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Non-Intrusive Load Monitoring (NILM)

Presentation to the EEAC
May 25th, 2016

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What is NILM?

- NILMs = Non-Intrusive Load Monitoring
- Hardware coupled with software that disaggregates whole house load into individual end use loads using algorithms and electric “signatures”
  - Comes in many different “flavors”
- Allows more granular insight into home energy use without requiring individual end use metering

NILMs has the potential to provide detailed information about a customer’s energy usage at a fraction of the cost of other metering technologies

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How are we going to use it in MA?

NILMs is going to be used in the Residential Baseline Study to help answer key questions

- How do people use energy in Massachusetts homes?
- How do various appliances and end-uses contribute to peak loads?
  - Cooling equipment
  - Heating equipment
  - Hot water equipment
  - Laundry
  - Dehumidifiers
  - Pool Pumps
  - EV chargers
- Create hourly load shapes of major end uses

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Phased approach allows us to course correct if necessary

NILM is a combination of software and hardware

Many different types of NILMs combinations exist

Software Based Solutions

Disaggregate data from third-party Hardware.

Key Providers:
Bidgely, Plotwatt, EEme

Utility Smart Meters

Data transmission from the meter Via a WiFi connected gateway

Key Providers:
Sensus, Itron, Landis+Gyr

Current Transformer (CT) Based Devices

Monitoring voltage and current at the home electrical panel.

Key Providers: *TED, Neurio, Smappee*

Utility Meter Reading Devices

Device installed at the meter, incorporates meter/optical sensors

Key Providers: *Blue Line, Enetics, Wattvision*

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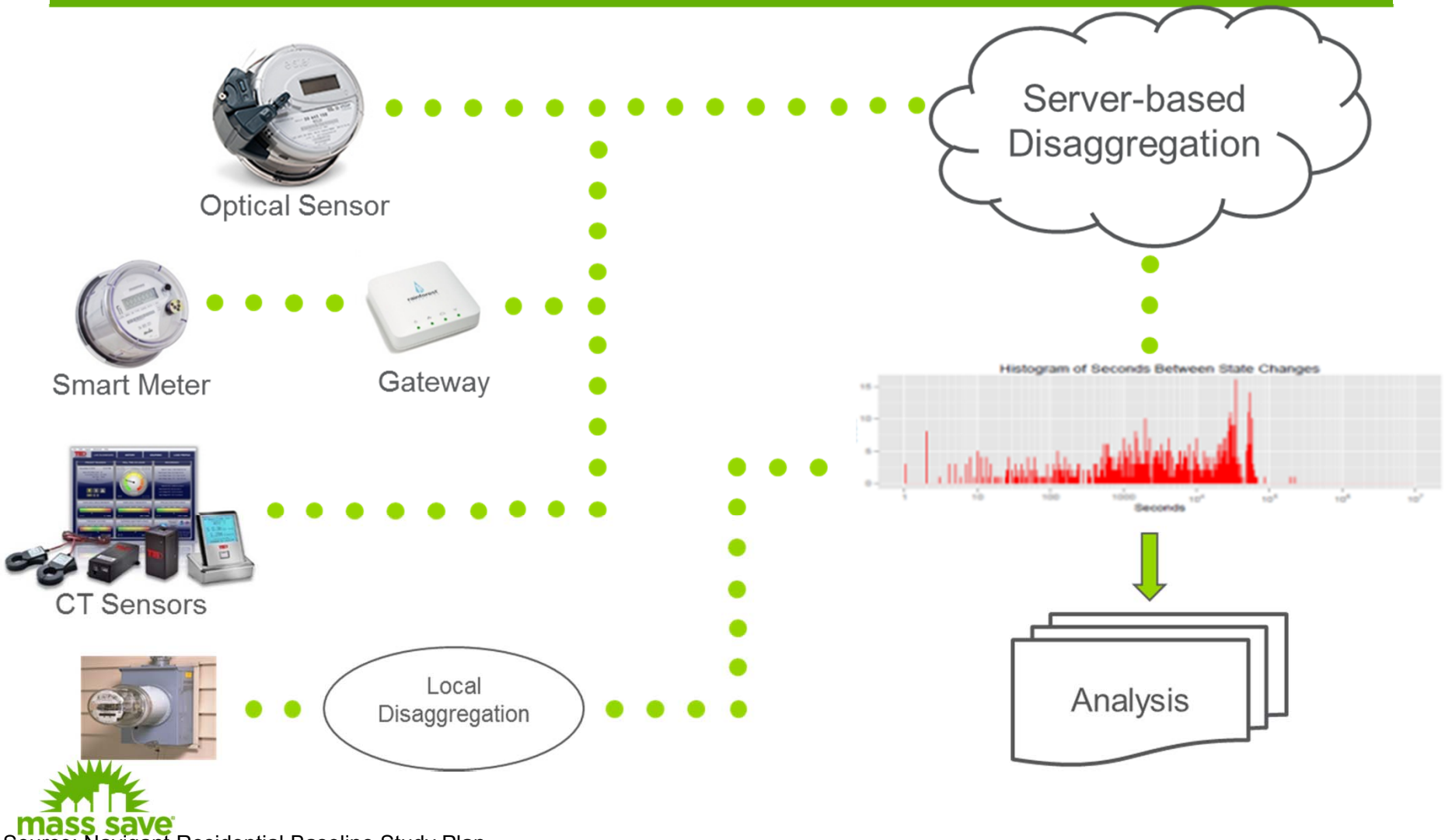
Source: Navigant Residential Baseline Study Plan

Different configurations lead to different data collection schemes

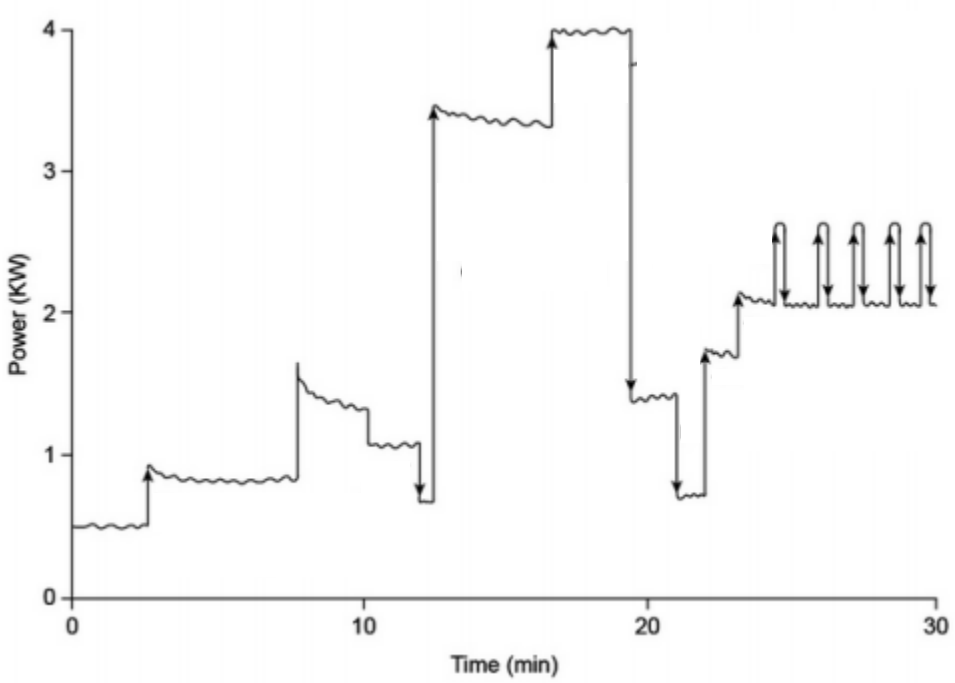


Source: Navigant Residential Baseline Study Plan

How does NILM work?

Household load shape appears to be random

→ Data is collected, disaggregated, and compared against library of appliance signatures



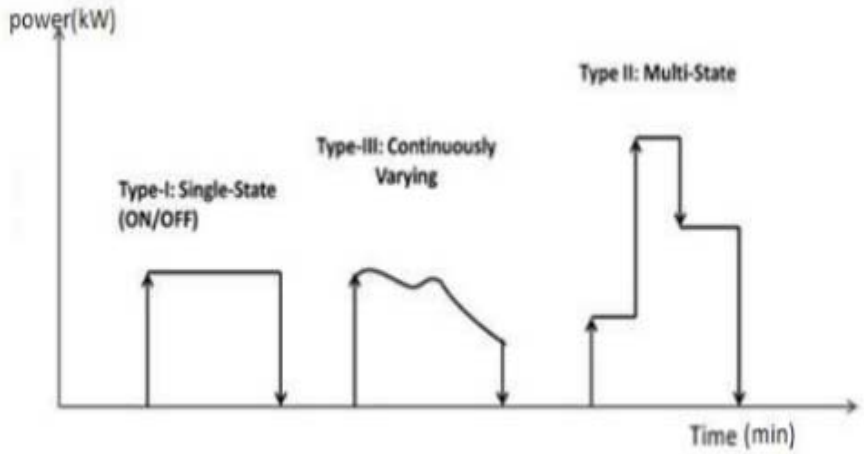


Fig2: Different load types based on their energy consumption pattern [1]

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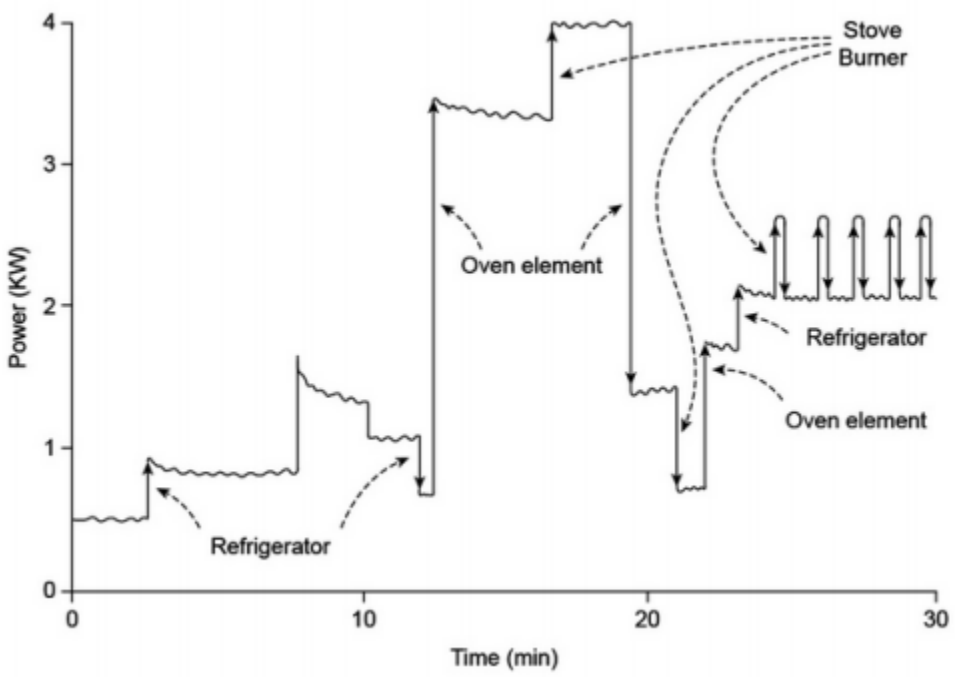
http://www.slideshare.net/saigouthamgolive/non-intrusive-load-monitoring

How does NILM work?

"Random" load shape can be broken down into constituent parts



Key Points

- The granularity of appliance identification depends on frequency of data collection
- The faster the interval of data collection, the smaller loads you can detect

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Benefits of NILM

- Non-intrusive
  - Do not have to go into a customer's home
  - Certain configurations do not require an electrician
  - Does not require regulatory approval in and of itself
- Cheaper than end use metering
  - Do not have to meter each appliance in the home
  - Cost savings between NILMs and end use metering is significant
- Can collect and report data in small intervals
  - Can collect data at the minute and sub-second interval

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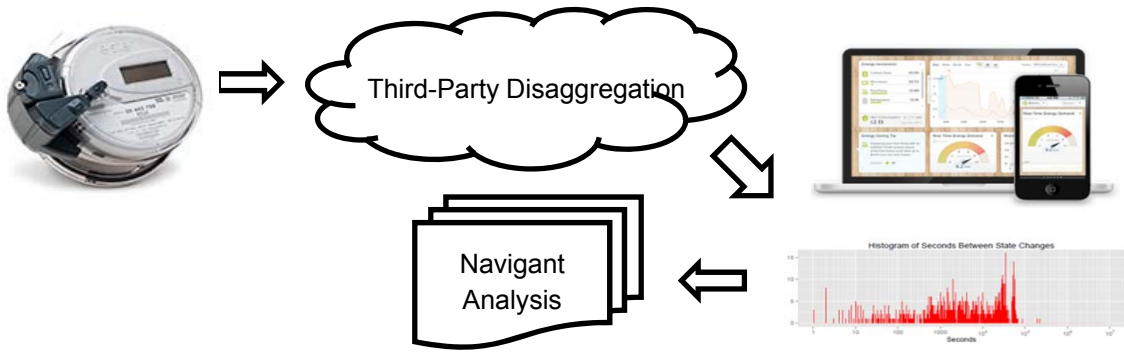
We will use optical sensors for the MA Baseline study

Optical sensor attached to utility meter and third-party disaggregation software	

Benefits of this configuration

- We do not currently have wide distribution of AMI – even if we did, it often reports in 15 or 60 min intervals
- CT devices can be expensive and their installation, maintenance, data collection processes, and failure rates present challenges for large-scale studies and drive up overall costs.
- Optical sensors do not require an electrician for installation and do not interfere with the operation of the meter

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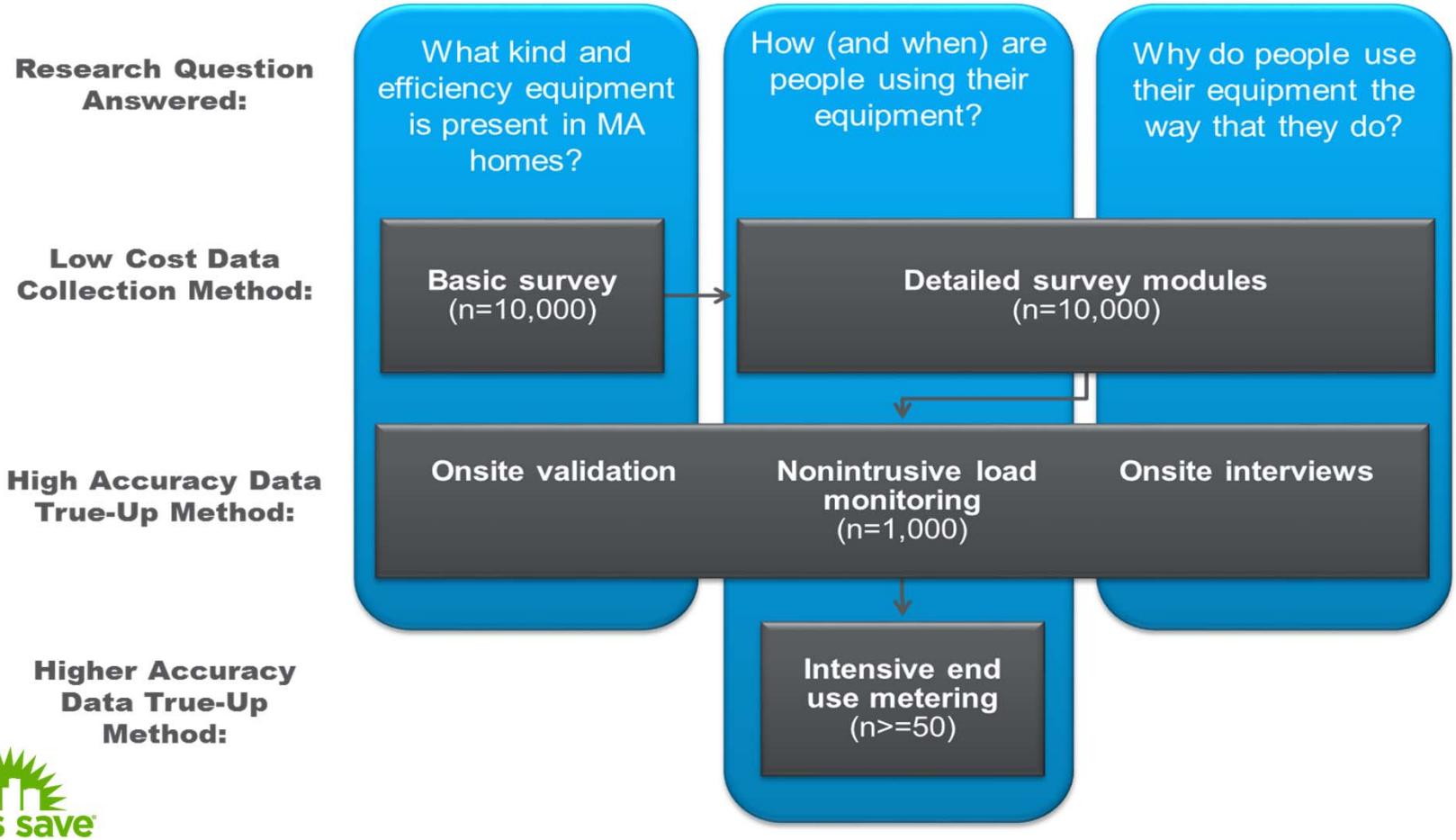
Research plan calls for a series of nested data collection techniques

Utilizing NILMs allows us to reduce the number of end use metering sites and still answer the research questions with a high degree of precision



Source: Navigant Residential Baseline Study Plan

End uses to be measured

Loads need to be relatively large to be detected at the intervals we will be measuring

End-use	Frequency of Occurrence	Number of Online Modules	Number of On-site visits/ NILM	Number of NILM True-ups
Central AC / Heat Pump	29.0%	2,000	290	15
Room AC	64.0%	2,000	640	50
Ground Source Heat Pump	1.0%	100	10	1
Other Electric Heat	7.0%	700	70	12
Other Fuel Furnace Fan	53.0%	2,000	530	35
Dishwasher	71.0%	2,000	710	36
Freezer	13.0%	1,300	130	29
Refrigerator	100.0%	2,000	1,000	50
Second Refrigerator	28.0%	2,000	280	24
Hot Water Heater	15.0%	1,504	150	8
Tankless Hot Water Heater	0.6%	64	6	0
Heat Pump Water Heater	0.3%	32	3	0
Washer	86.0%	2,000	860	43
Electric Dryer	68.1%	2,000	681	34
Dehumidifier	50.0%	2,000	500	35
Pool Pump	5.0%	500	50	3
EV Charger	0.4%	38	19	7
Total		10,000	1,015	133

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Source: Navigant Residential Baseline Study Plan

Implications for future work

- Will allow us to test different software solutions
- Will allow us to test how accurate NILMs is within certain bounds
  - Do the NILM load shapes look like the metered load shapes?
- Gain a better understanding of how new technologies can help facilitate EM&V efforts
- Will allow for better targeting for demand reduction programs

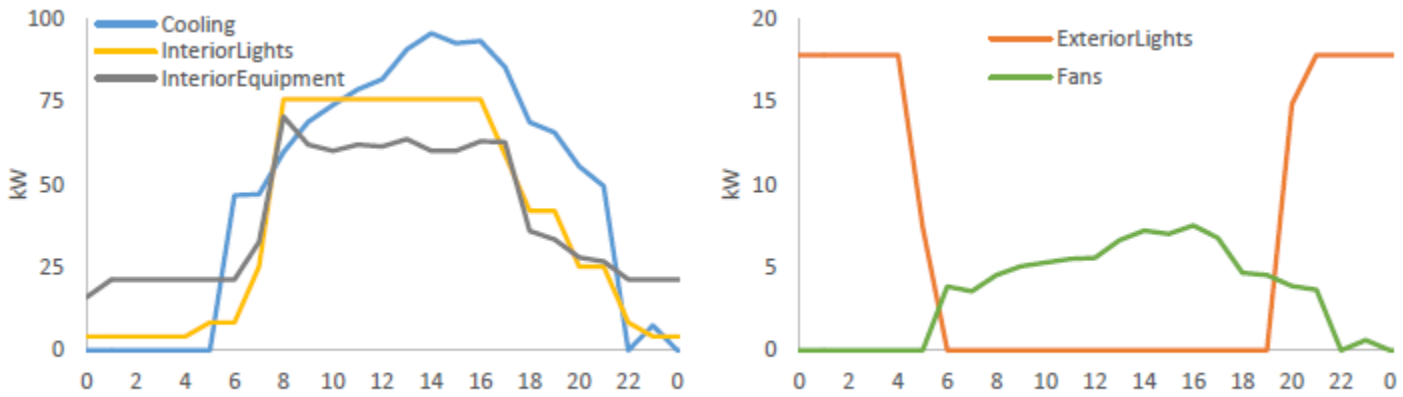

Figure 1-2. Simulated commercial building electric load components by hour on peak day.