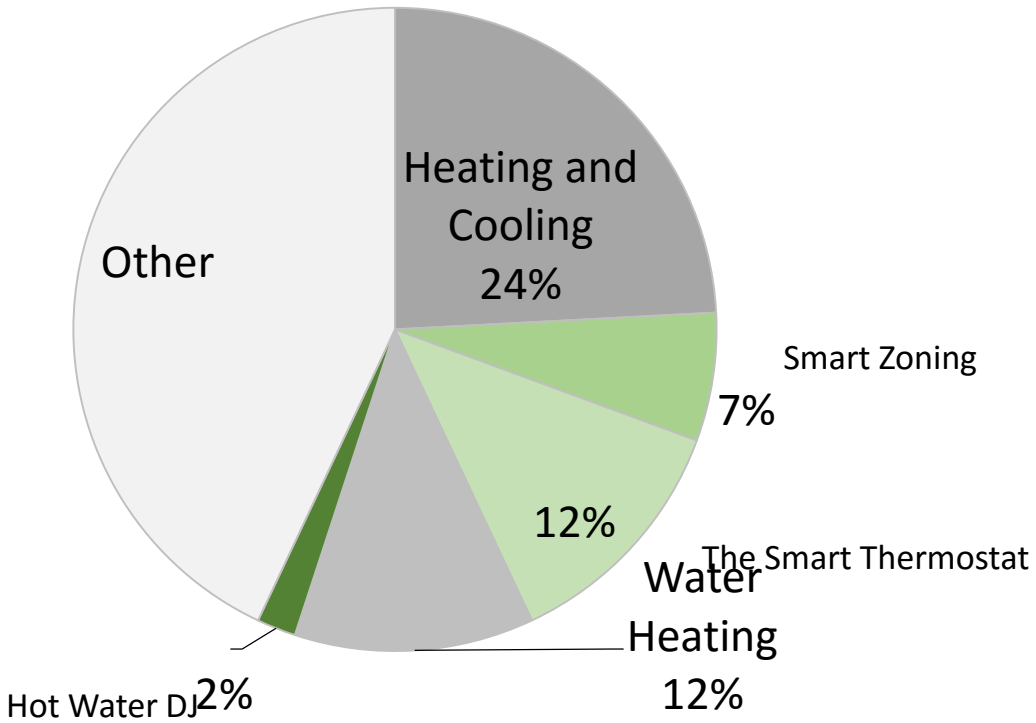
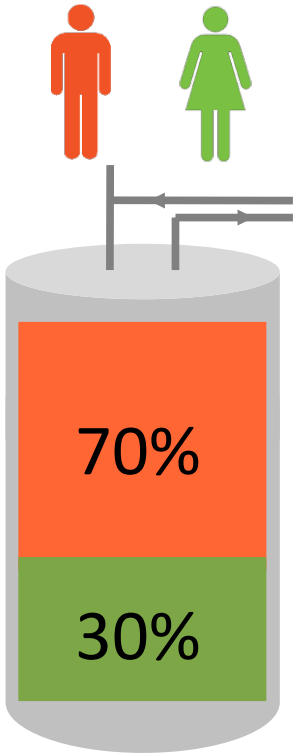
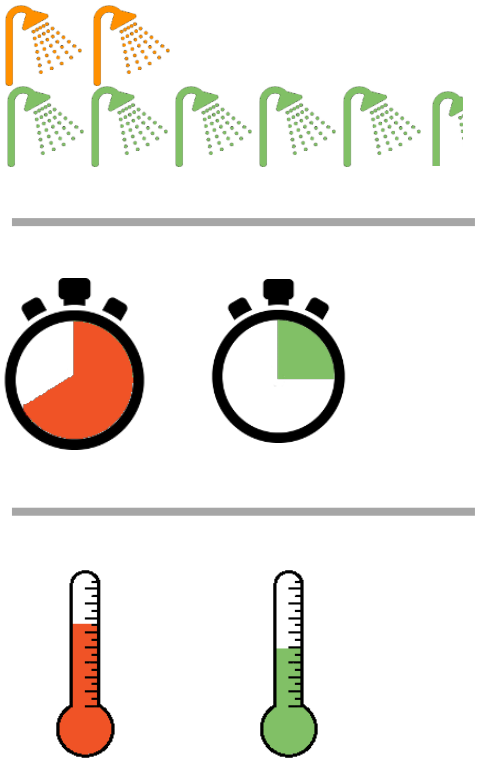


* National Academy of Science, 2006

Hot Showers Per Person





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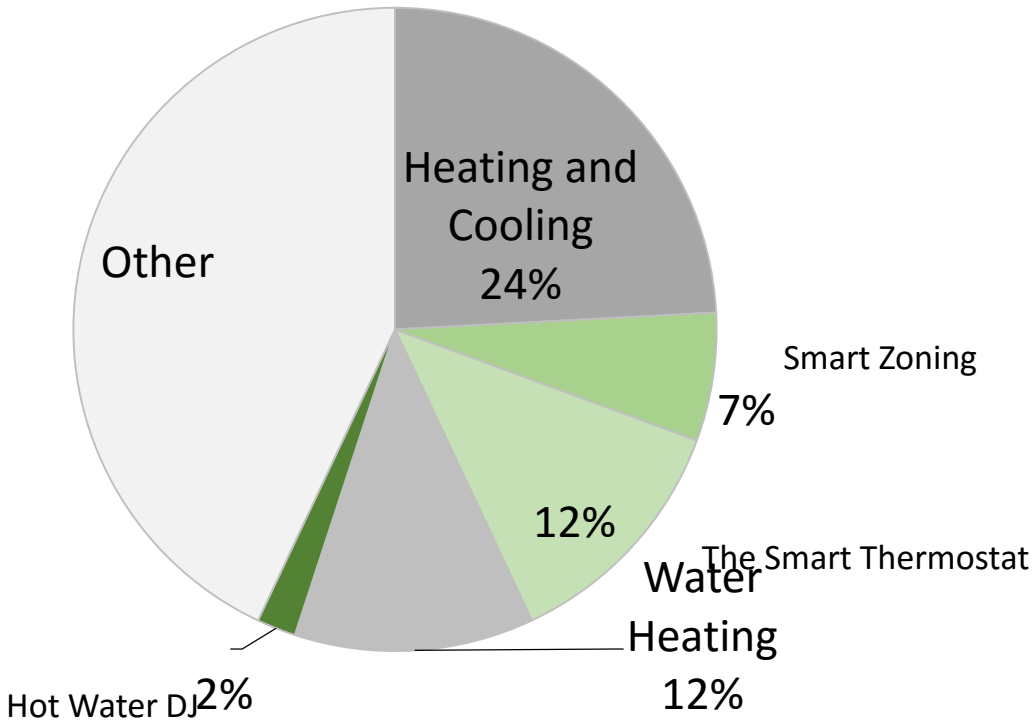

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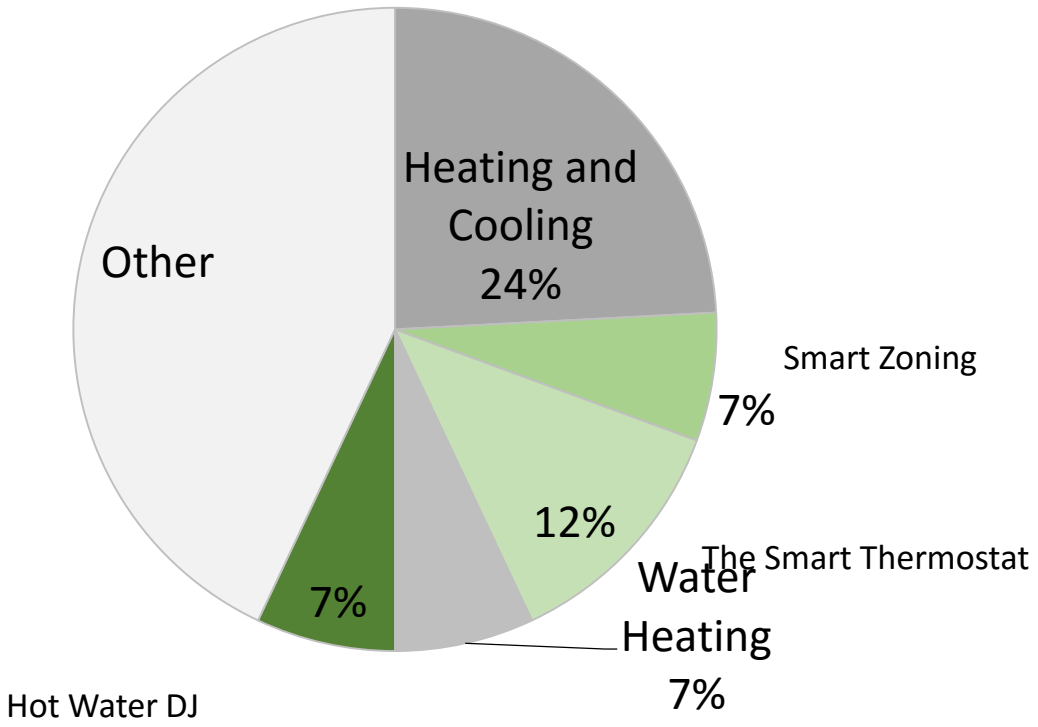

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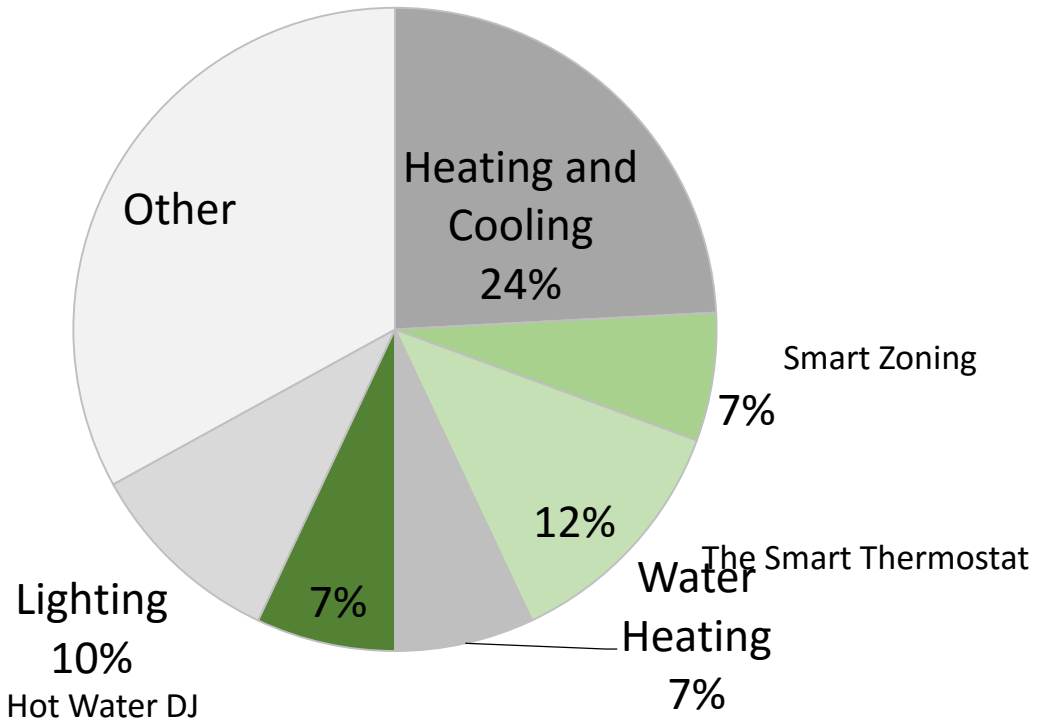

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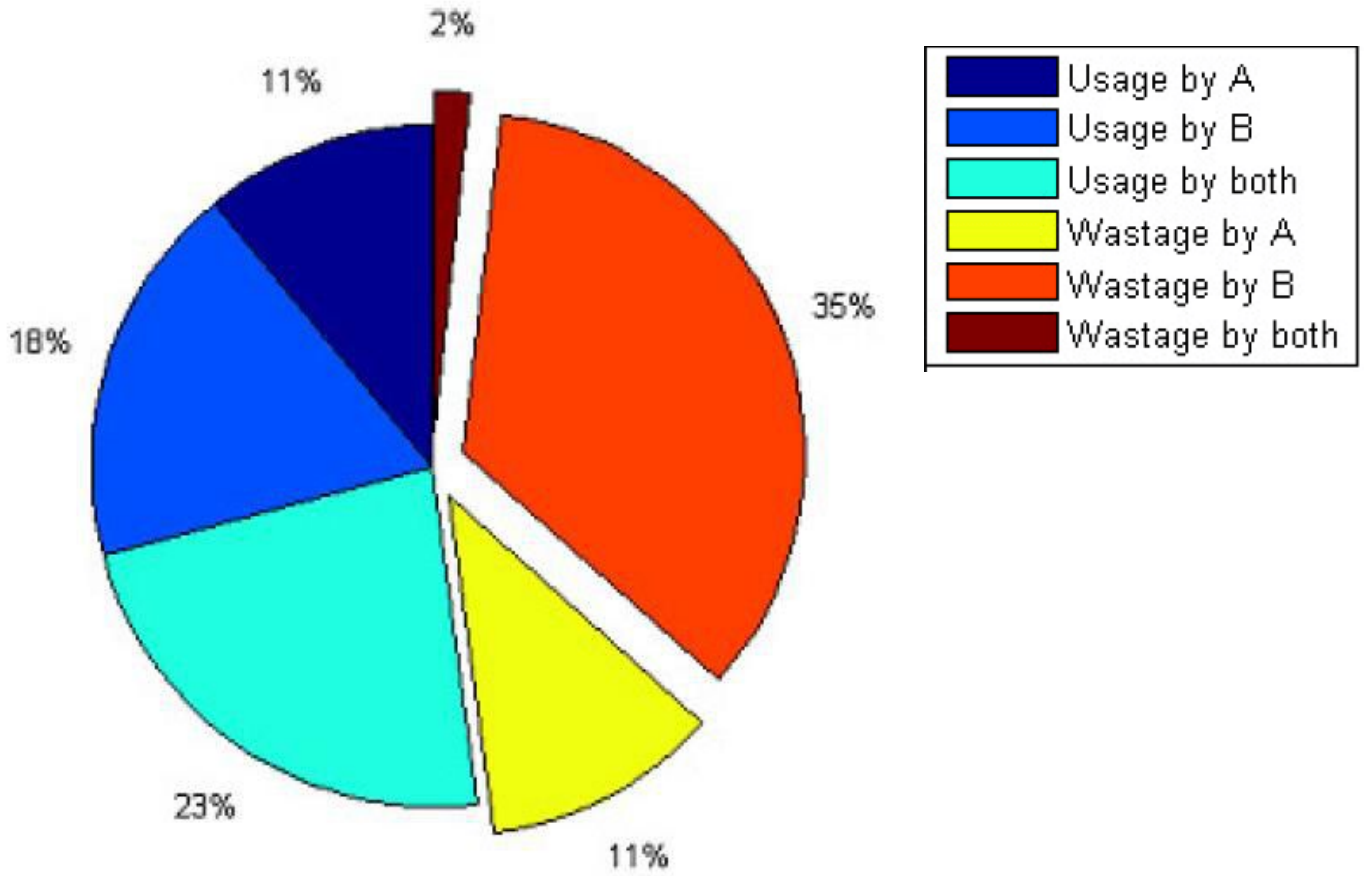
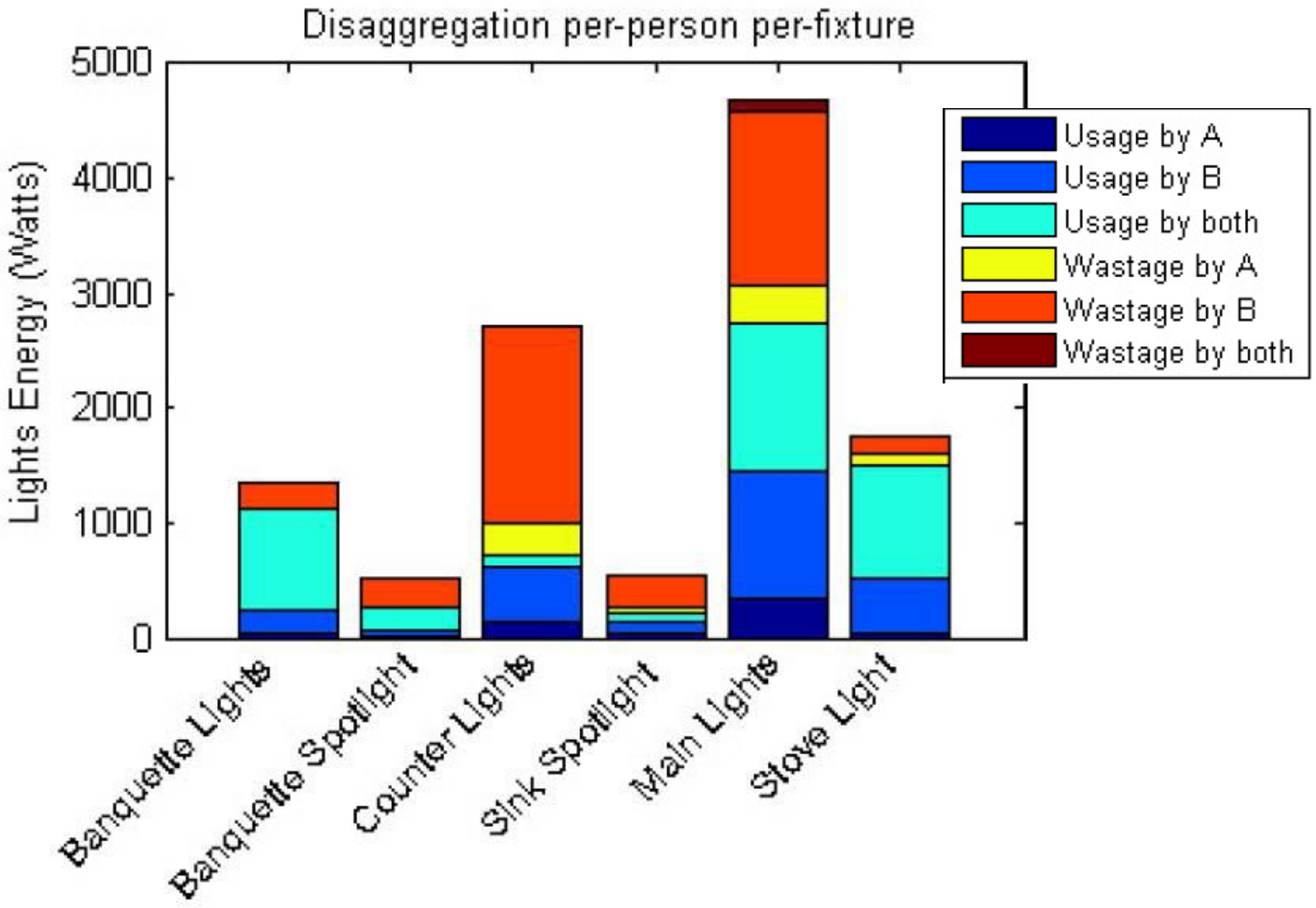
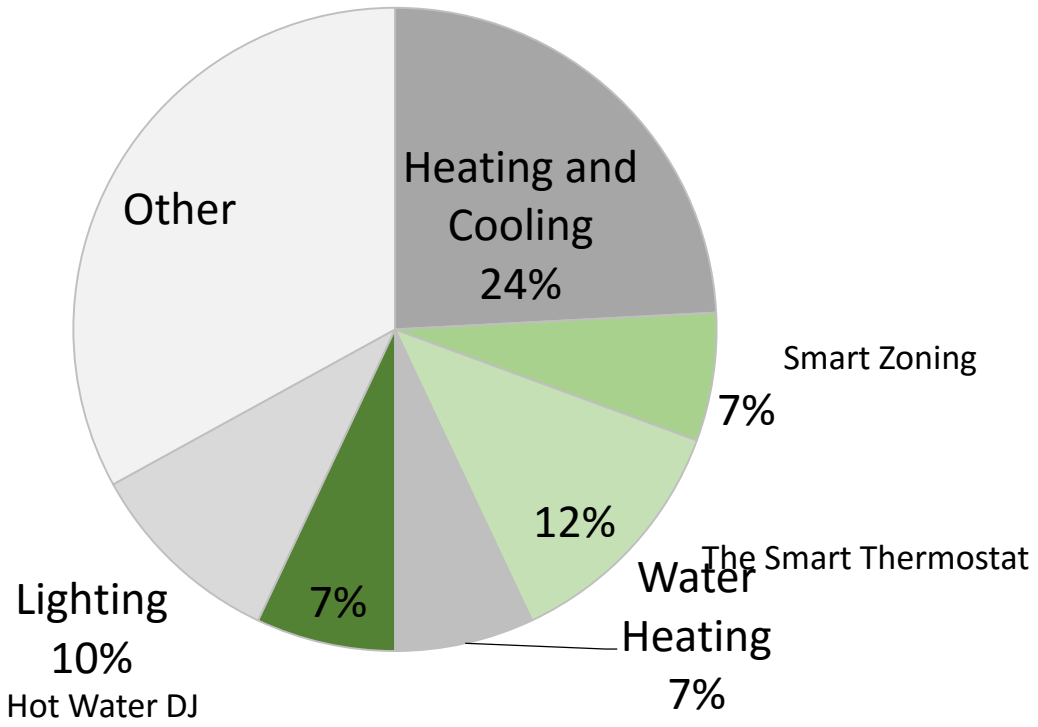

2%
11%
35%
18%
23%
11%
Usage by A
Usage by B
Usage by both
Wastage by A
Wastage by B
Wastage by both


Disaggregation per-person per-fixture
Lights Energy (Watts)
5000
4000
3000
2000
1000
0
Usage by A
Usage by B
Usage by both
Wastage by A
Wastage by B
Wastage by both
Banquette Lights
Banquette Spotlight
Counter Lights
Sink Spotlight
Main Lights
Stove Light

US Residential Energy Use*



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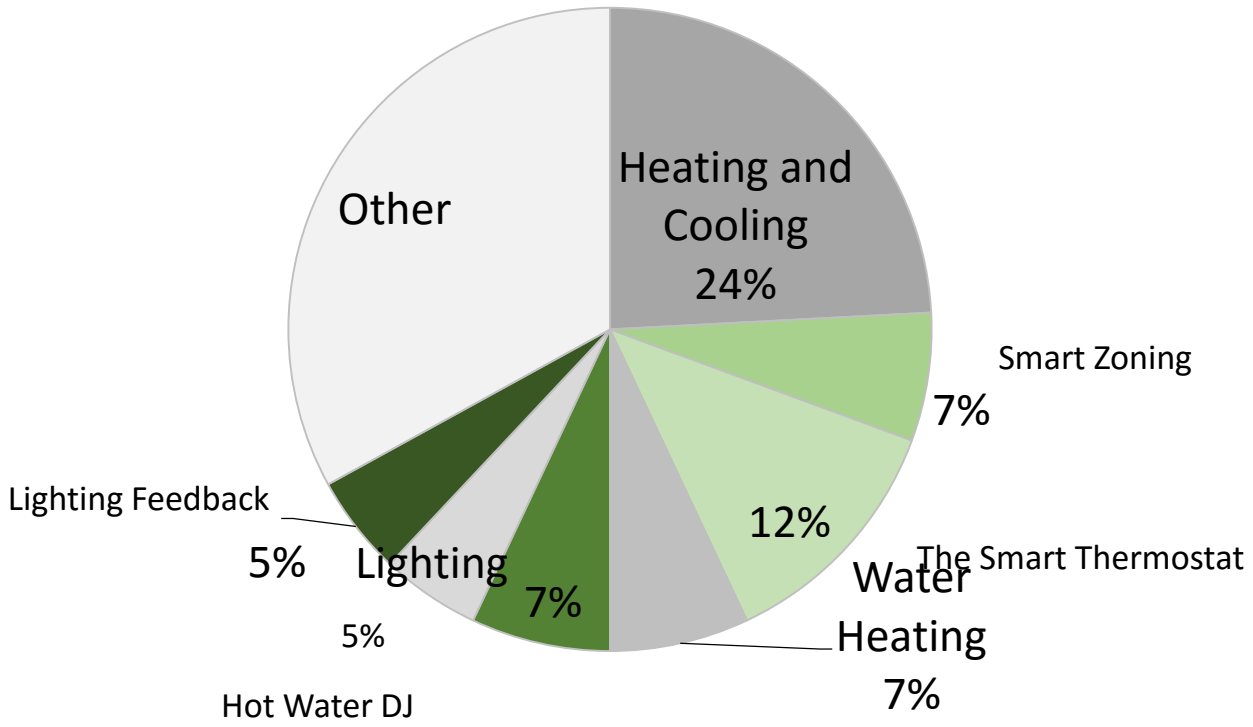
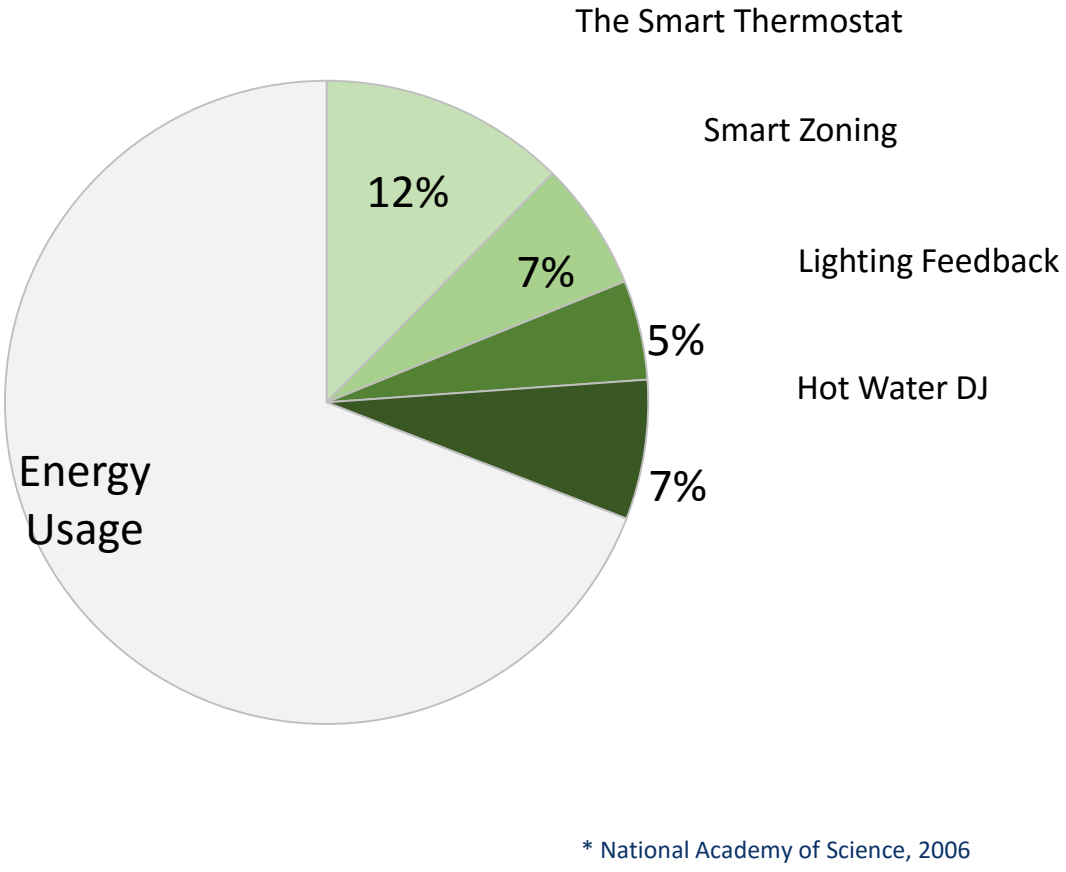


* National Academy of Science, 2006

US Residential Energy Use*



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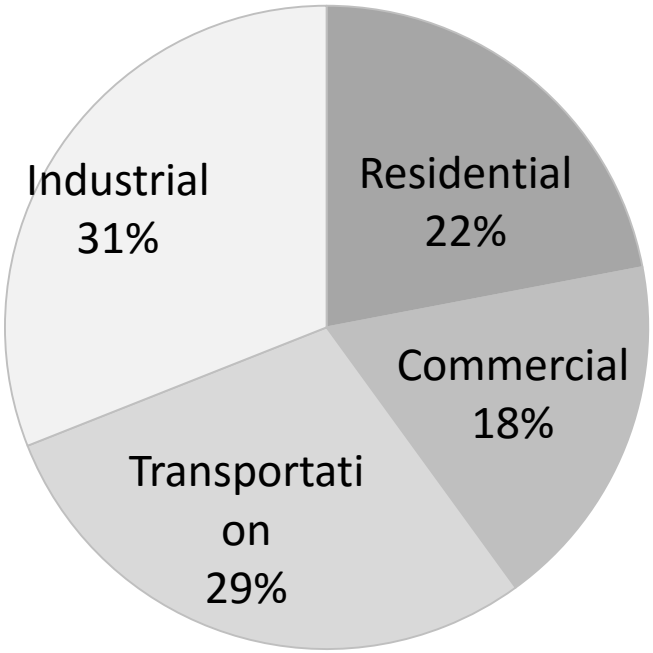
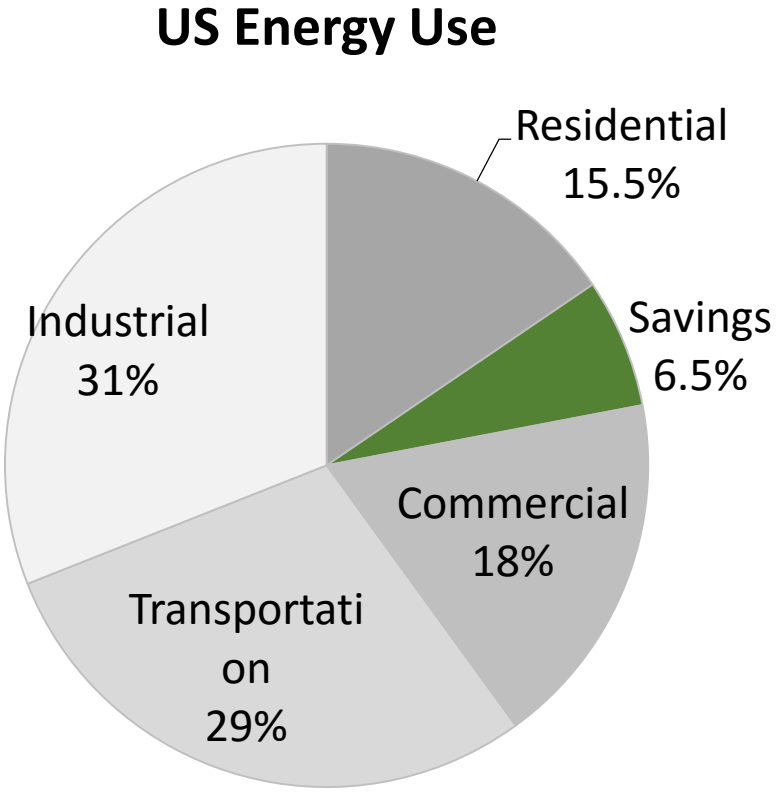
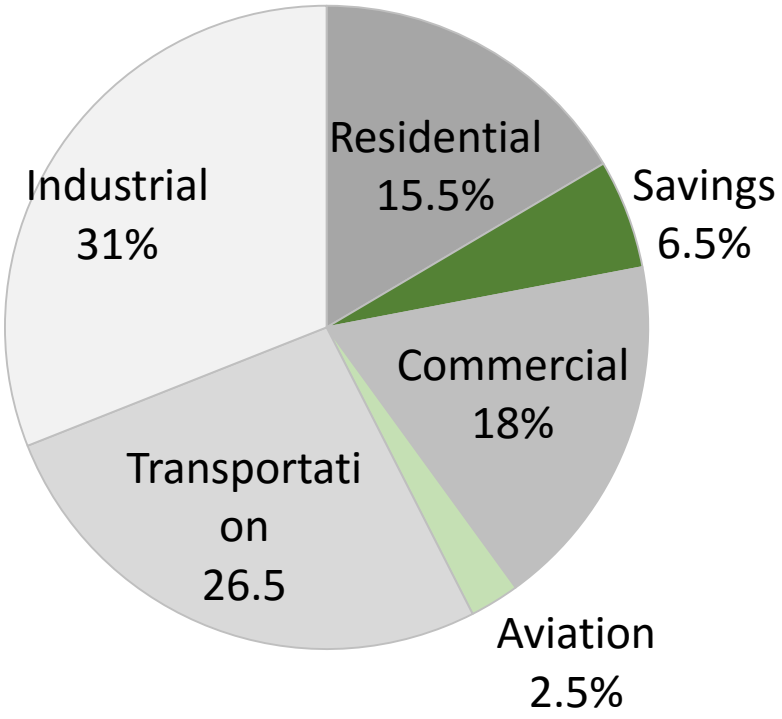
US Energy Use




US Energy Use
Residential
15.5%
Savings
6.5%
Commercial
18%
Transportati
on
29%
Industrial
31%

US Energy Use

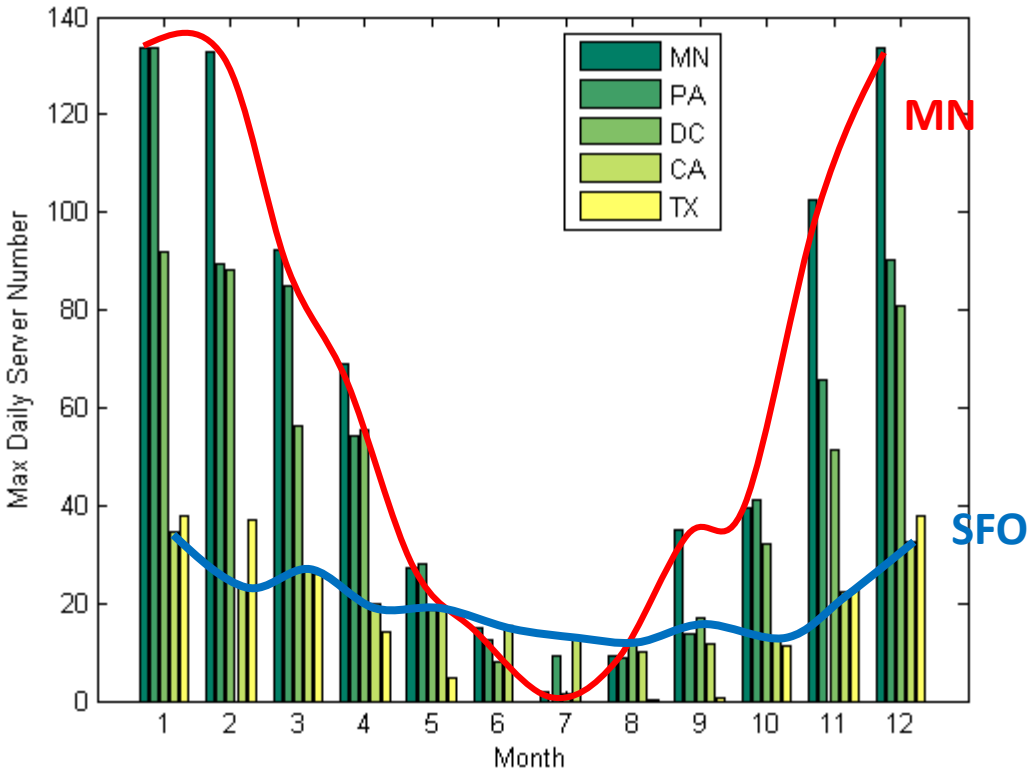


Ties to Smart Cities

Ties with Computing Network

The Data Furnace

- Cheaper than data centers
- Free heat in your home
- Faster than data centers

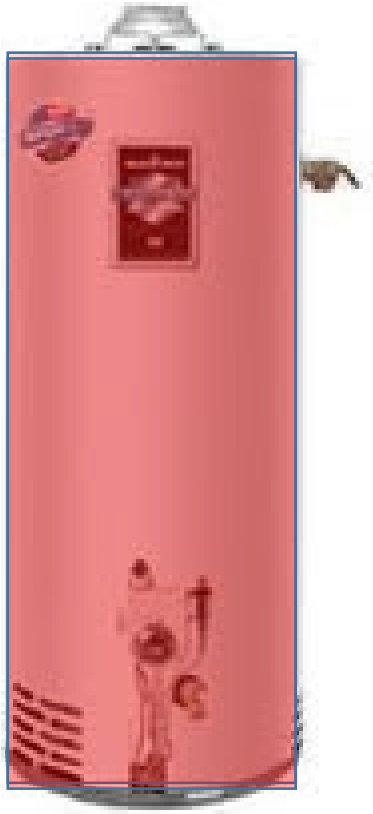


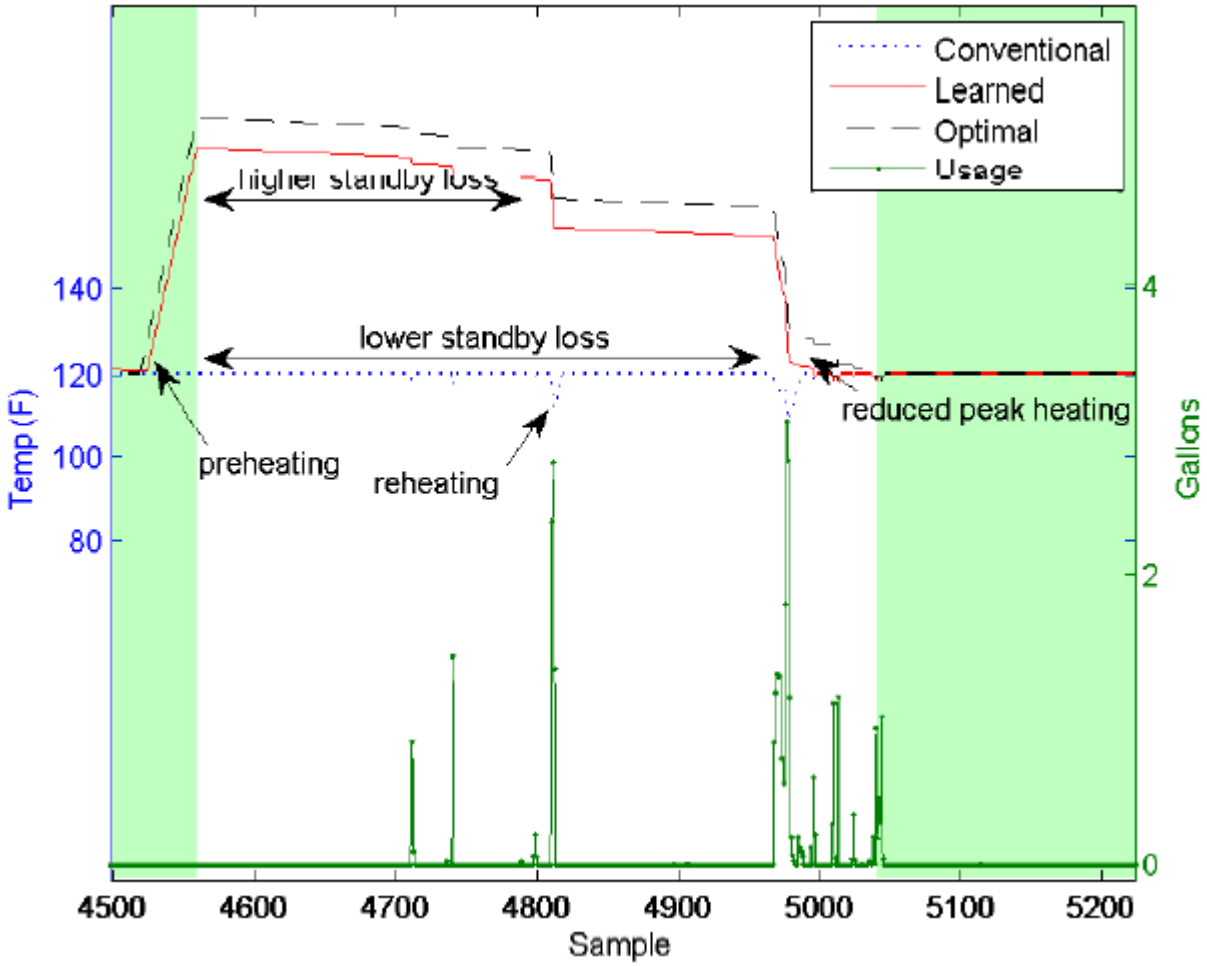
Ties with Smart Grid

Load-shifting Water Heater

120F

190F





Ties with Transportation, Water…

- Occupancy and activities can be used to predict
  - Road trips
  - Destinations
  - Sewage usage
  - Power usage

Summary

- People are the most important thing in the home
- Identity, Location, and Object usage are key
- This information can be used for many applications
  - Sanitation
  - Elderly monitoring
  - Energy conservation
  - Other ideas? Let’s talk!

Credits and Questions

Thank you