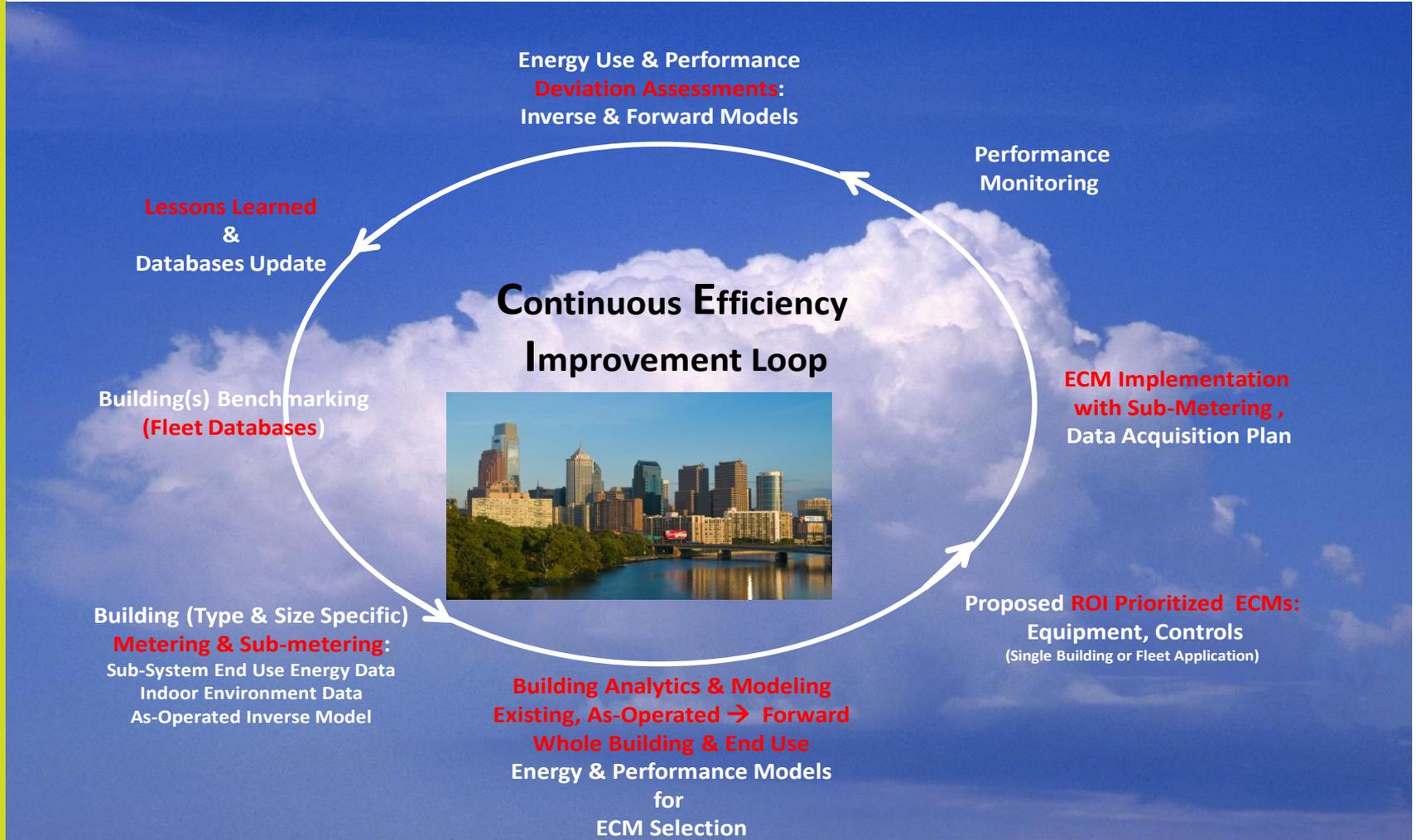


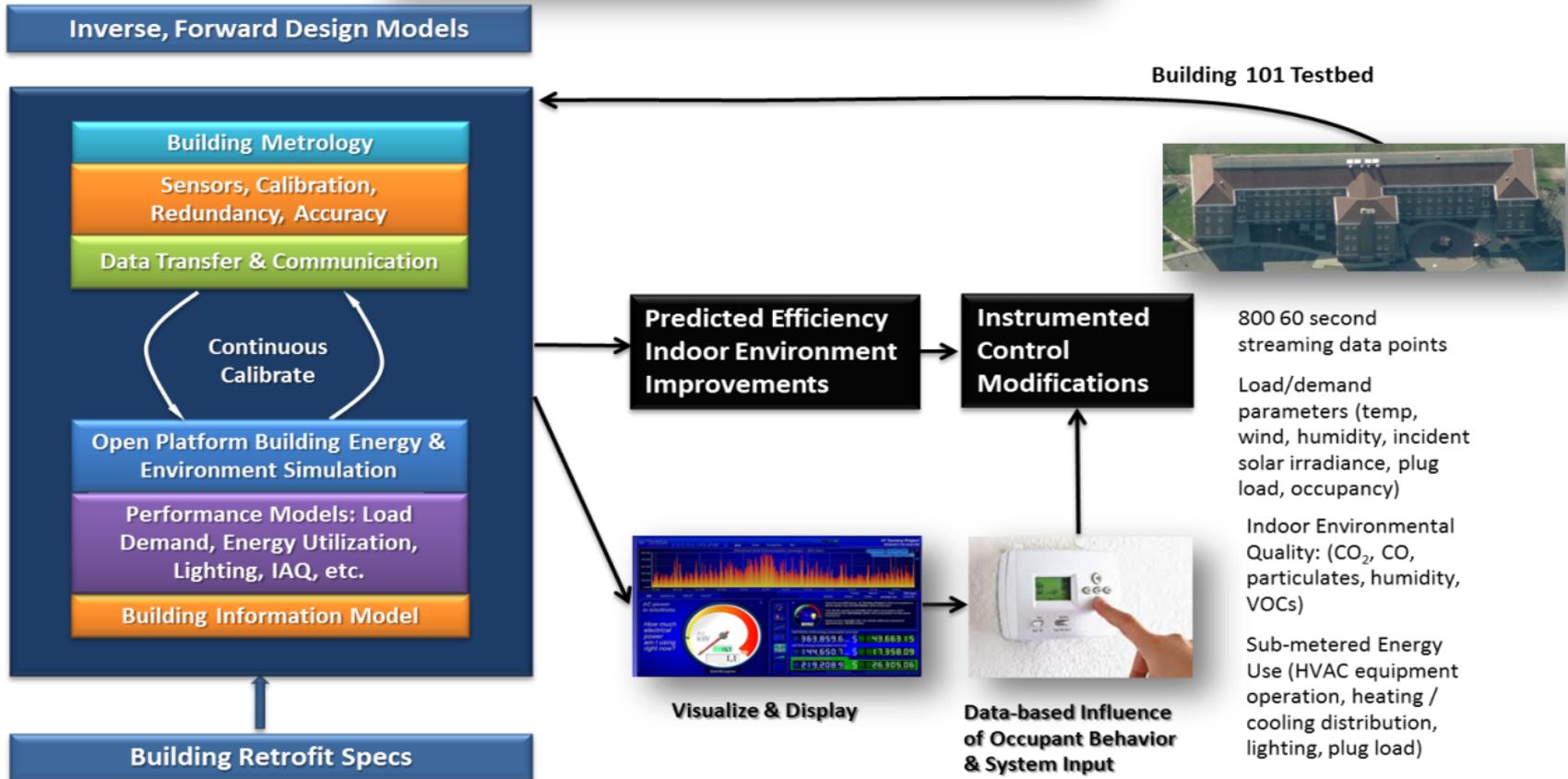
# Make Data Driven, Continuous Efficiency Improvements as Standard Practice:

## Technical Loop



# Make Data Driven, Continuous Efficiency Improvements as Standard Practice

## Data-based Continuous Improvement of Building Modeling

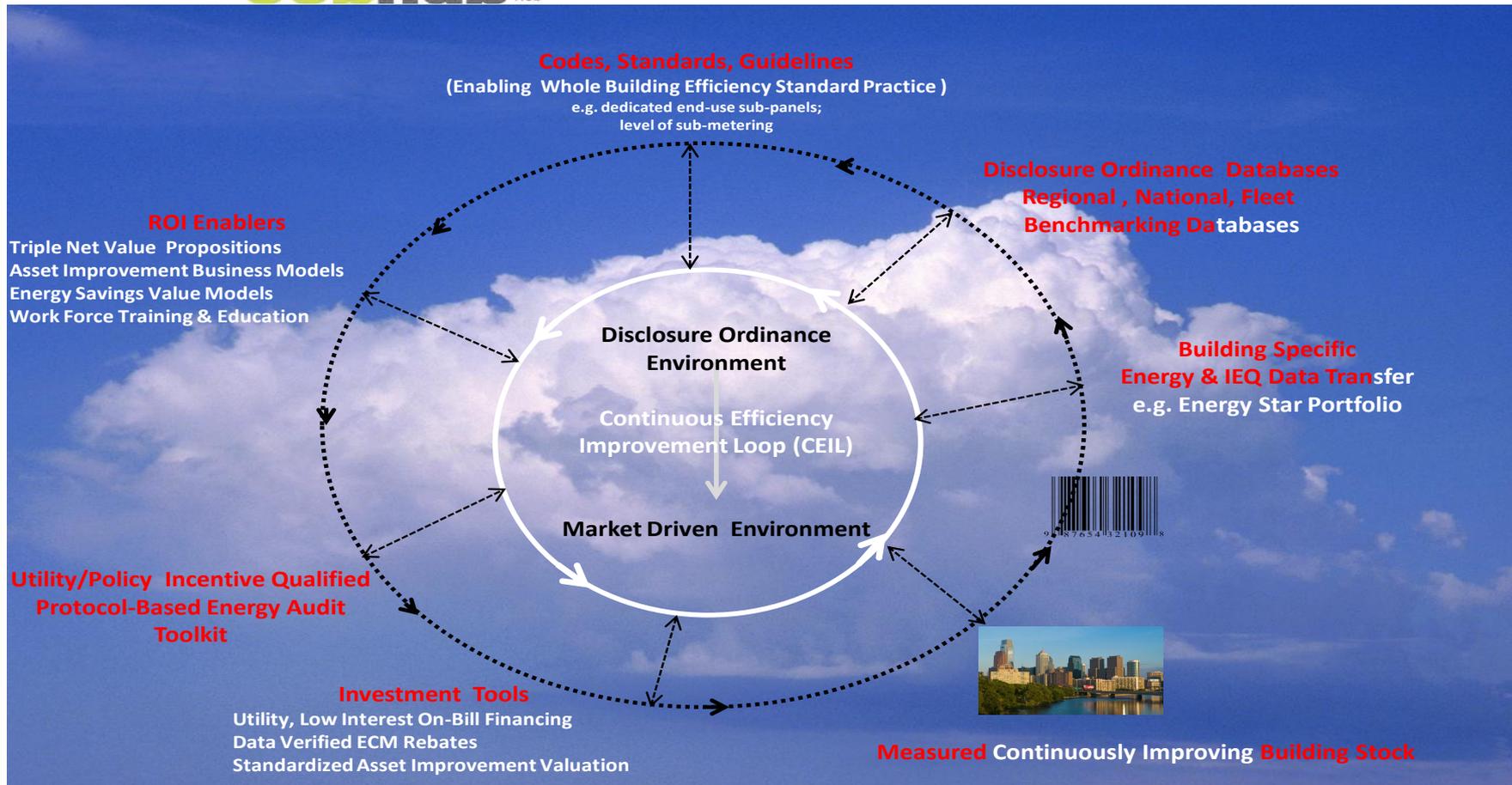


# Make Data Driven, Continuous Efficiency Improvements as Standard Practice

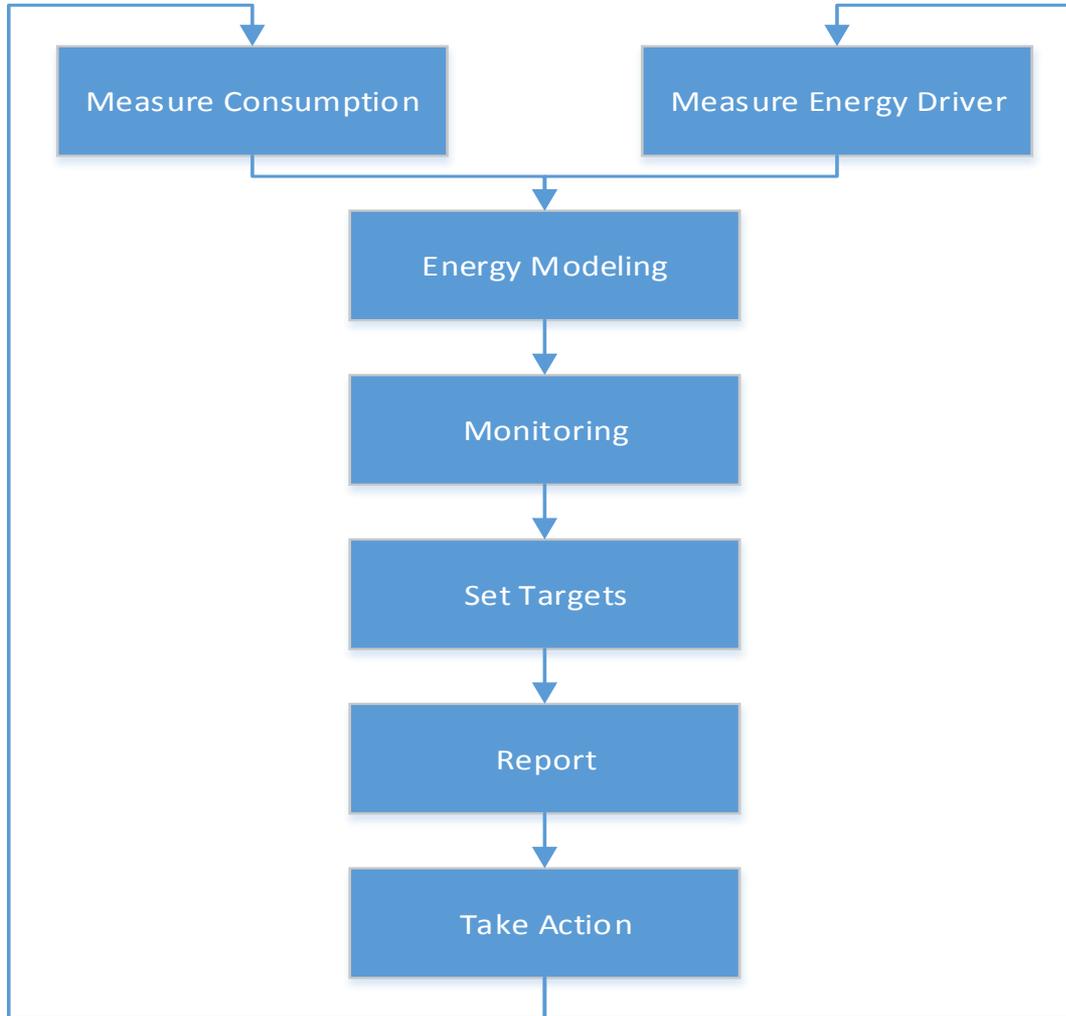
## Policy-Market-Behavior Loop



### Outer Policy-Market-Behavior (PMB) Loop



## Make Data Driven, Continuous Efficiency Improvements as Standard Practice



**Convenience Store Chain Seeks to Substantially Reduce Energy Use in Fleet**  
*EEB Hub Seeks to Establish CEI Loop Paradigm for All Such Energy Intensive Fleets*

**FLEET Characterization**

**A local Office Building**

- 101,700 ft<sup>2</sup>
- 2,175,880 kWh/year
- 0 therms/year
- 73 kBtu/(ft<sup>2</sup>-year)

× 6 =

**A typical Philadelphia Convenience Store**

- 5,589 ft<sup>2</sup>
- 648,080 kWh/year
- 1,351 therms/year
- 420 kBtu/(ft<sup>2</sup>-year)



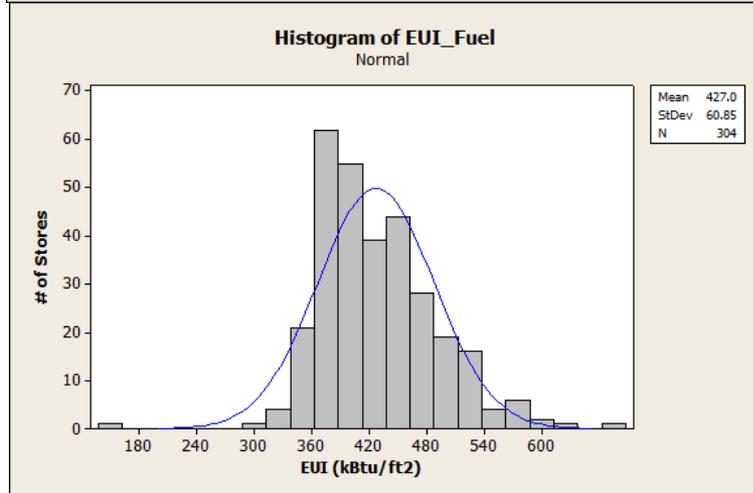
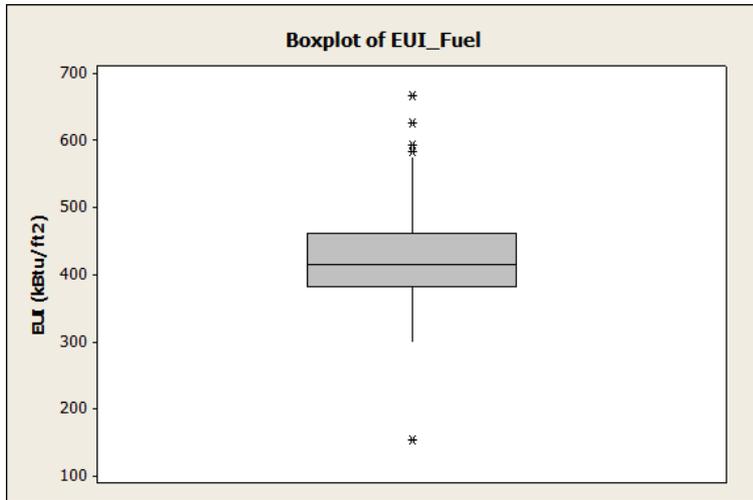
<http://www.acepa.net/office%20buildings.htm>



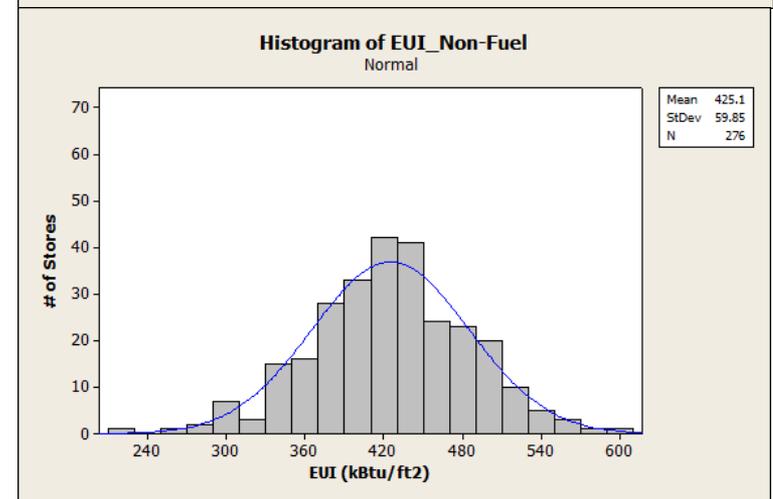
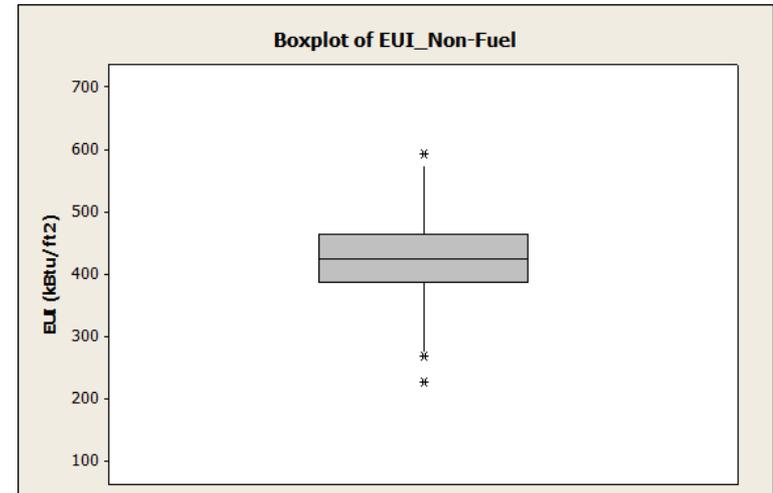
**600 "Full Service Convenience Stores = 3,500 Mid-Sized (35- 40,000 ft<sup>2</sup> ) Office Buildings**

# Benchmarking within Wawa's Portfolio

## Stores w Gas Station (Fuel)

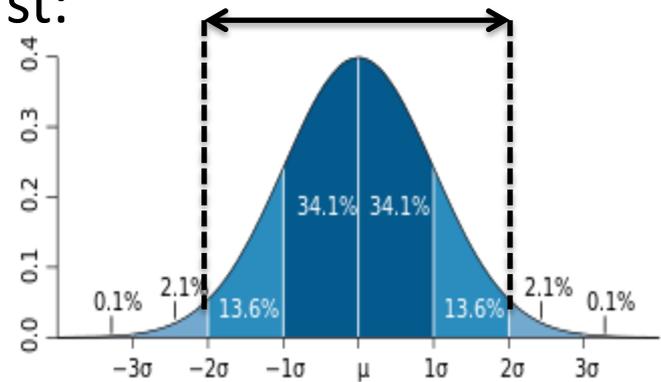


## Stores w/o Gas Station (Non-Fuel)



# Identify “Energy Outlier” Stores

- Excessive Energy ? Check outliers first:
  - Incorrect metering
  - Malfunctioning equipment
- 95% Confidence Interval:
  - Fuel Stores: 305 – 549 kBtu/ft<sup>2</sup>-yr
  - Non-Fuel Stores: 305 – 545 kBtu/ft<sup>2</sup>-yr



A plot of a normal distribution where each band has a width of 1 standard deviation.

	Fuel Stores (Threshold, kBtu/ft <sup>2</sup> -yr)	Non-Fuel Stores (Threshold, kBtu/ft <sup>2</sup> -yr)
Outliers	5 (582)	1 (581)
Top 2.2% (EUI>Mean+2*StDev)	11 (549)	6 (545)

- Benchmarking within Convenience Store Fleet Portfolio**

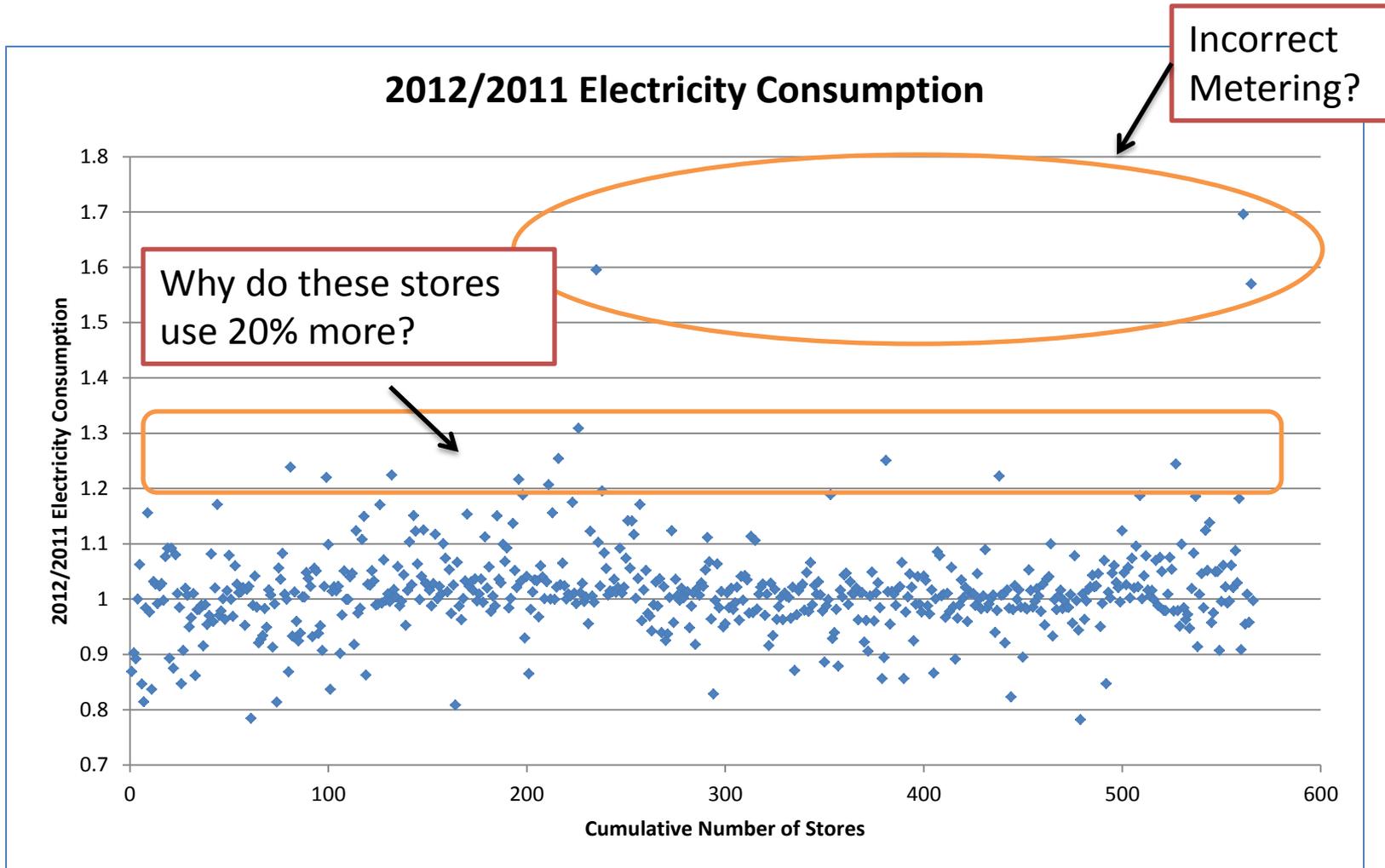
EUI (kBtu/ft <sup>2</sup> -yr)	All Stores	Fuel Stores	Non-Fuel Stores
Sample Size (N)	580	304	276
Max	668.6	668.6	592.9
Q3	463.4	462.7	465.3
Median	421.7	415.5	425.2
Mean	426.1	427.0	425.1
Q1	384.7	383.4	387.9
Min	153.1		

**No difference!**

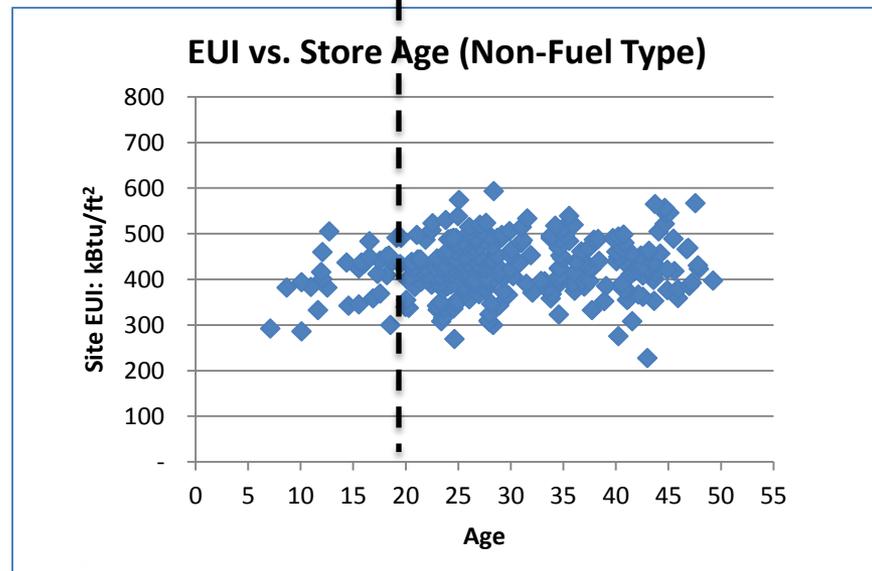
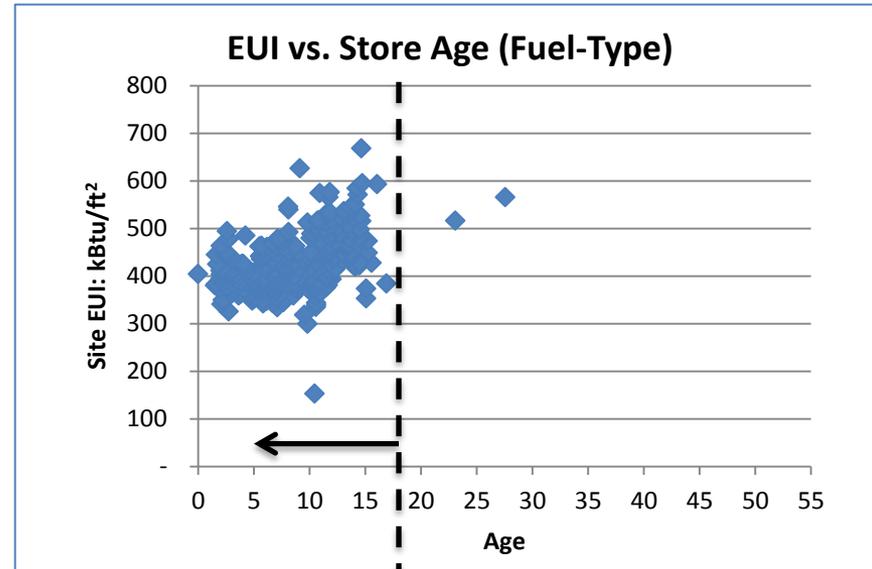
	Median Site EUI (kBtu/ft <sup>2</sup> )	BPD (under 7,650 SF)
All Convenience Stores	344	(62 stores)
Fuel Stores	385	(46 stores)
Non-Fuel Stores	200	(16 stores)

**185 kBtu/ft<sup>2</sup>-yr difference!**

# Operation Changes in 2012?



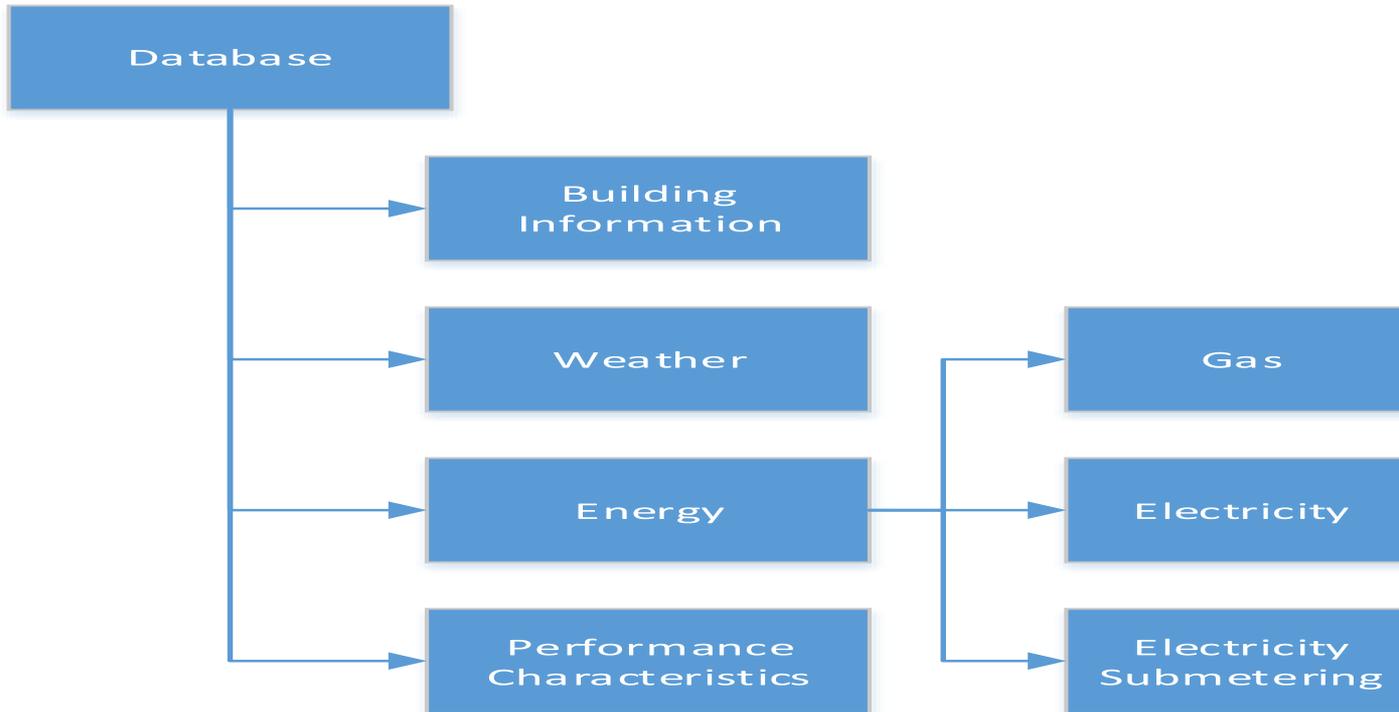
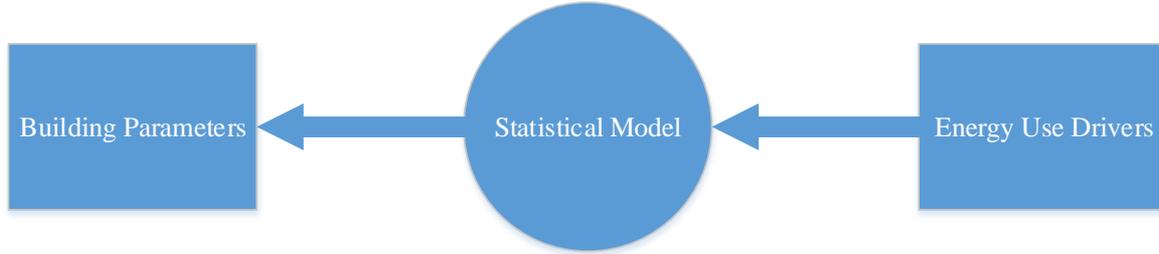
- Fuel Stores have better energy efficiency than Non-Fuel Stores.
- Newer fuel stores (better efficient refrigeration sys. & bldg. efficiency) might offset the dispenser fuel pumps & outdoor lights.
- This assumption can be further investigated by comparing **end-use data** between Fuel and Non-Fuel Stores.



# Summary

- In general, Fuel Stores consume less energy per square foot **per transaction** than Non-Fuel Stores.
- 95% of Fuel Stores use  $427 \pm 122$  kBtu/ft<sup>2</sup>-yr, while 95% of Non-Fuel Stores use  $425 \pm 120$  kBtu/ft<sup>2</sup>-yr.
- Identified 17 “Excessive Energy Use” Stores.
- Identified stores that consume significantly more energy in 2012 than that of 2011.
- Conducted statistical tests, identified three most influential independent parameters – customer transaction #, square footage, store age, based on currently available store info.

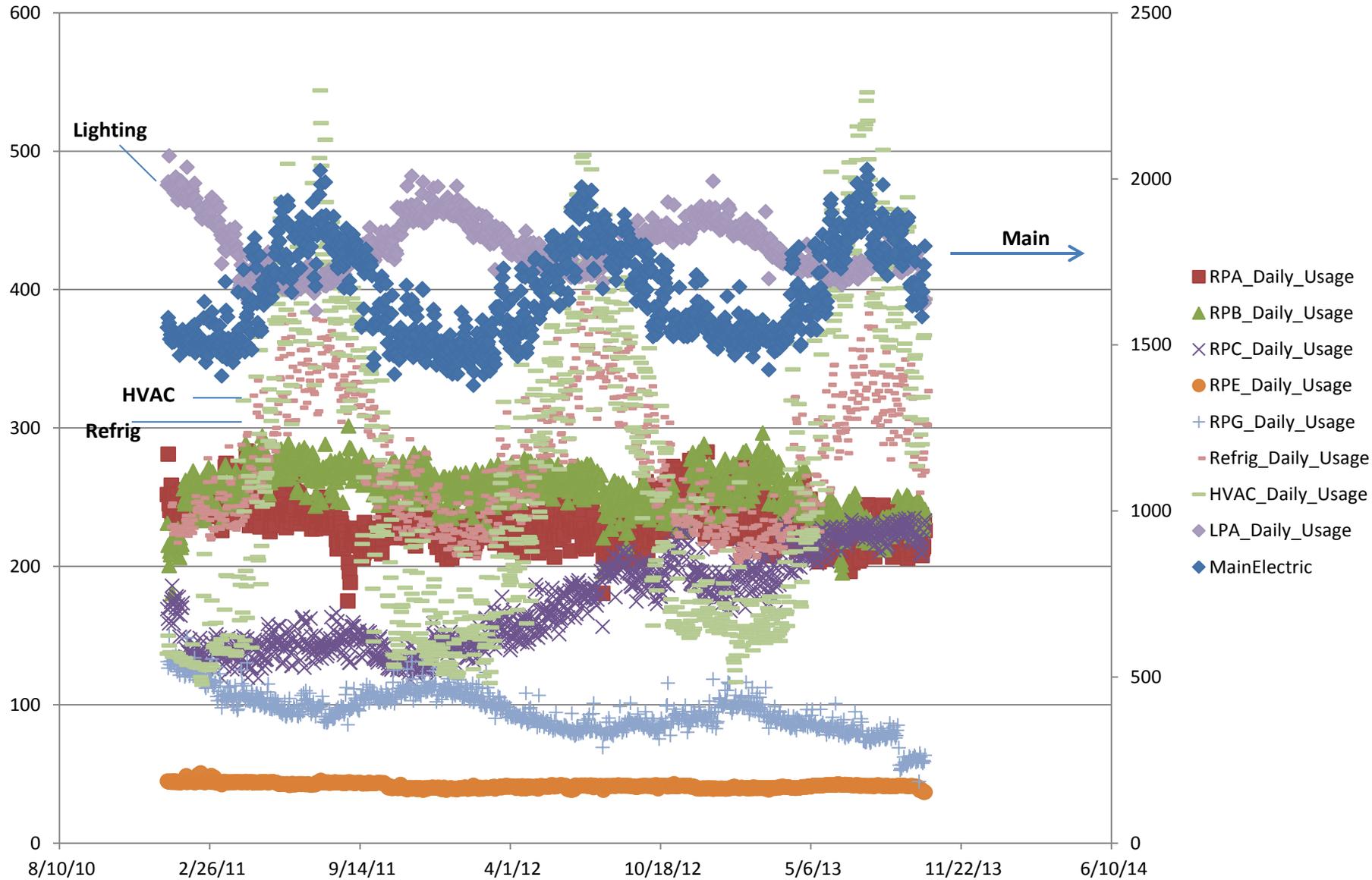
# Data Requirements for CEIL



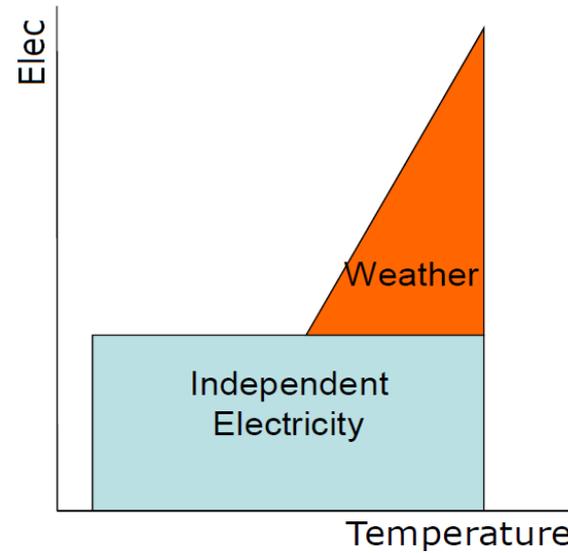
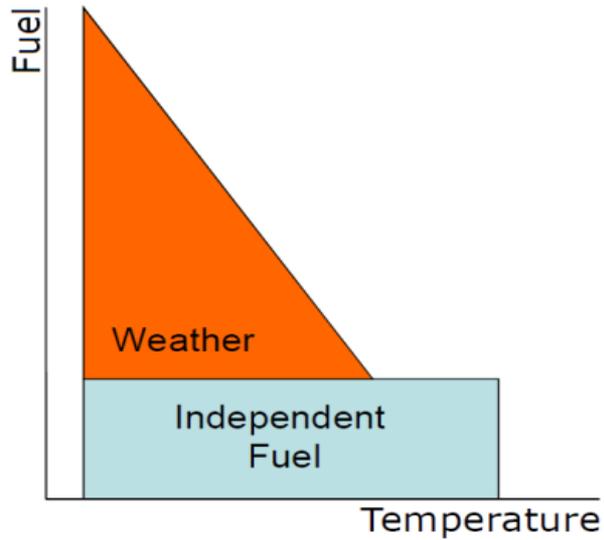
# Store 592 Energy Utilization Data

Kwhr (Sub Panels)

Kwhr (Main Feed)



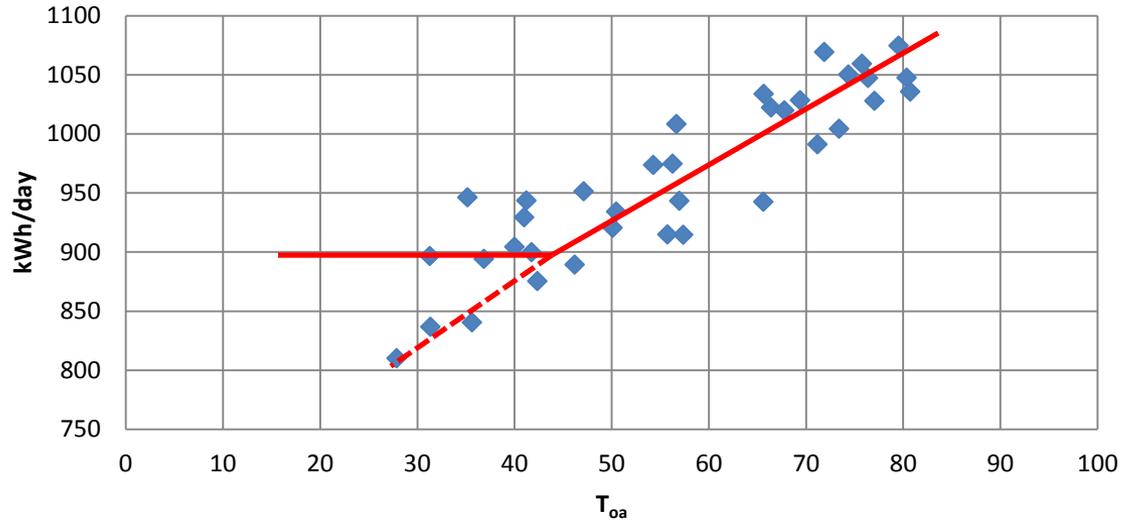
## Make Data Driven, Continuous Efficiency Improvements as Standard Practice



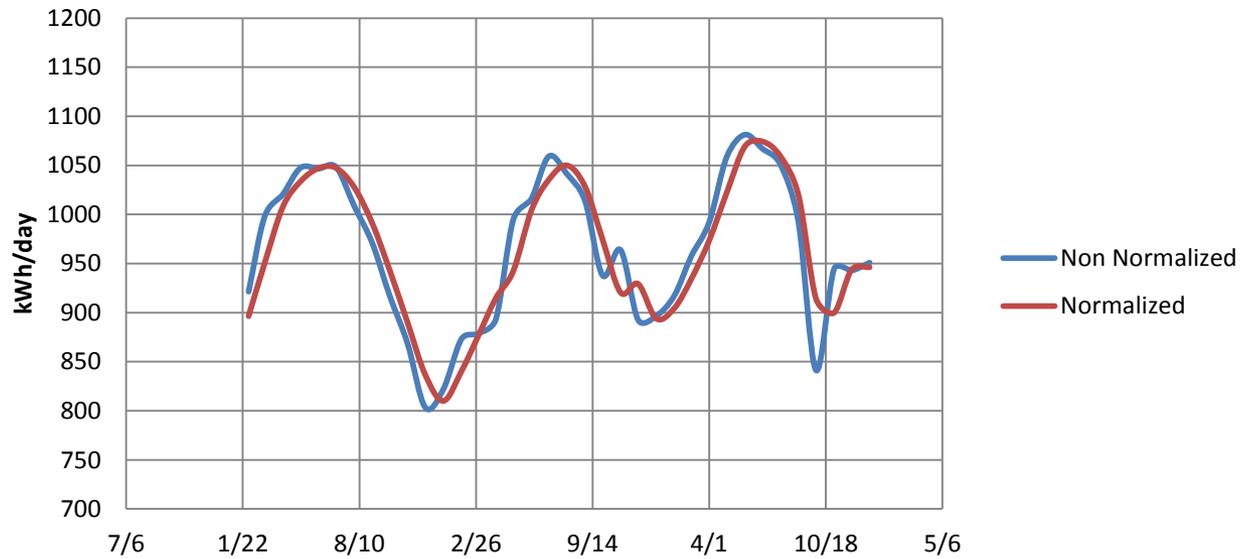
Weather/Non weather dependent energy use (MMT) (Kissock, 2010)

# MMT Control Group (Electricity)

## $T_{oa}$ Store 43

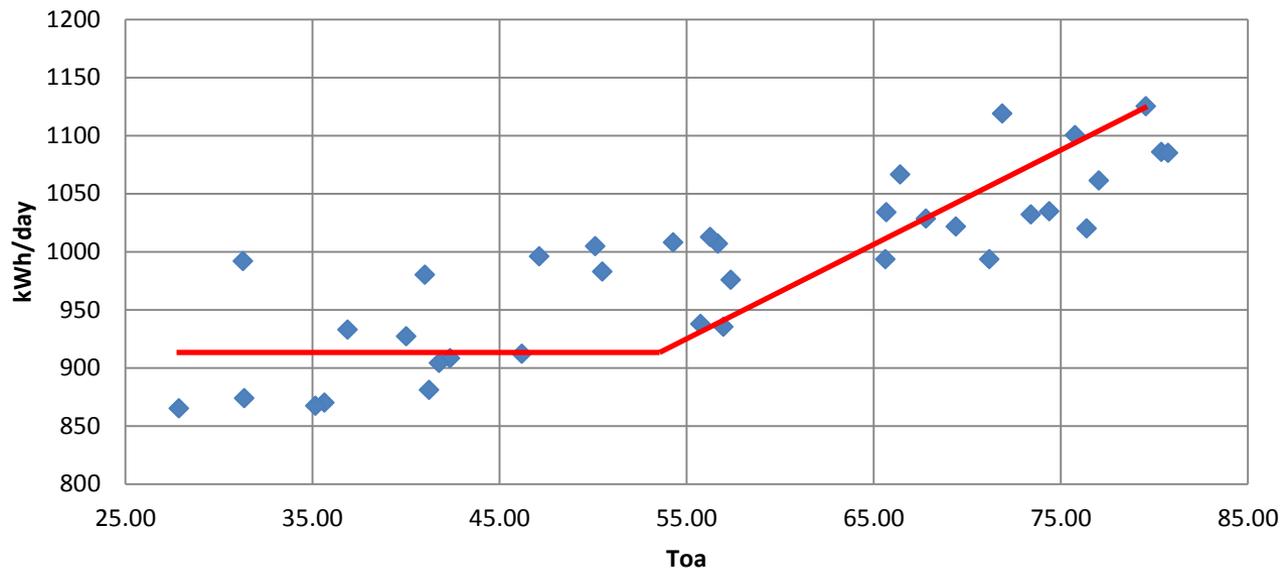


## Normalization Store 43

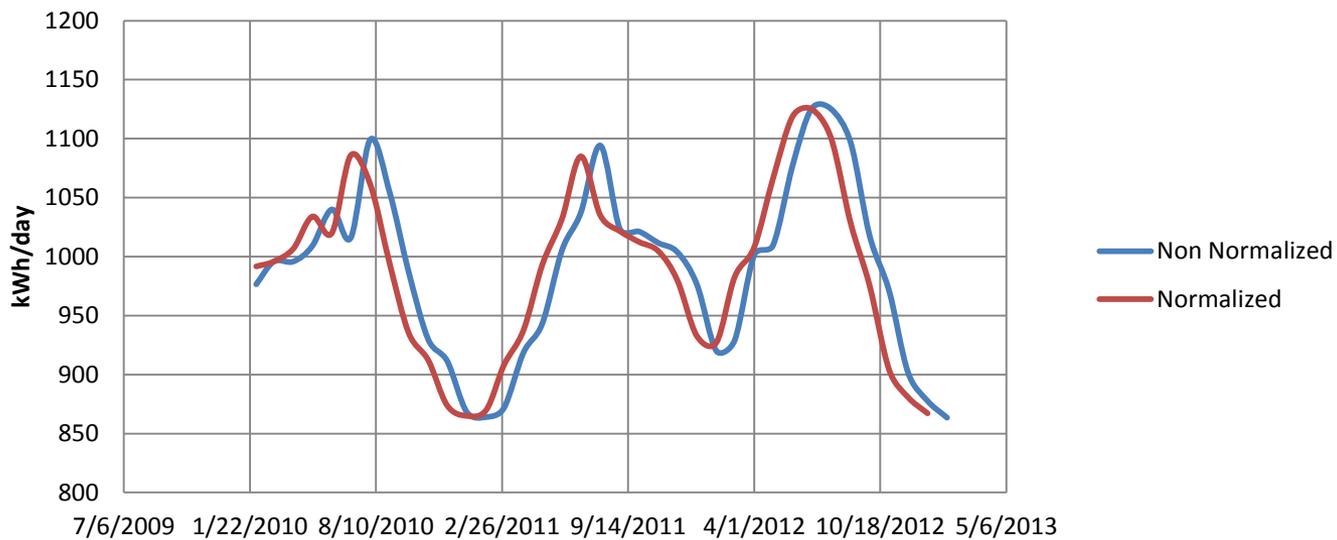


# MMT Control Group (Electricity)

## Toa Store 88

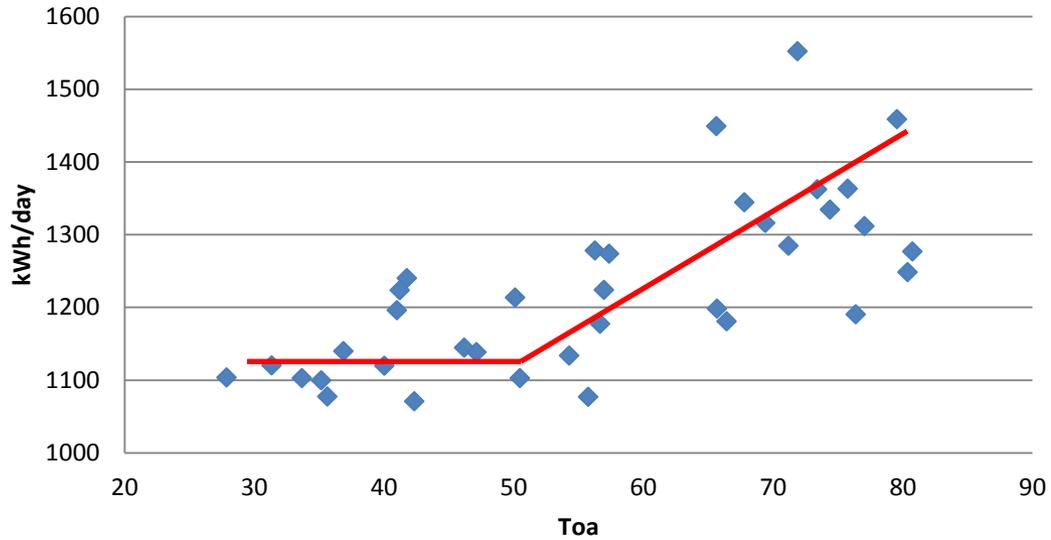


## Normalization Store 88

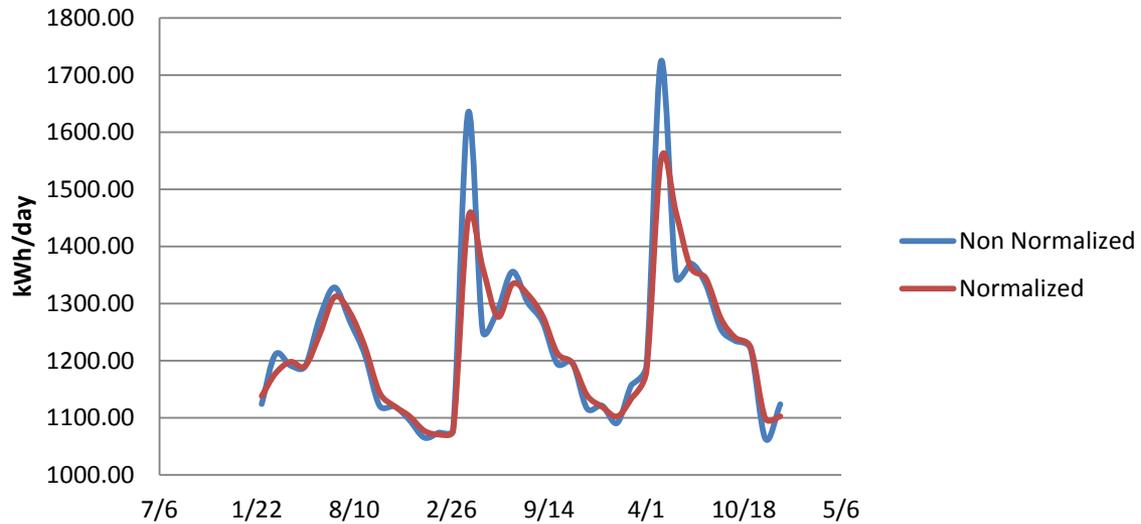


# MMT Control Group (Electricity)

## Toa Store 165



## Normalization Store 165



# Data Summary / IMT Results All Data

## IMT based calculations (All Data)

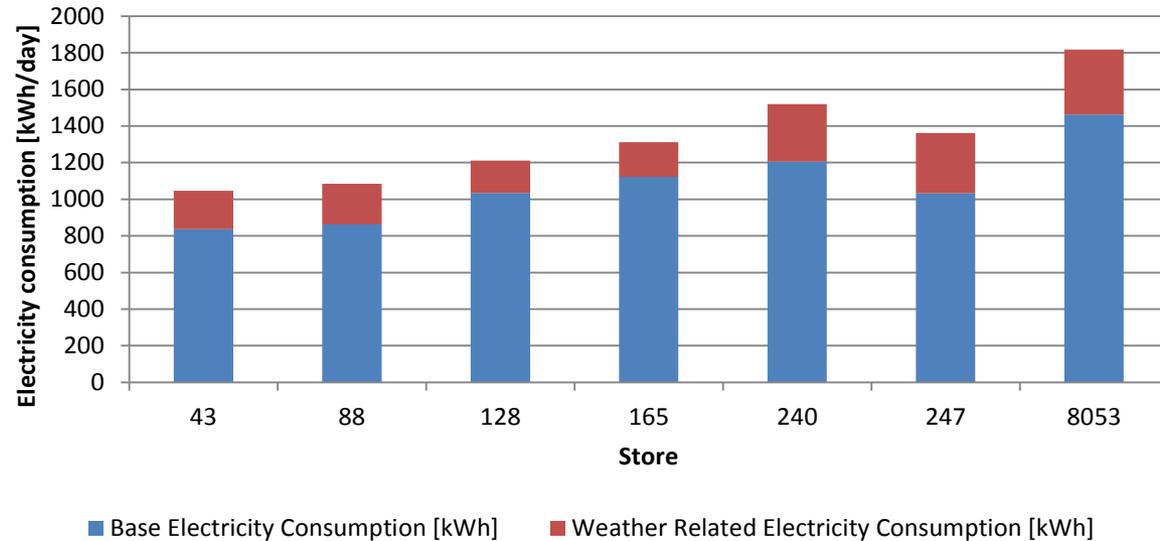
	Store	Best Model	Cooling Balance Temperature [°F]	Electric consumption at balance temperature [kWh/day]	Approximated Storefront orientation direction [°]	Store Area [ft2]	R2 All data	kWh/day ft2 at balance temp
Control	43	4P	31.04	867.00	240 / SW	3104	0.82	0.28
	88	3P	36.7	900.42	300 / NW	3029	0.738	0.30
	128	3P	28.92	1048.25	45 / NE	3744	0.737	0.28
	165	4P	66.99	1314.95	120 / SE	3456	0.581	0.38
	240	4P	46.9	1316.47	135 / SE	4548	0.863	0.29
Special case	247	4P	62.76	1195.76	100 / SE	3780	0.88	0.32

# Data Summary / IMT Results Base Line

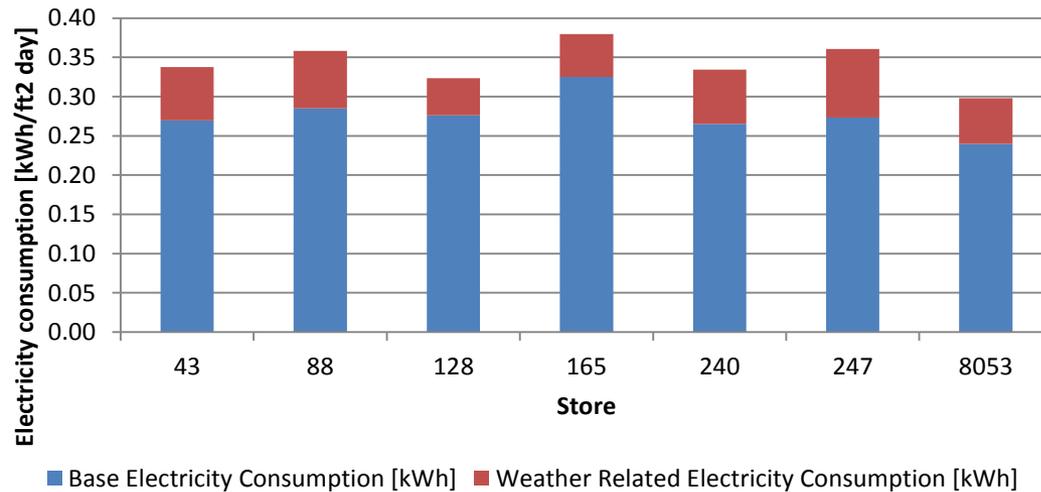
IMT based calculations (Base Line)								
	Store	Best Model	Cooling Balance Temperature [°F]	Electric consumption at balance temperature [kWh/day]	Approximated Storefront orientation direction [°]	Store Area [ft2]	R2 Base line	kWh/day ft2 at balance temp
Control	43	4P	31.02	868.45	240 / SW	3104	0.89	0.28
	88	4P	71.49	988.62	300 / NW	3029	0.983	0.33
	128	4P	28.92	1045.60	45 / NE	3744	0.930	0.28
	165	4P	73.02	1218.41	120 / SE	3456	0.914	0.35
	240	4P	47.82	1272.29	135 / SE	4548	0.933	0.28
Special case	247	4P	53.24	1113.94	100 / SE	3780	0.98	0.29

# Weather Related Energy Consumption Comparison

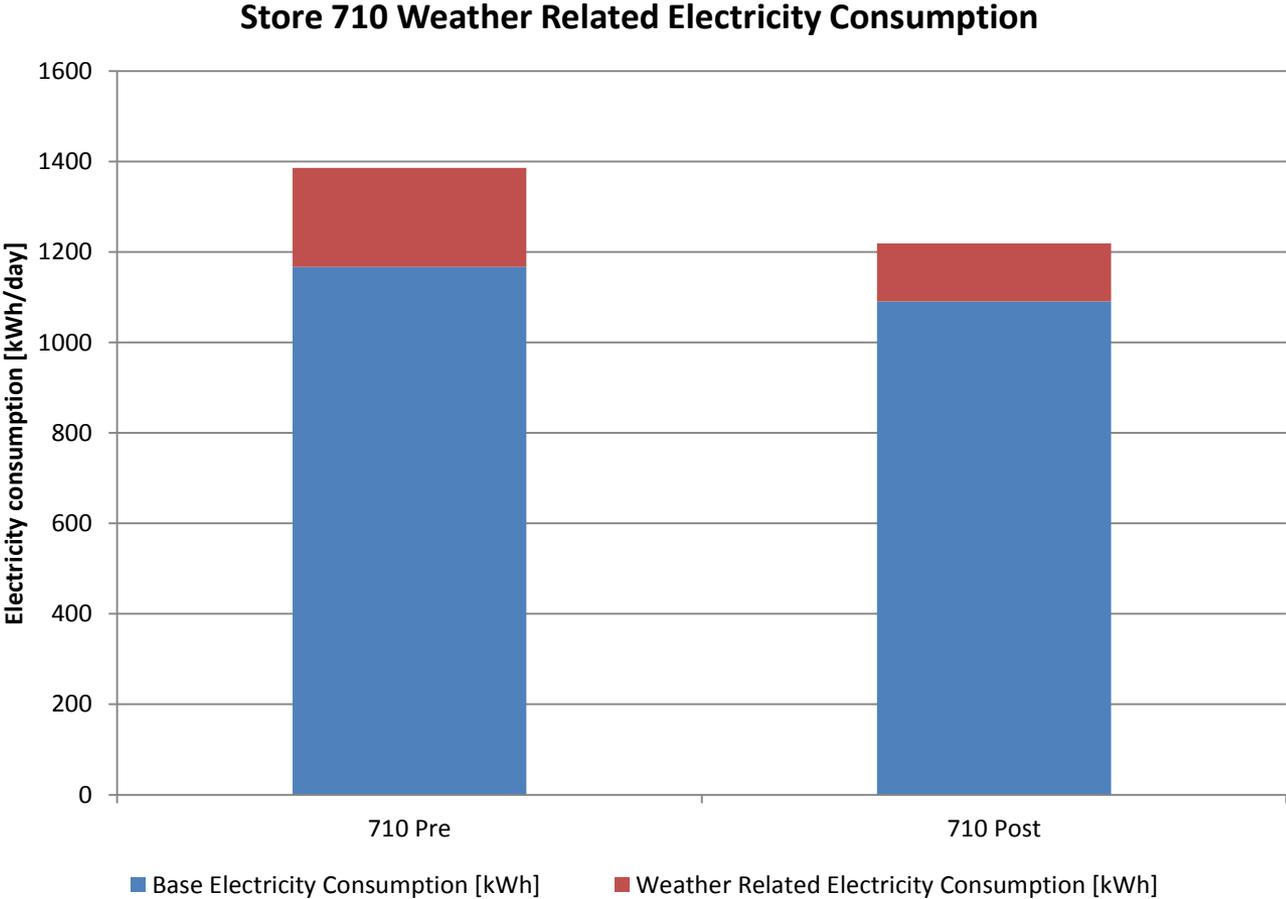
## Weather Related Electricity Consumption



## Weather Related Electricity Consumption (Normalized)

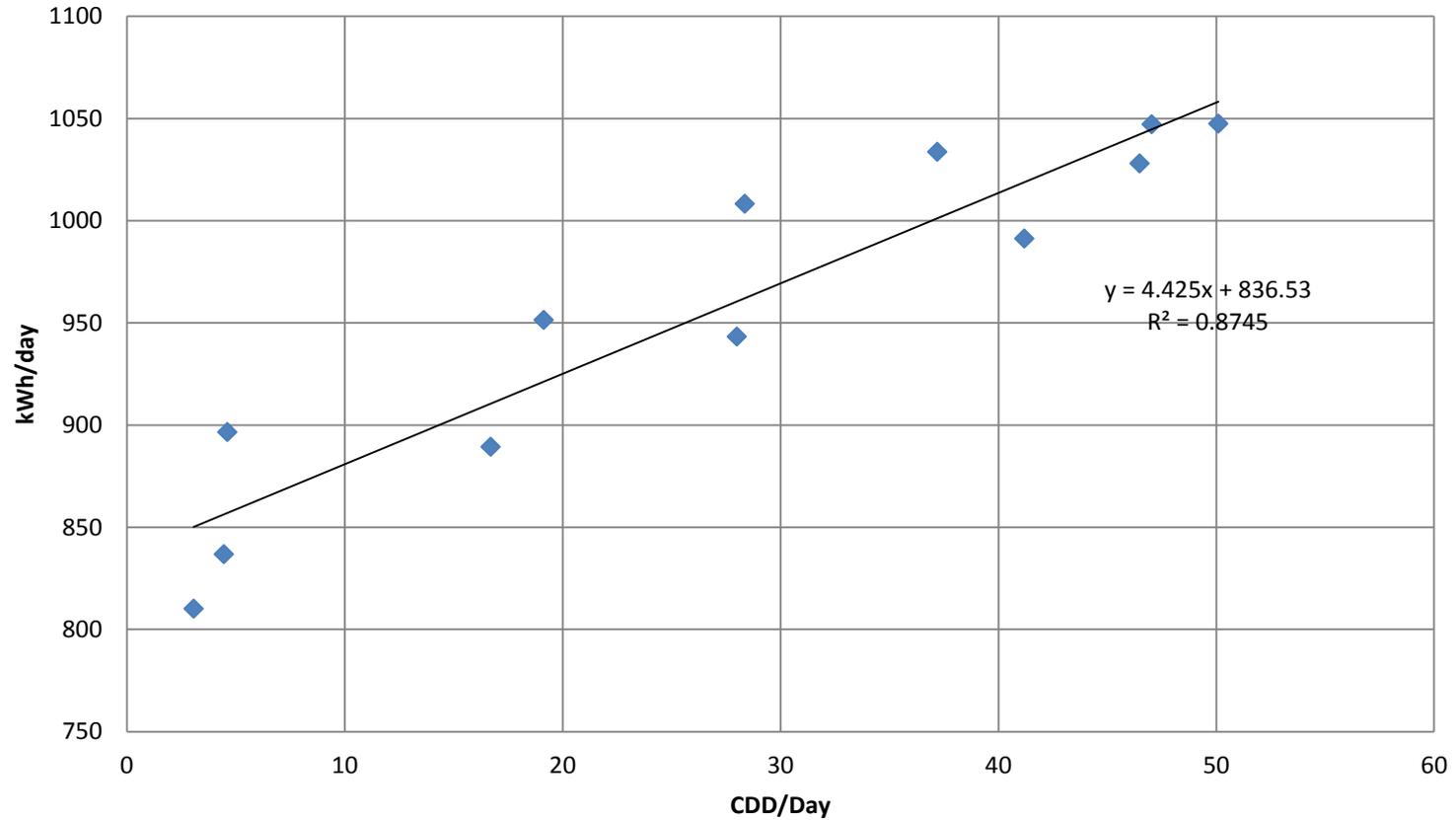


# Weather Related Energy Consumption Comparison (Store 710)



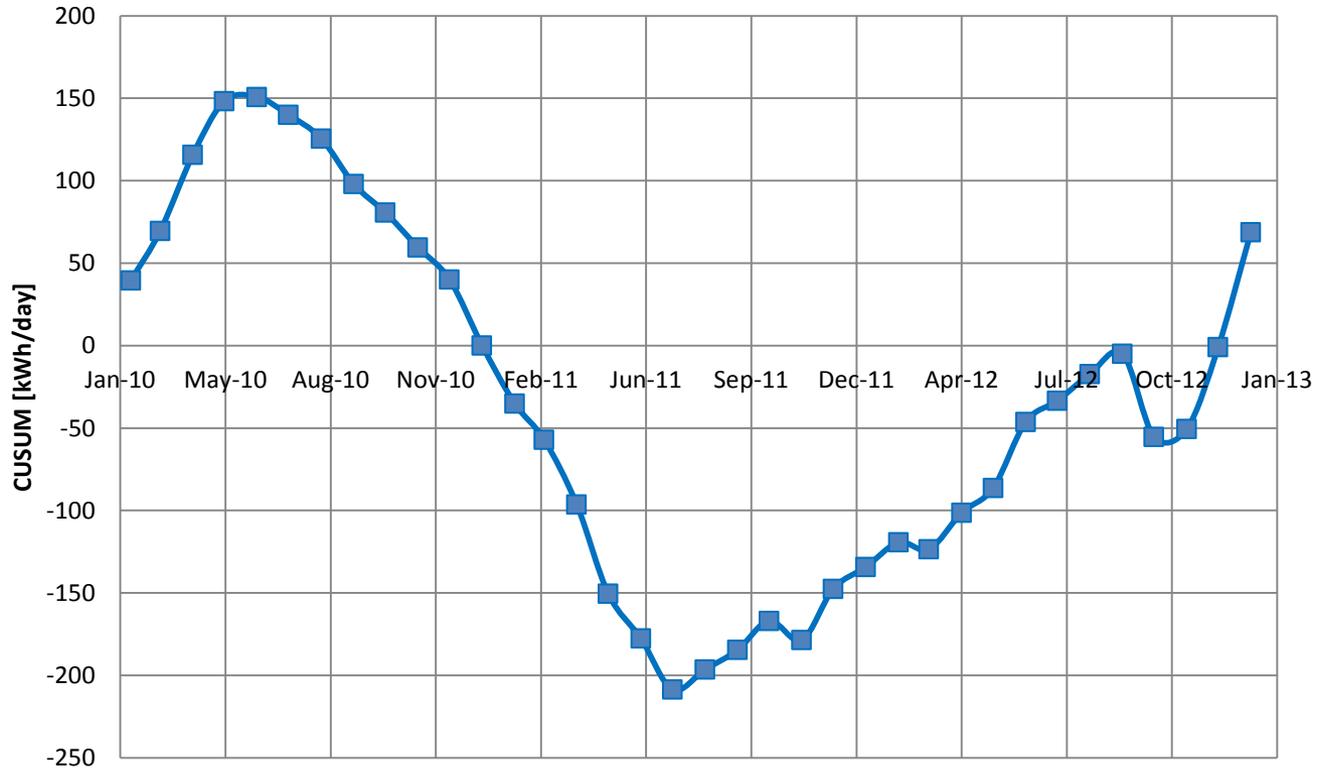
# CVDD Store 43 (Electricity / Base Line)

## CVDD Store 43 (28 F Base Temperature / Base line 2-2010 / 1-2011)

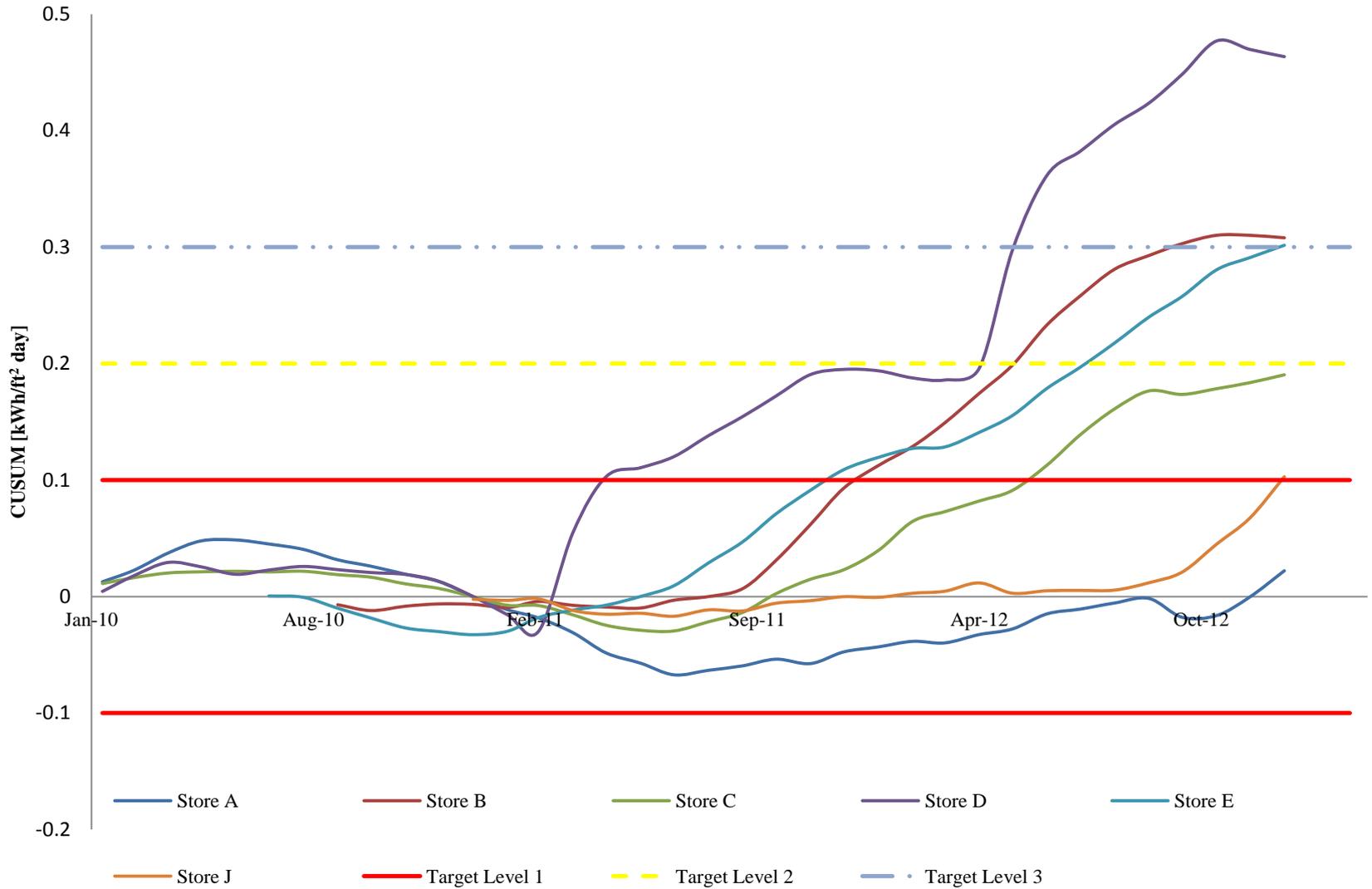


# CUSUM Store 43(Electricity)

## CUSUM / Store 43

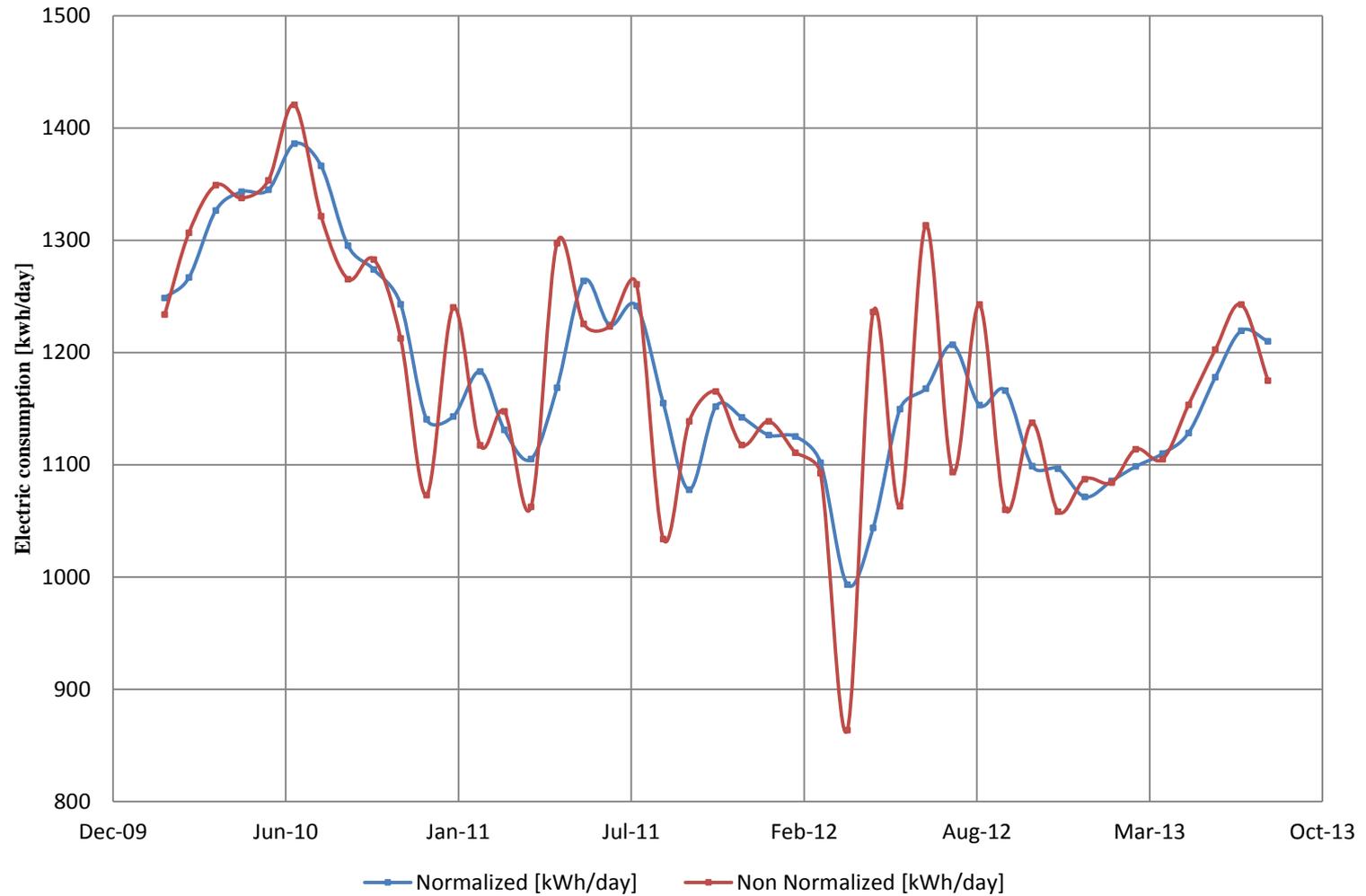


### Comparative CUSUM per Store Area



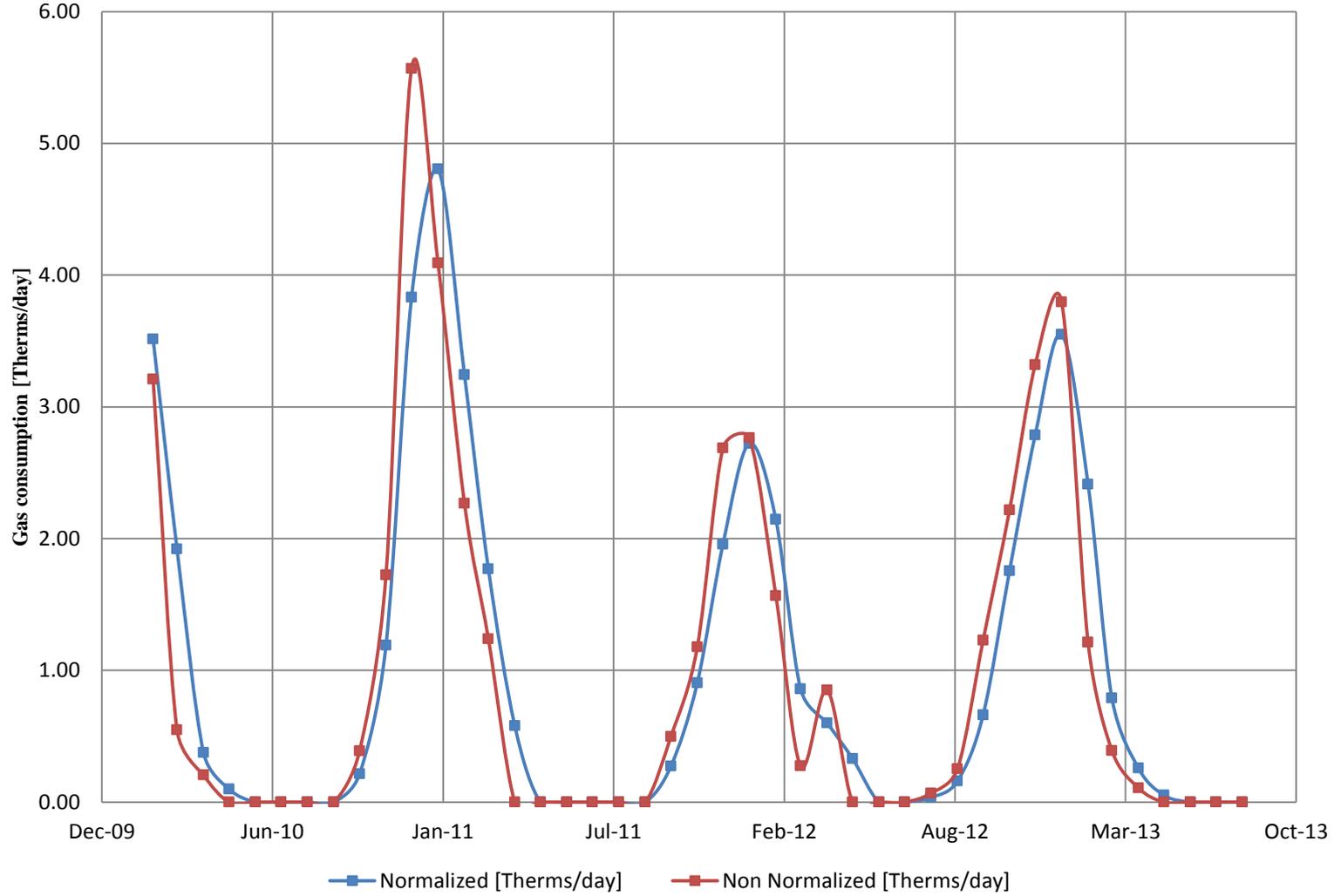
# Retrofits and CEIL

## Normalization Store K / Electricity

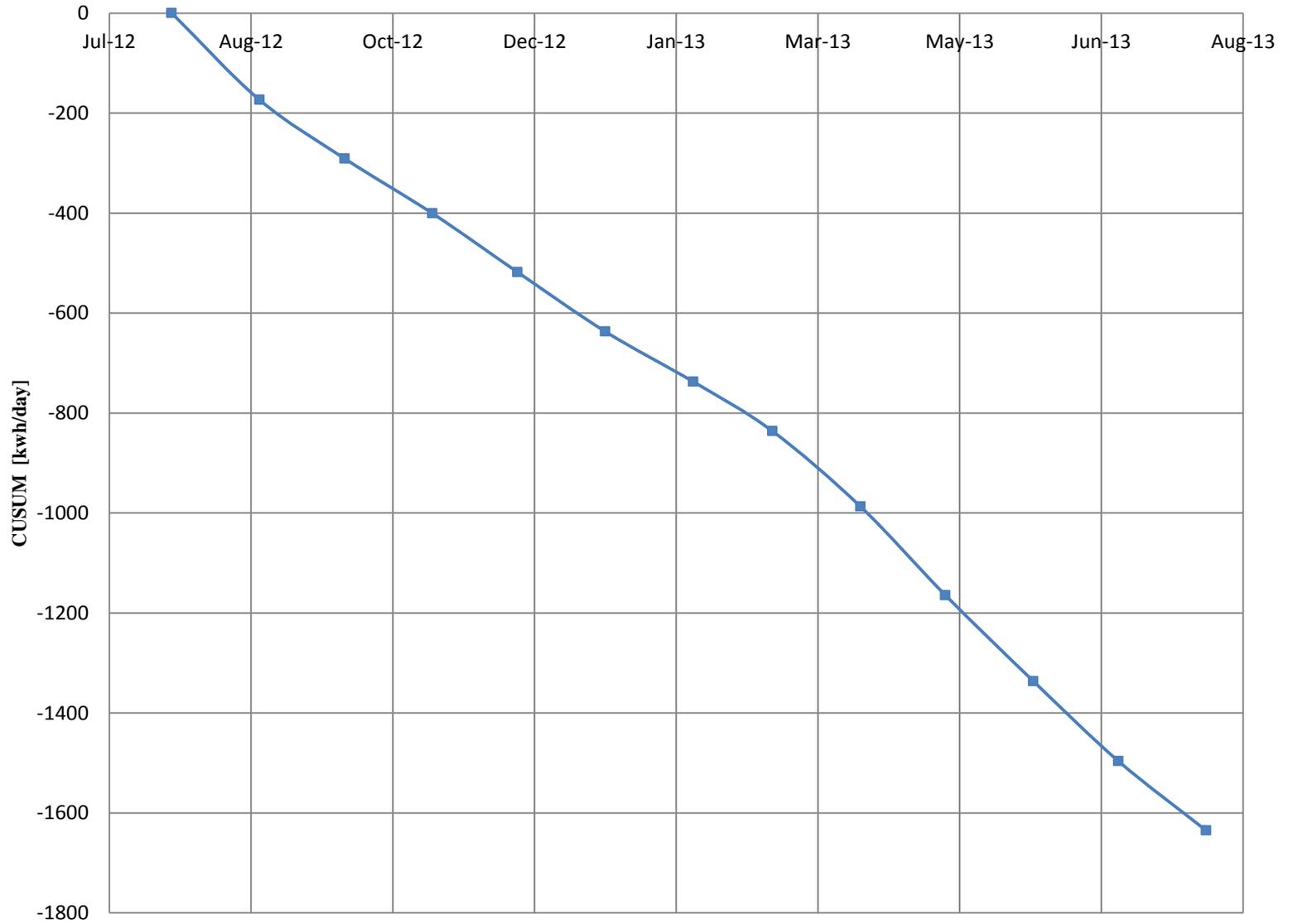


# Retrofits and CEIL

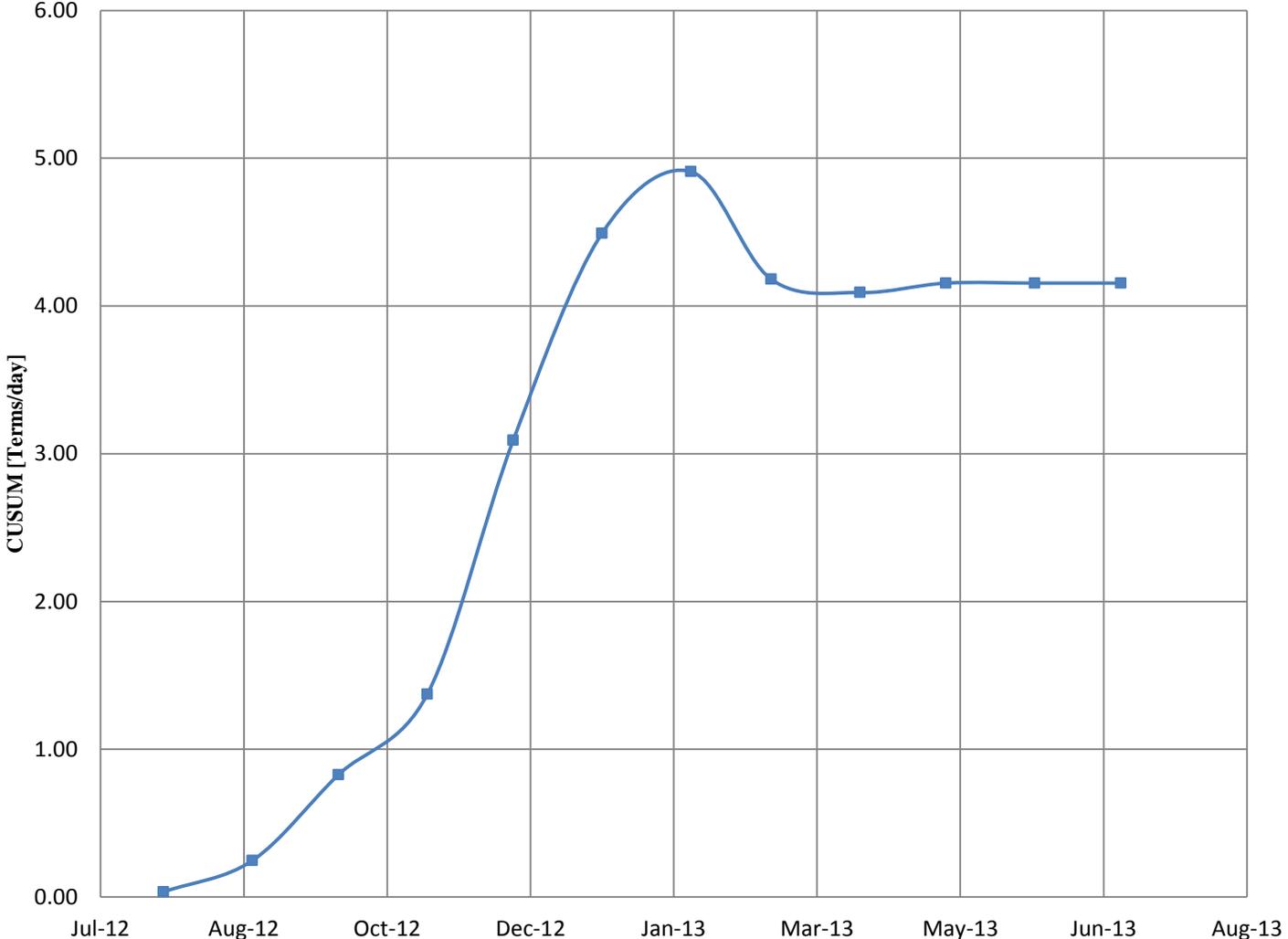
## Normalization Store K / Gas



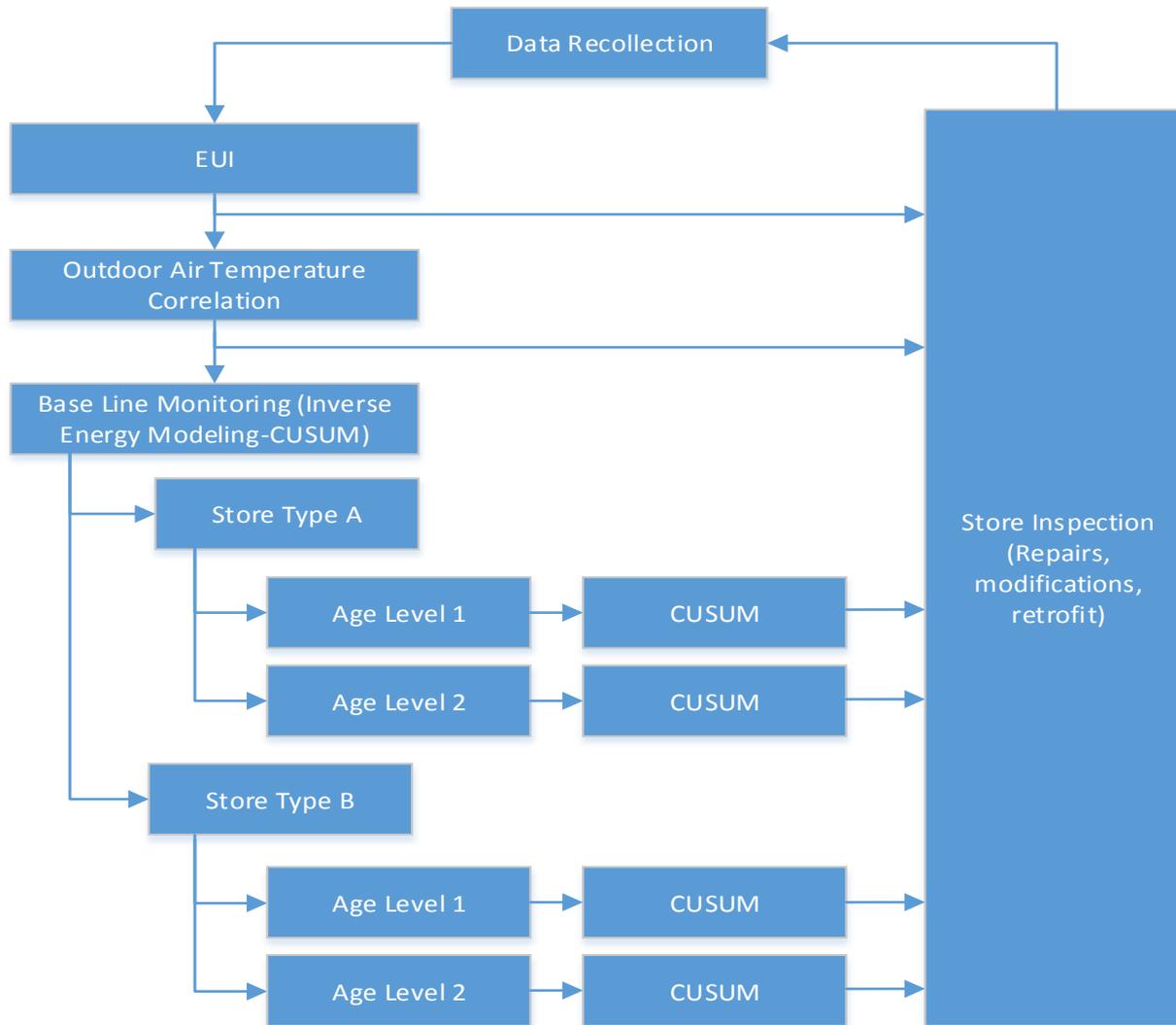
**CUSUM / Store K (Post retrofit savings)**



**Cusum / Store K (post remodel savings)**

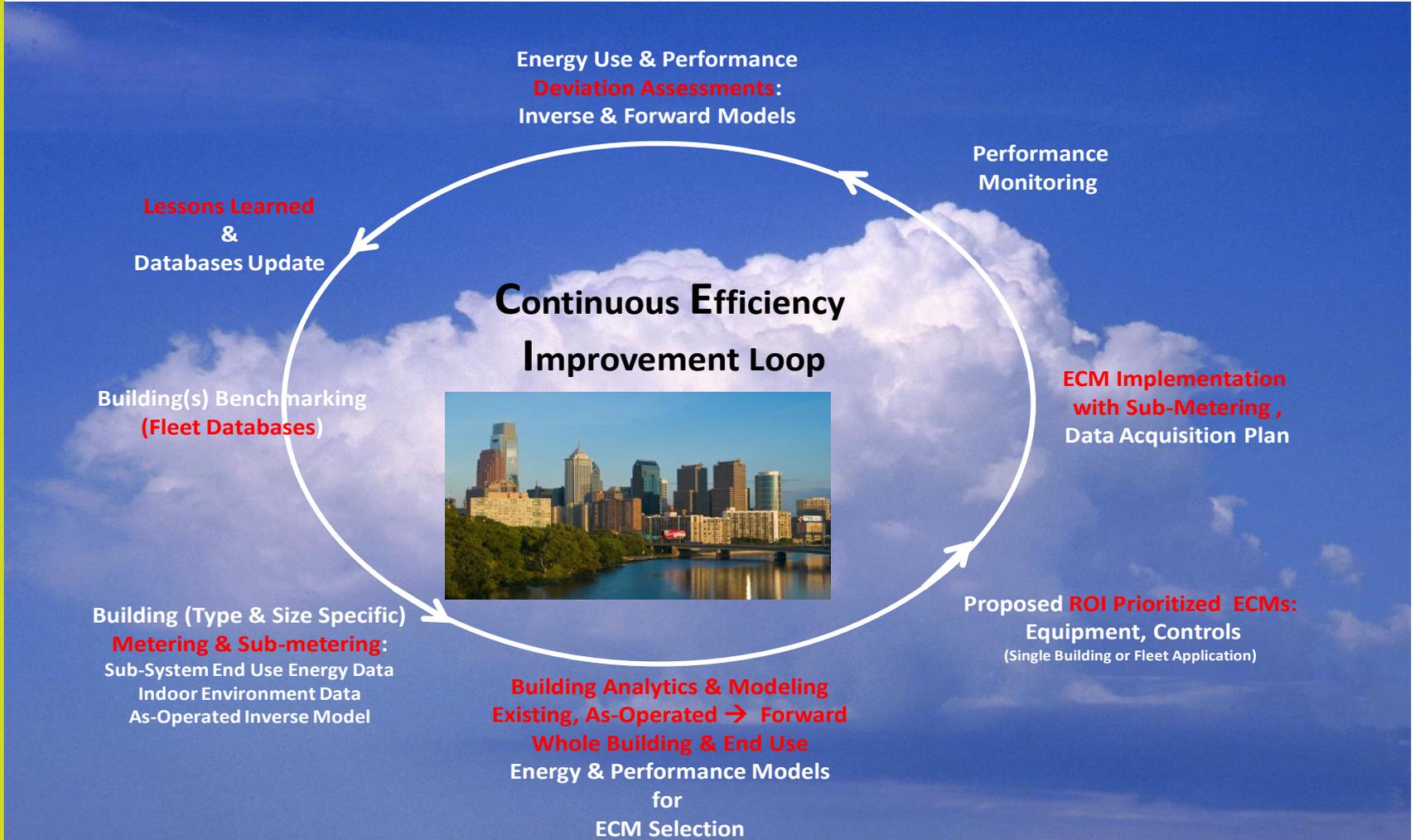


# The CEIL Process for Energy Intensive Stores

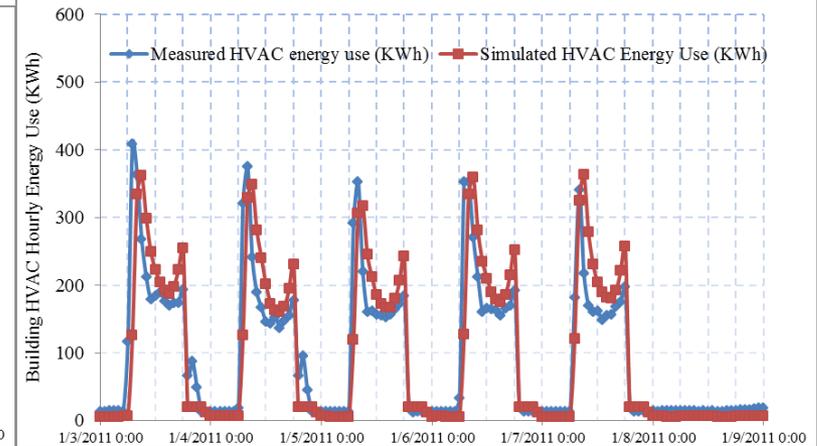
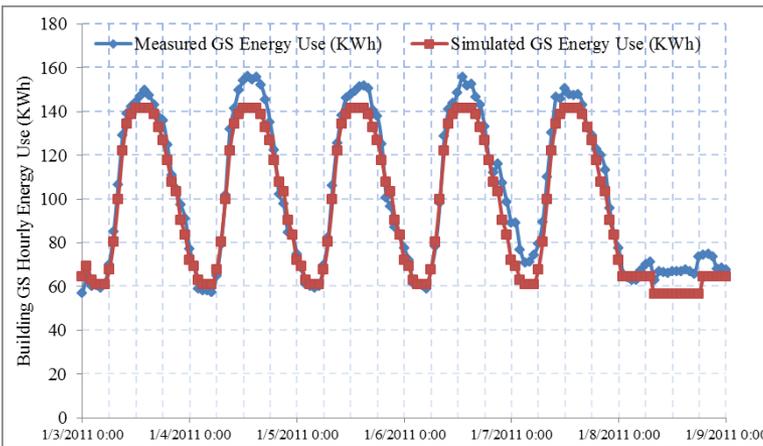
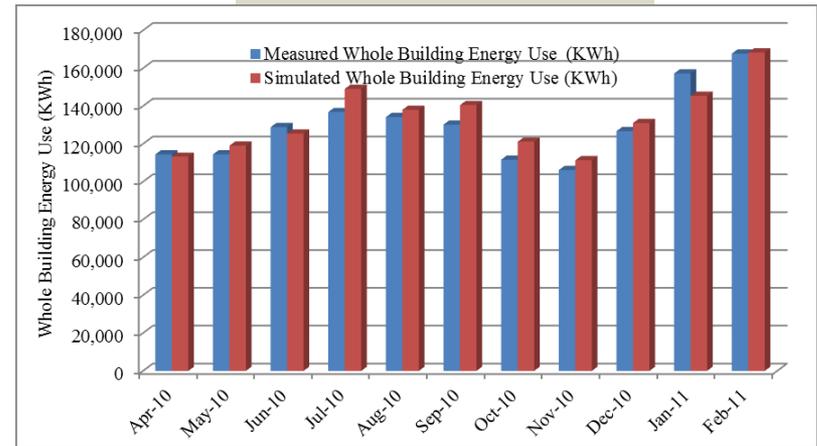
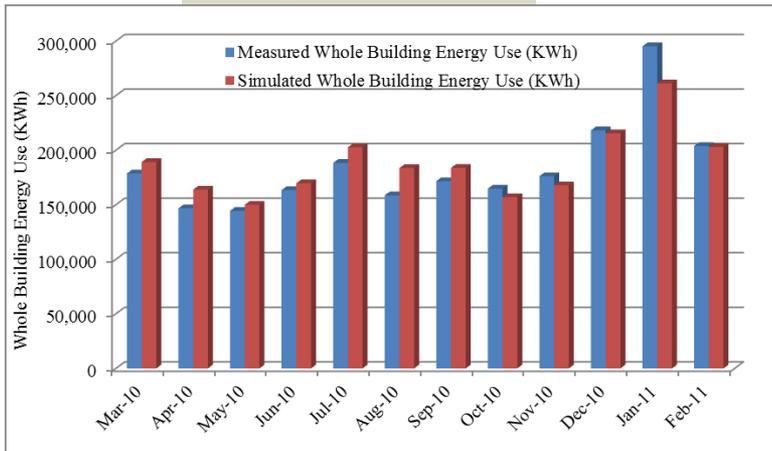
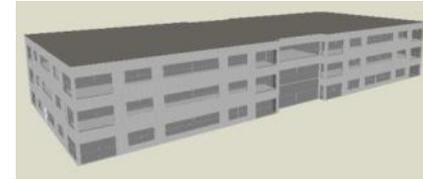
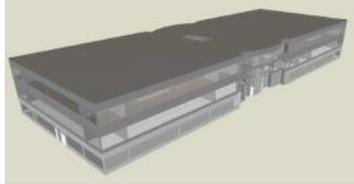


# Make Data Driven, Continuous Efficiency Improvements as Standard Practice

## Technical Loop

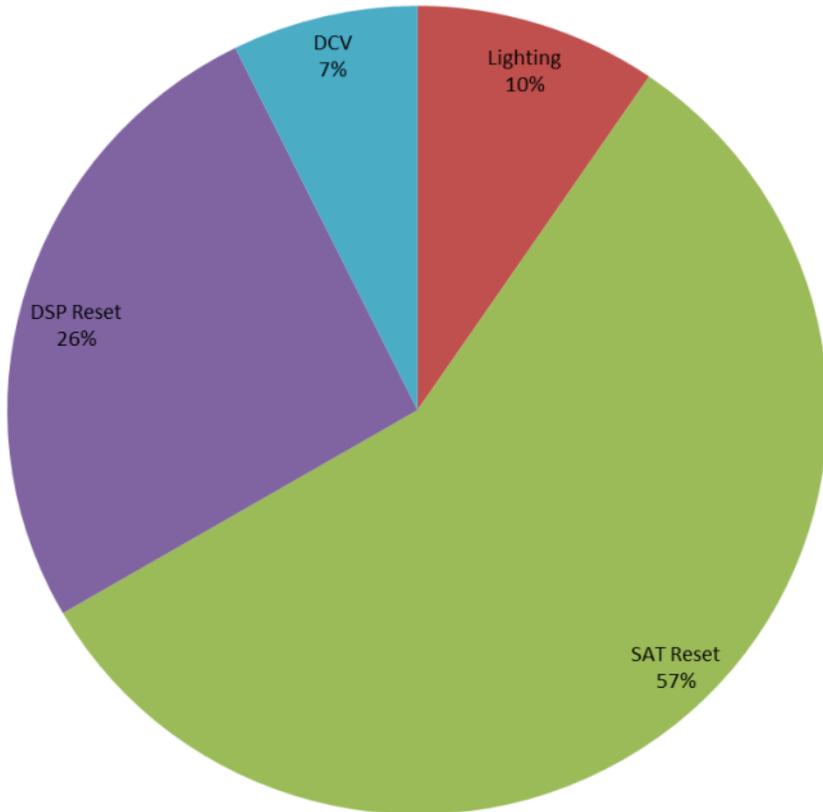


## “As-Operated” Building EnergyPlus Models Importance of Plug Load Input

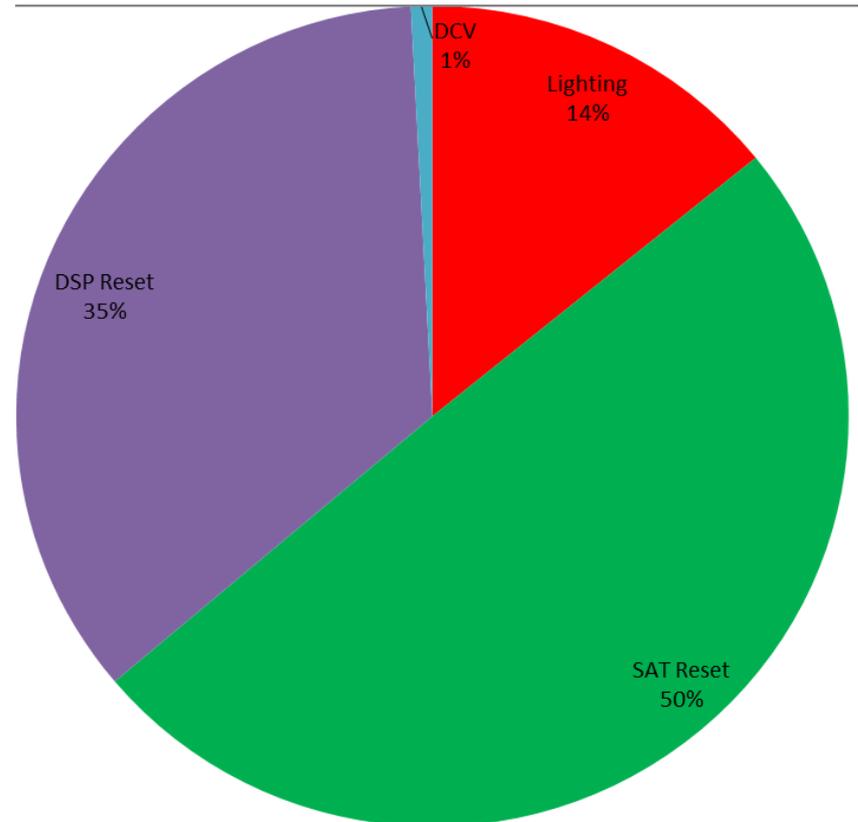


# Savings Breakdown

**Building #1 (saves 11% of annual energy use)**



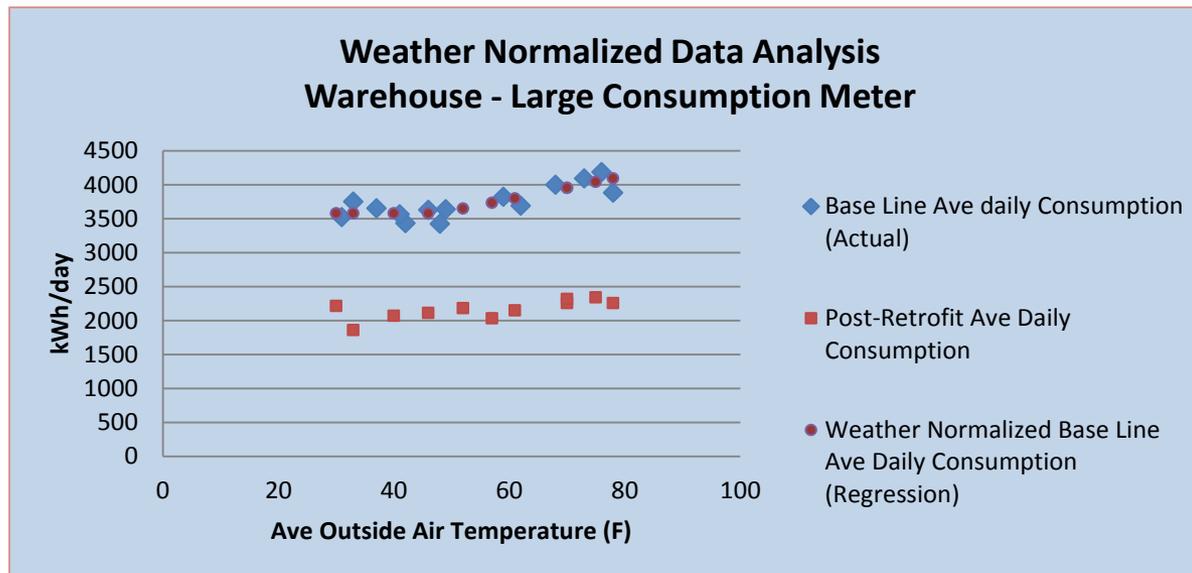
**Building #2 (saves 14% of annual energy use)**



Note: Lighting- lighting related retrofits including day lighting harvest, occupancy sensor based control, etc.; DCV- Demand Control Ventilation; DSP- Duct Static Pressure Reset; SAT Reset- Supply Air Temperature Reset;

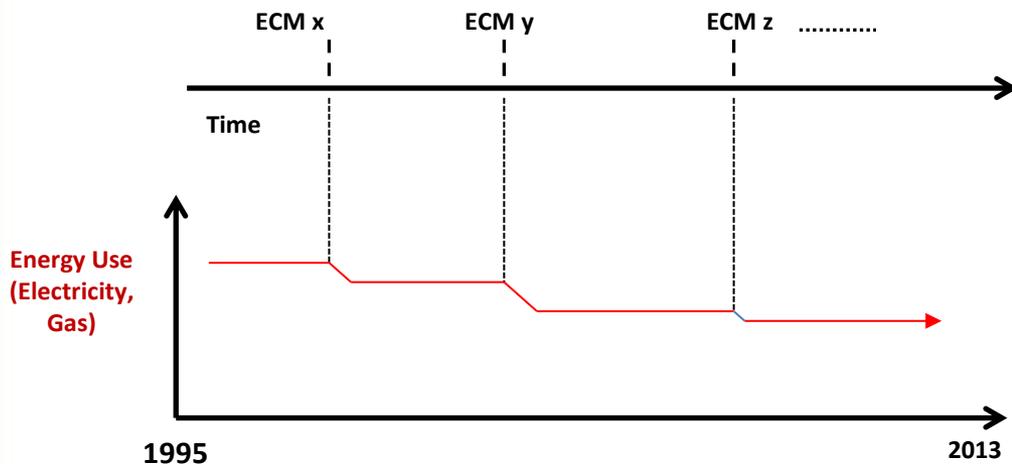
## ***Analysis of Warehouse Electric Energy Use Data:***

- Two electric accounts serve the warehouse space (387,500)
- Total electric usage for base line year was: 1,783,000 kWh
- One electric account showed relationship between outside air temperature and building energy use; other electric account did not show this type of relationship
- Three methods were used to determine energy savings:
  - Monthly year-to-year comparison based on utility billing data
  - Weather normalized base line comparison
  - Average weekday and weekend hourly loadshape comparison



## Develop Long Term , Staged ECM Investment Plan Methodology Based on Analysis of Ten Year Data for ECM Performance

### Property A, B, C, .....



**Kevon Office Center Building Summary**  
2500 McClellan Blvd., Pennsauken, NJ 08109

**Building Information**

- Year built: 1970-1972
- # of stories: 4
- Partial basement
- Square footage: Approx. 100,000
- Construction: Steel & Concrete Panels with Glass Panels
- Sprinklers: Partial

**400 Market Building Summary**  
400 Market Street, Philadelphia, PA 19106

**Building Information**

- Year Built: 1971
- # of Stories: 12

**Constitution Place Building Summary**  
325 Chestnut Street, Philadelphia, PA 19106

**Building Information**

- Year Built: 1960
- # of Stories: 13
- Rentable Square Footage: 187,760
  - Gross Sq.Ft.: 211,237 (including 5,075 of outdoor parking)
- Construction: Steel & Masonry with Glass Curtain Wall
- Sprinklers: Yes
- Ground floor of building consists of building lobby, restaurants and retail stores
- On-site maintenance personnel

**Most Recent Renovations and Energy Efficiency Upgrades:**

- Window glazing 2010-ongoing
- Green Revolution 2012
  - <http://www.greenrevolutionems.com/>
- VFDs on domestic pumps 2012
- VFDs on HVAC equipment 2008
- Roof 1998
- Carrier Comfort Systems 1997
- A/C 1996
- Plumbing, Heating, Electrical are ongoing

- Natural Gas Use
  - Domestic Hot Water (Meter 2)

