BEST Center 2016

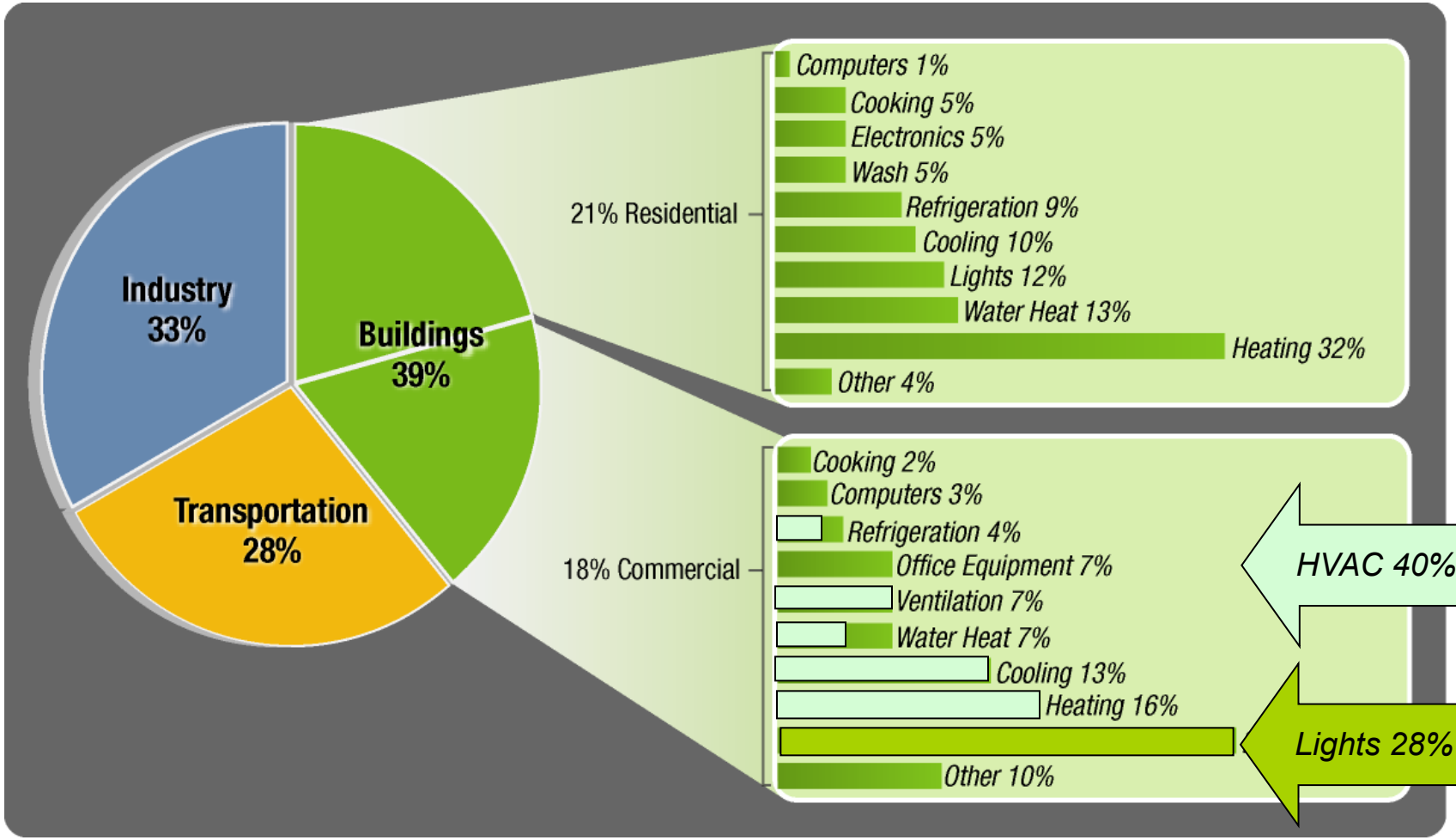
Maintaining Buildings for High Performance

Paul Ehrlich, PE
Building Intelligence Group

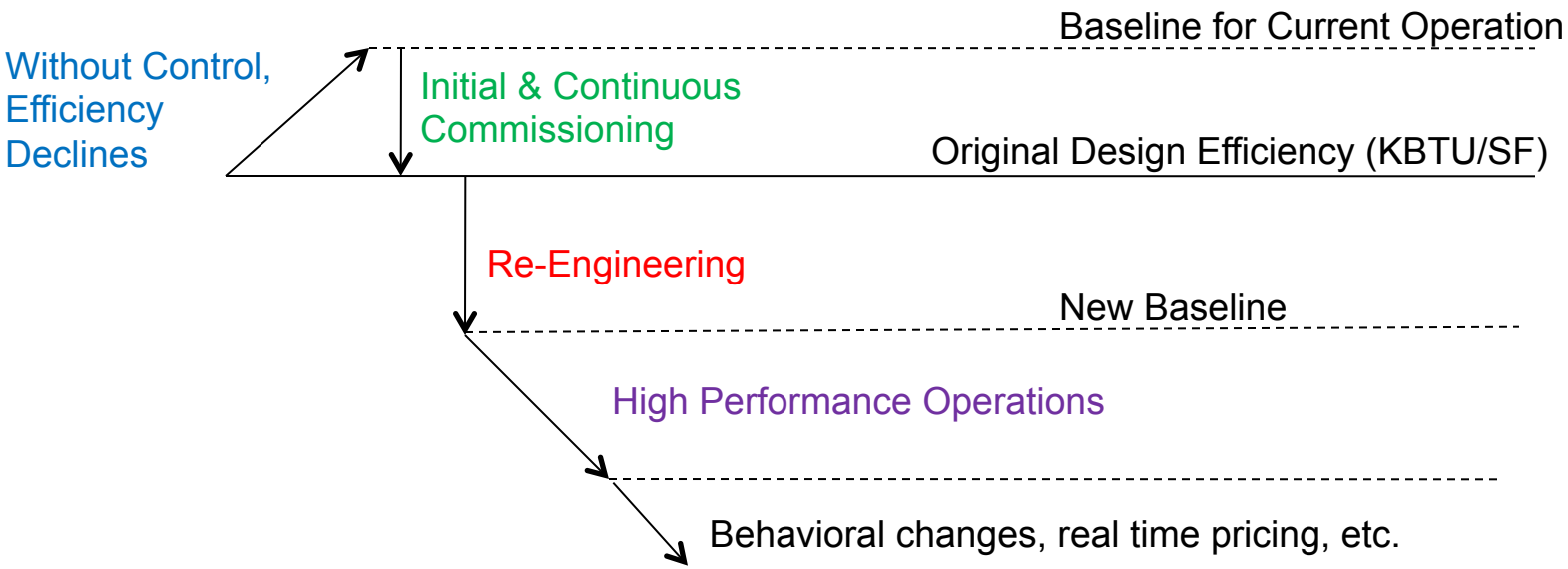
Presenter

- Paul Ehrlich, PE
- 30+ years of industry experience
- Frequent industry author and speaker
  - Columnist, Engineered Systems
- Consultant working with owners, integrators, and manufacturers

US Energy Use



Real World Challenges



Facility Data Sources

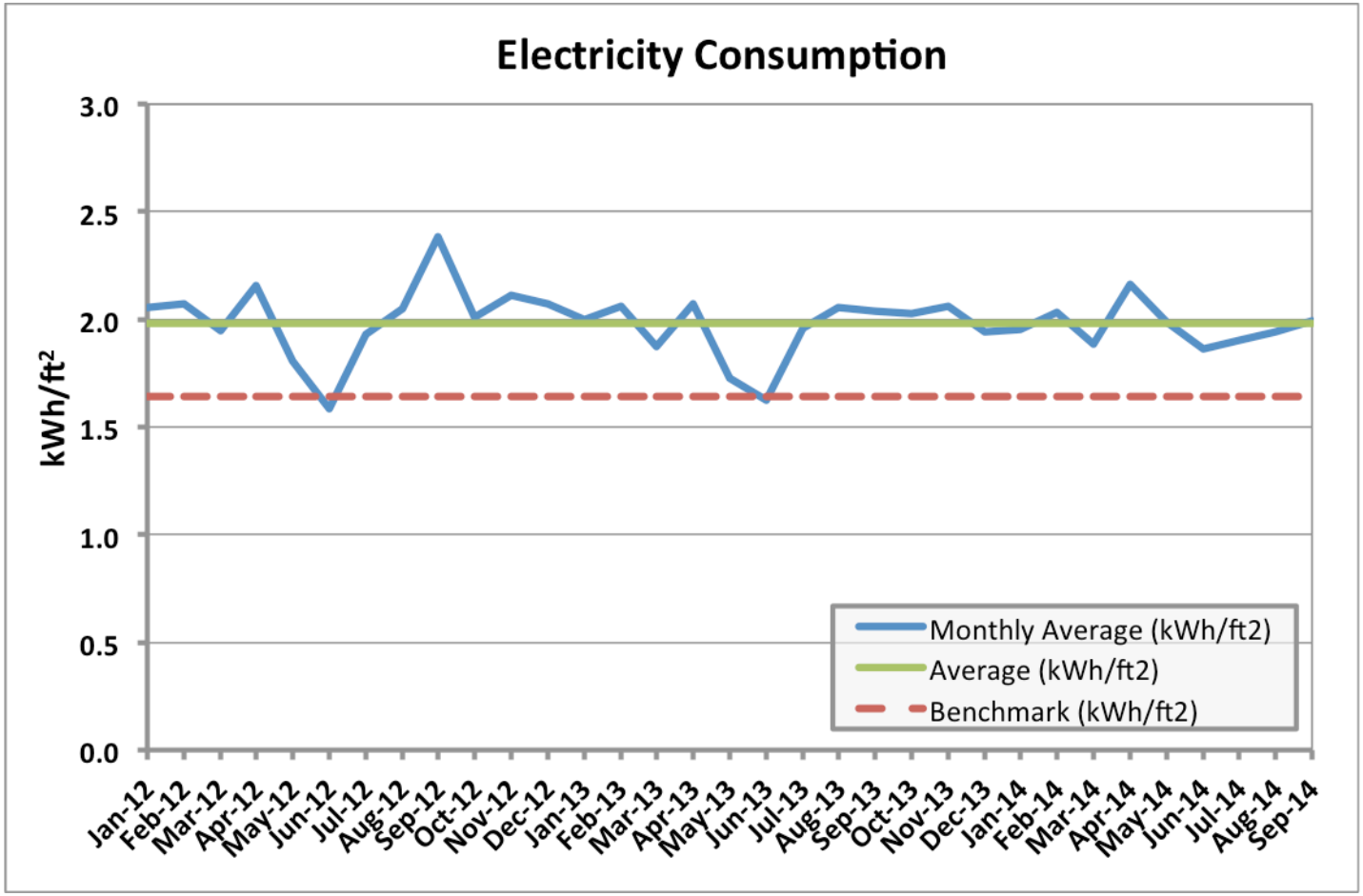
- System Data
  - BAS (HVAC and other system information
  - Electrical (PQM, sub-metering, etc.)
- Utility data (electric, gas, other)
- Weather data (NWS, BAS, other)
- Operational data (number of flights, occupancy, building size. etc.)
- Portable data logging

Data to Knowledge to Action

Data – Knowledge - Action

- Data
  - Raw information
  - May be real time or historical
  - Limited context and processing
- Knowledge
  - Required to process data
  - Can come from many sources
- Action
  - Needed to drive efficiency and performance

Data – Knowledge - Action

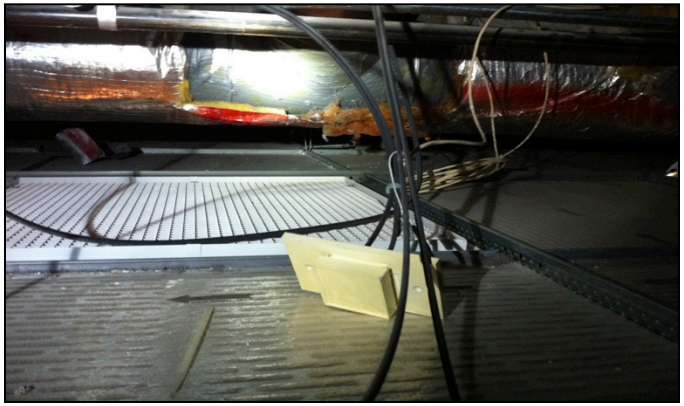


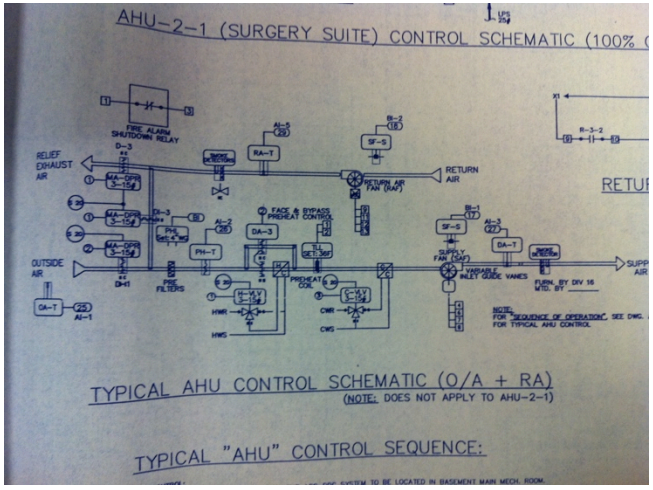
HVAC System Challenges

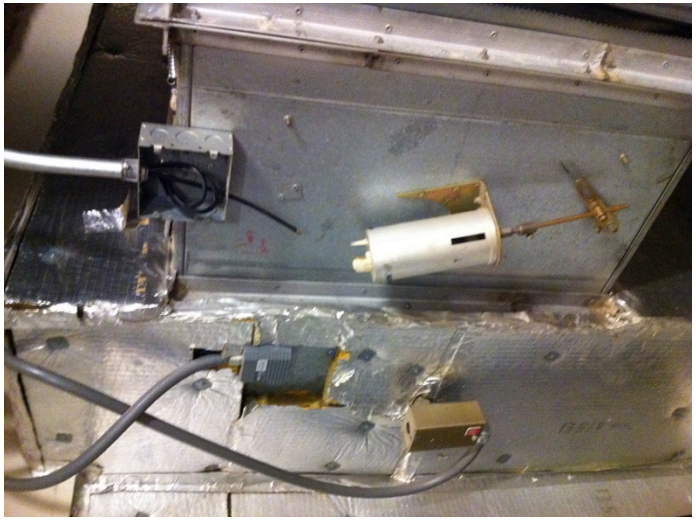
BUILDING INTELLIGENCE GROUP LLC

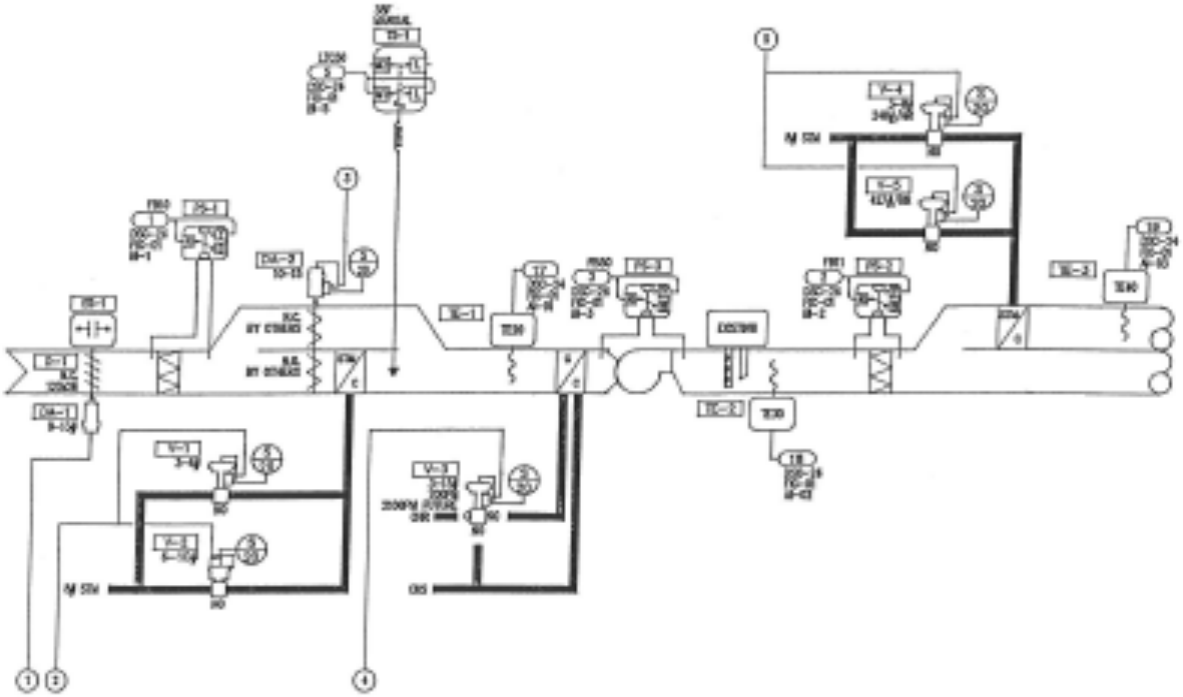
- Controls problems
- Equipment runs much more then needed
- Inefficient air and water delivery
- Simultaneous heating and cooling
- Inefficient heat rejection or introduction

HVAC

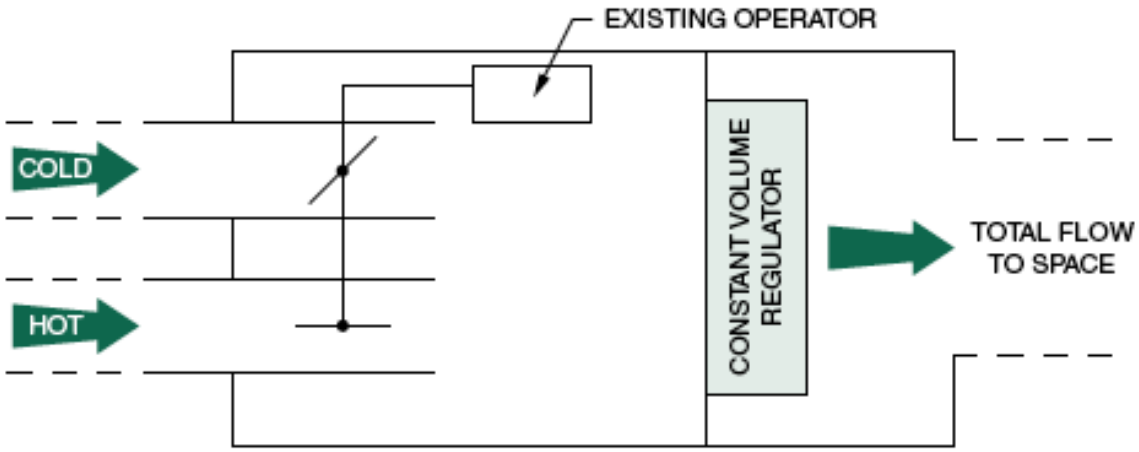


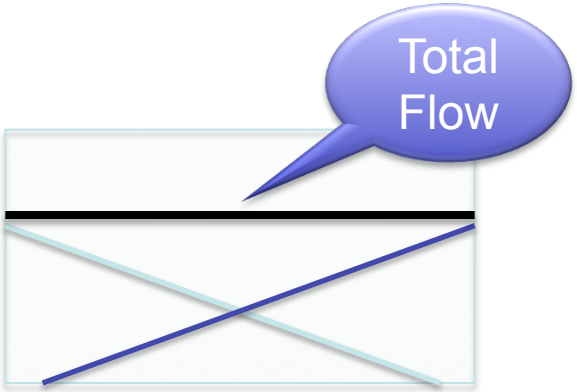

AHU-2-1 (SURGERY SUITE) CONTROL SCHEMATIC (100%
RELIEF EXHAUST AIR
OUTSIDE AIR
RETURN AIR
RETURN AIR FAN (RAF)
FACE & BYPASS PREHEAT CONTROL
PREHEAT COIL
FIRE FILTERS
VARIABLE INLET GUIDE VANES
TYPICAL AHU CONTROL SCHEMATIC (O/A + RA)
(NOTE: DOES NOT APPLY TO AHU-2-1)
TYPICAL "AHU" CONTROL SEQUENCE:



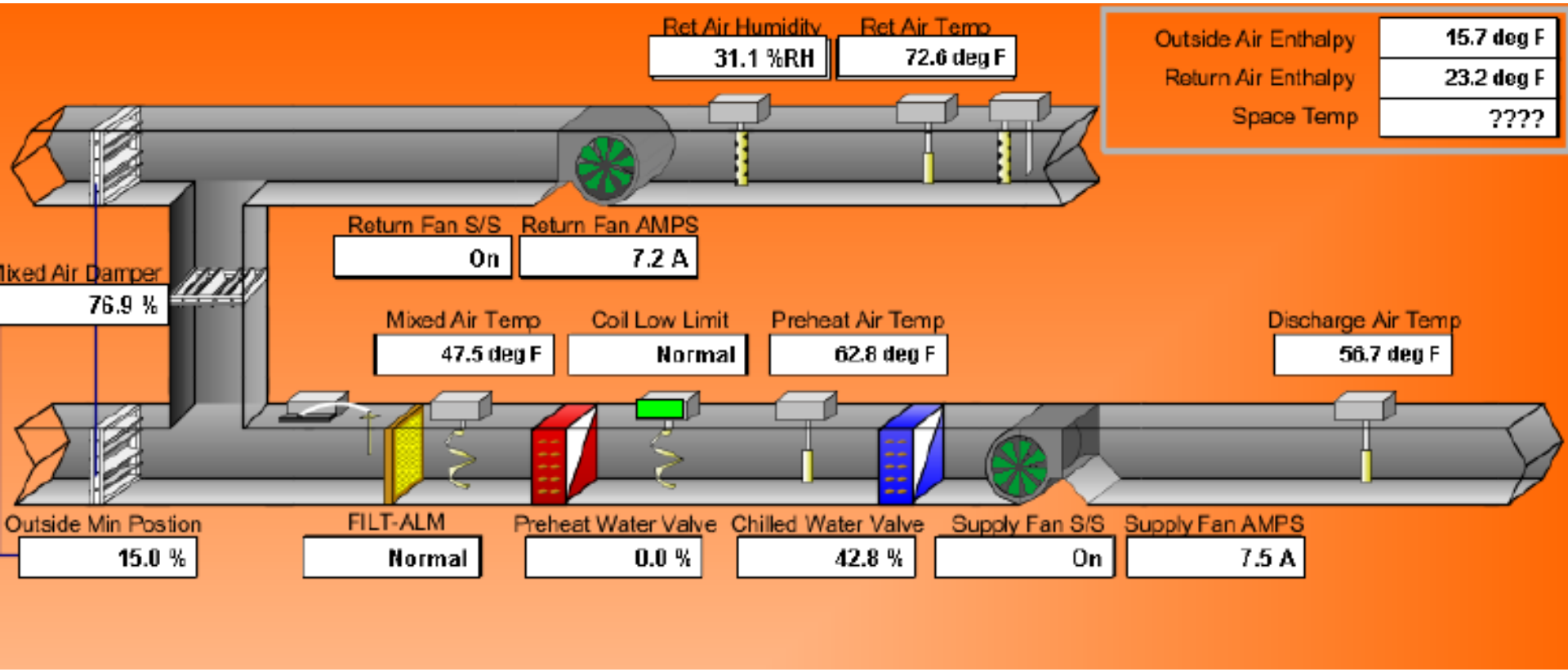


BUILDING INTELLIGENCE GROUP LLC



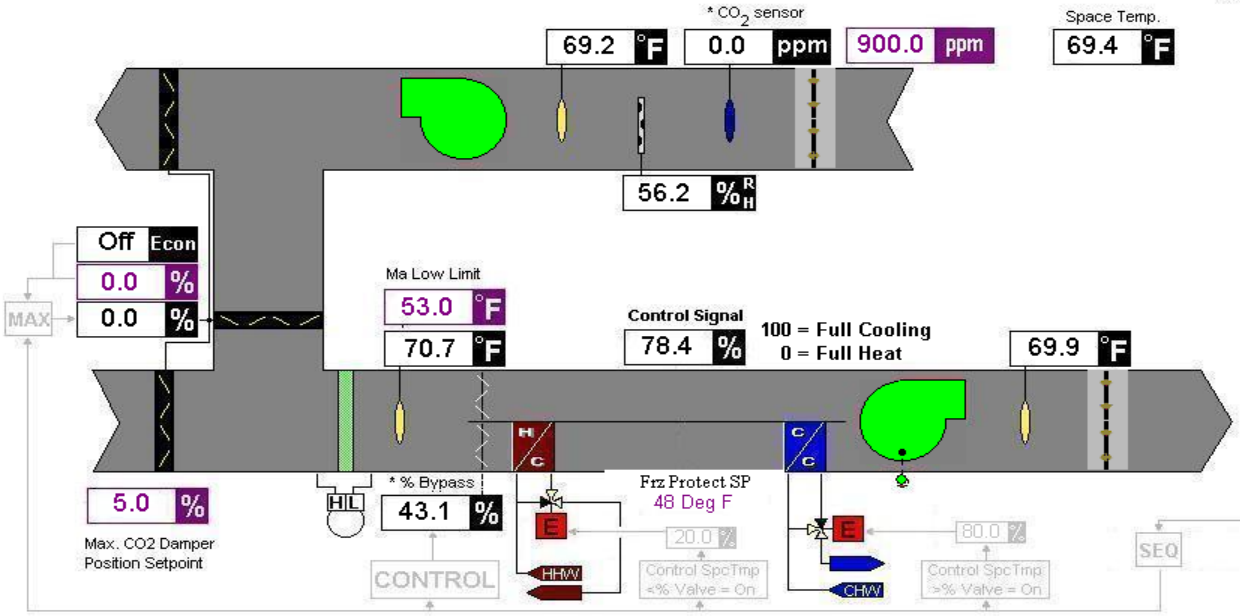


What's Wrong?


Ret Air Humidity
31.1 %RH
Ret Air Temp
72.6 deg F
Outside Air Enthalpy
15.7 deg F
Return Air Enthalpy
23.2 deg F
Space Temp
????
Return Fan S/S
On
Return Fan AMPS
7.2 A
ixed Air Damper
76.9 %
Mixed Air Temp
47.5 deg F
Coil Low Limit
Normal
Preheat Air Temp
62.8 deg F
Discharge Air Temp
56.7 deg F
Outside Min Postion
15.0 %
FILT-ALM
Normal
Preheat Water Valve
0.0 %
Chilled Water Valve
42.8 %
Supply Fan S/S
On
Supply Fan AMPS
7.5 A

Concert Hall
AHU 1

OVERVIEW



PROCESS COLOR CODE
Chilled Wtr
Heating Hot Wtr

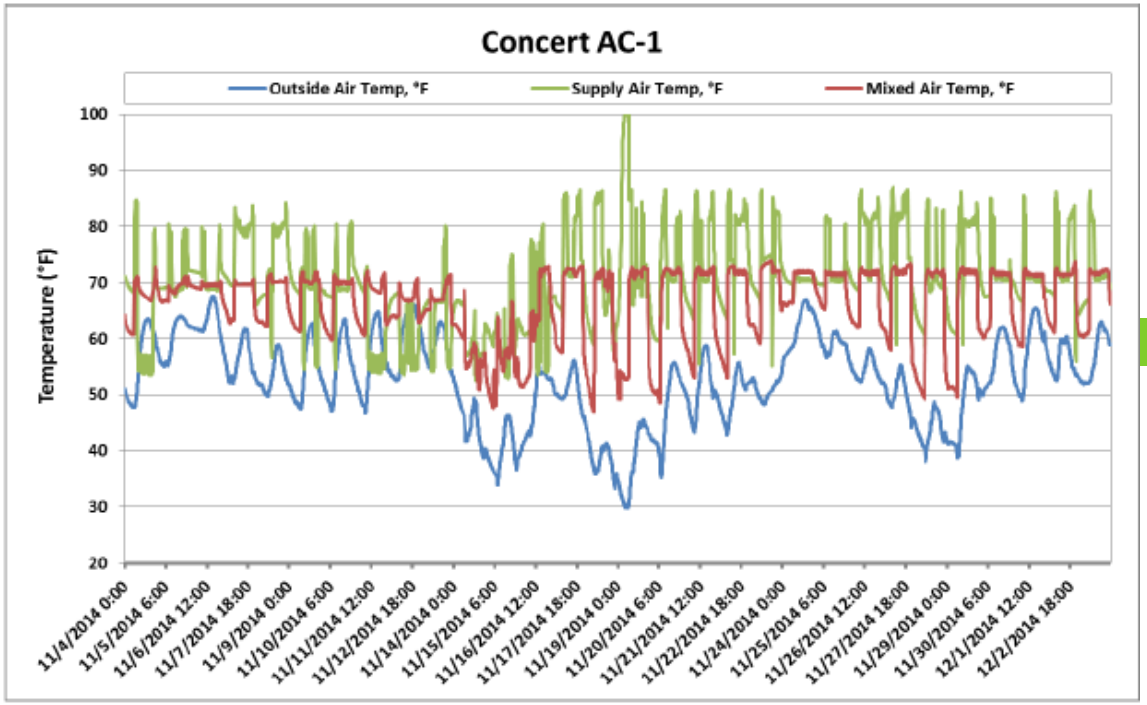
NOTE:
When a PROCESS TAG is blank it is INDICATION ONLY. When it contains characters HHW it is a BUTTON.

SYSTEM
On
REQUEST

OUTSIDE AIR
TEMP 61.0 F
RH 56 %

SYSTEM
OccupiedMode
MODE

TRENDS



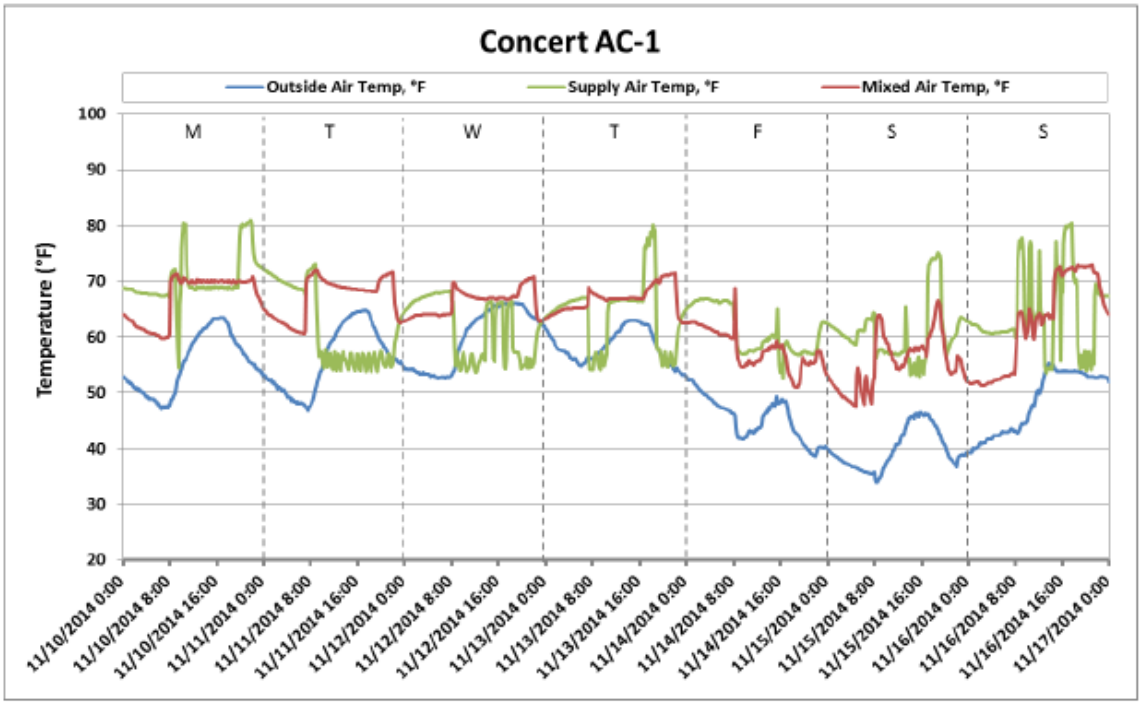
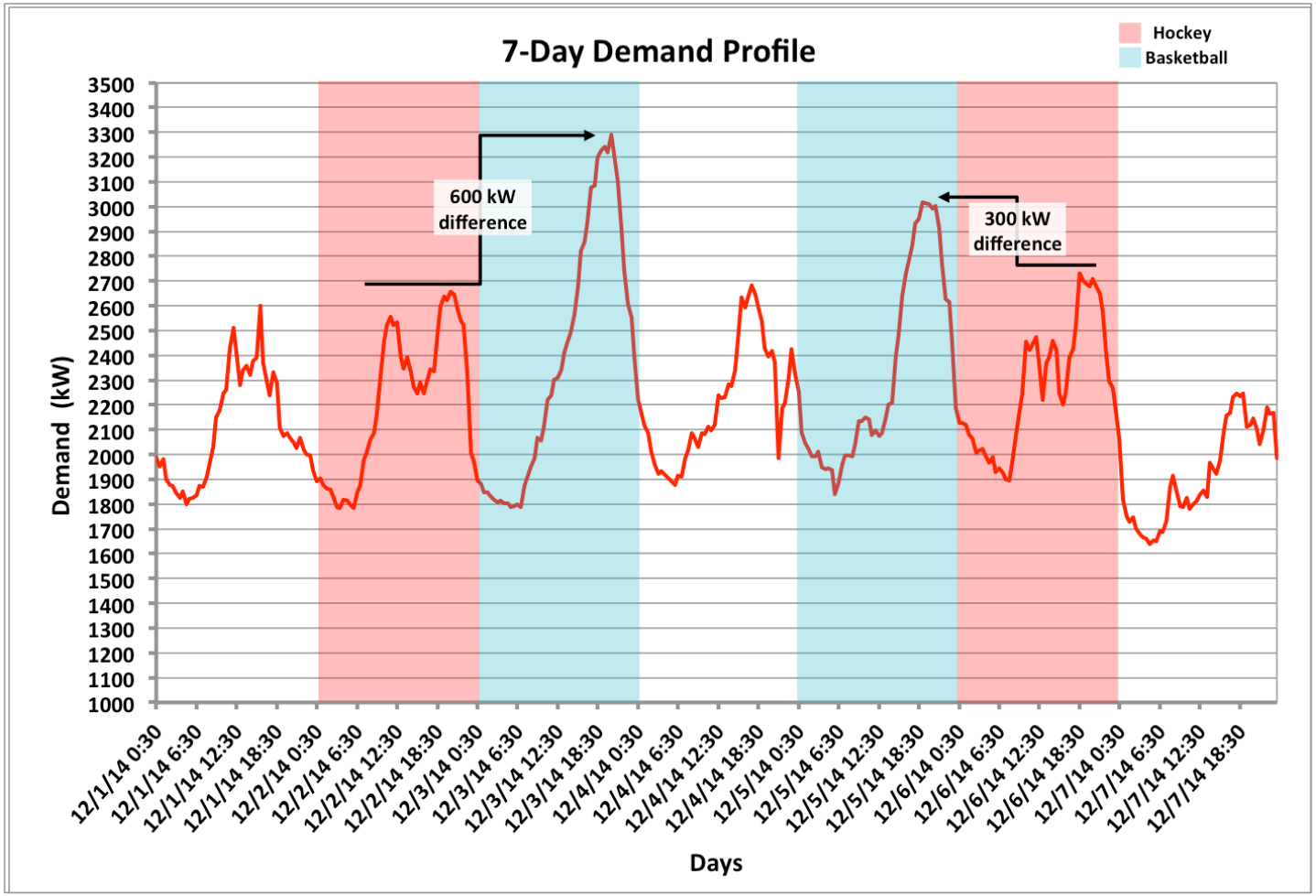


Figure 26: Concert Hall AC-1 trends

What's Wrong?

AC-1	Concert Hall	CO_2 sensor indicates 0 PPM – defective or missing
		RA enthalpy is 25.9 BTU/# - OA is 21.56 BTU/# but unit is not in economizer since it is doing a DB changeover.
		Supply and return fans are CV and both running
		Current sequence has valves as two position with use of face and bypass. Recommending new sequence for improved control and efficiency.
		Unit does appear to be scheduled based on trend data.

Data – Knowledge



Tools for Analysis

BUILDING INTELLIGENCE GROUP LLC

- Walk and look!
- Data logging
- Plan analysis
- Modeling

Benchmarking

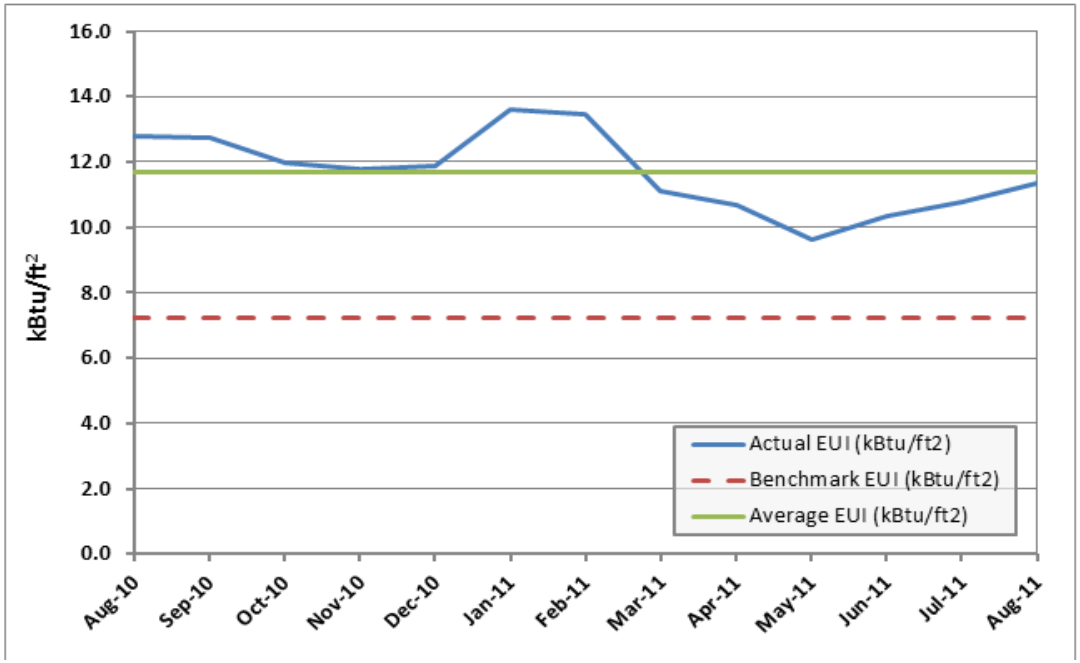
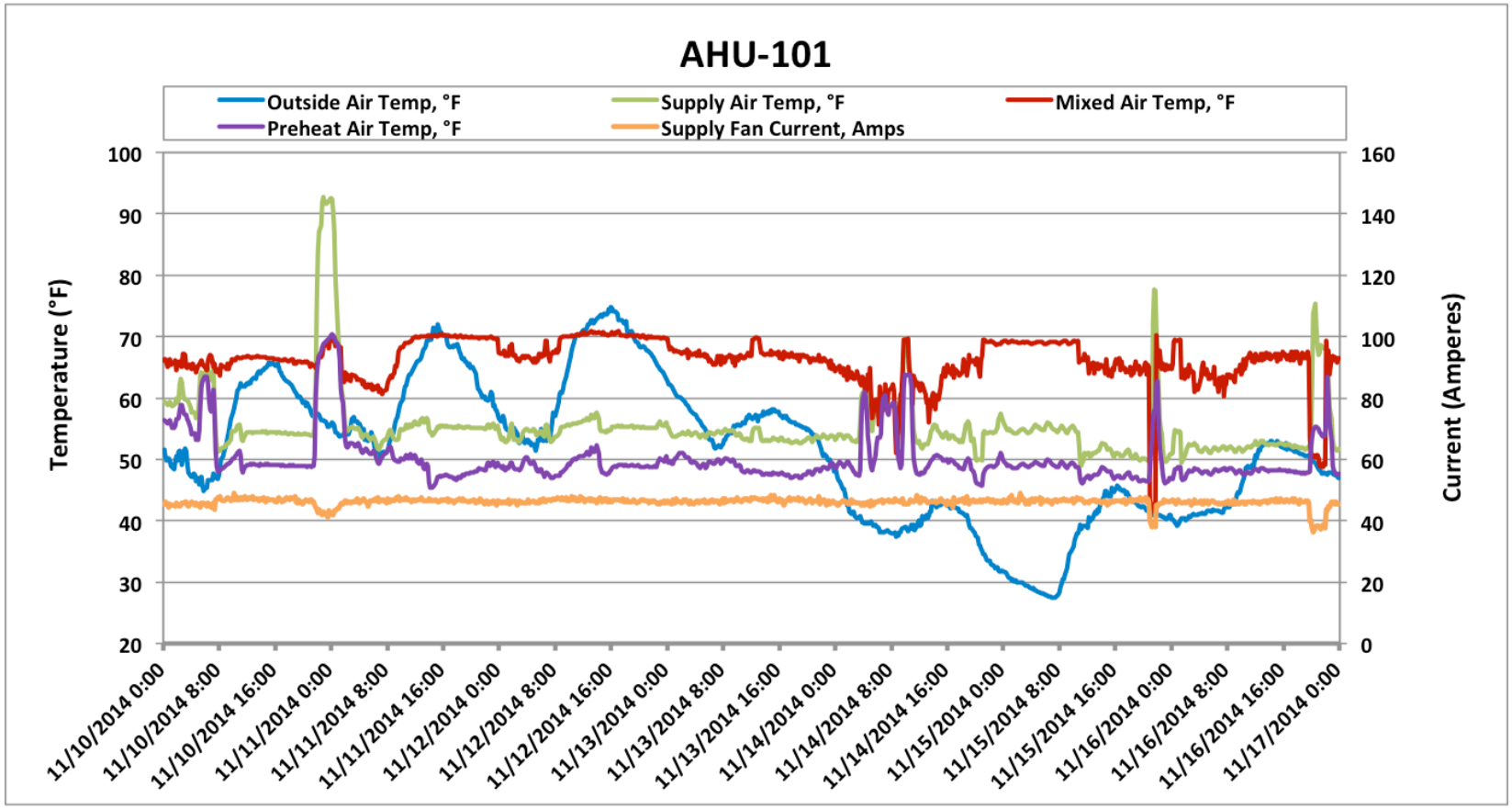


Table 1: Average annual energy intensity

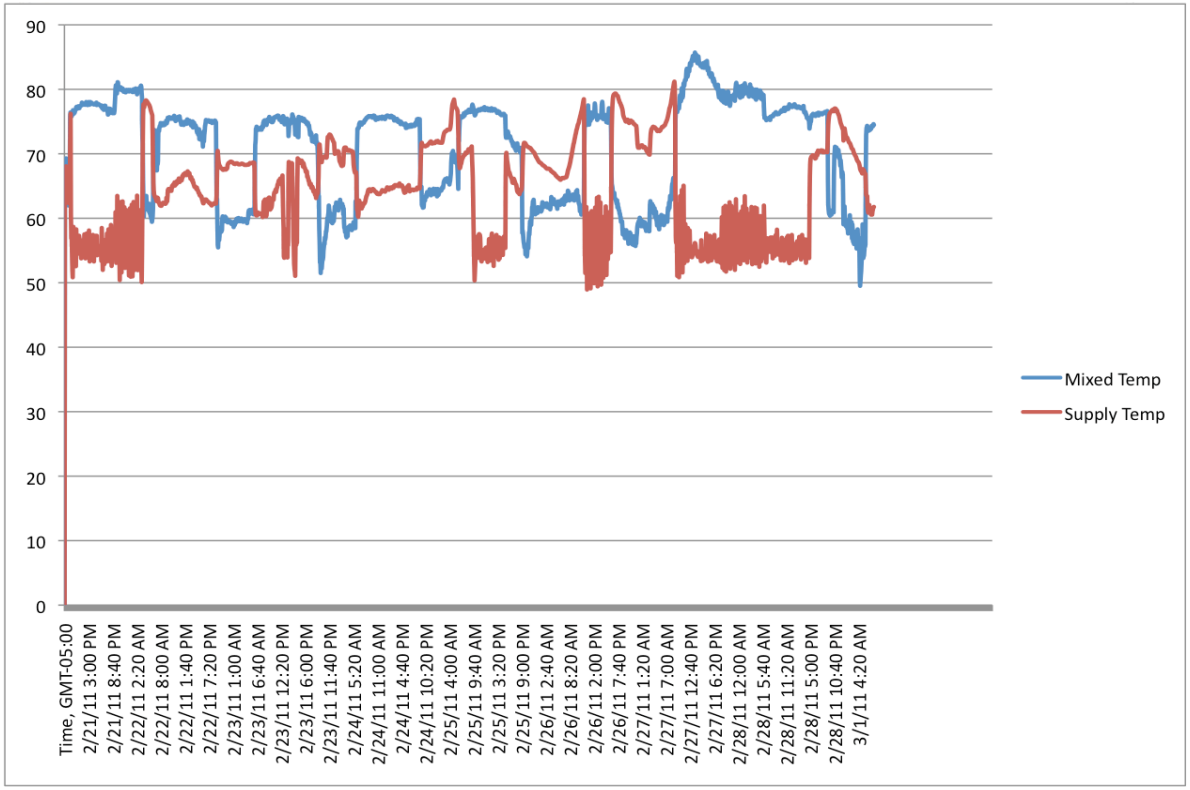
Energy Type	Energy Intensity		Percent Difference
	Actual	Benchmark[1]	(%)
Electricity (kWh/square foot/year)	41.17	18.80	119.9%
Total (kBtu/square foot/year)	140.49	87.00	61.5%

Notes:
1) Benchmark energy intensities derived from U.S. EIA CBECS 2003 for office buildings in the same region.

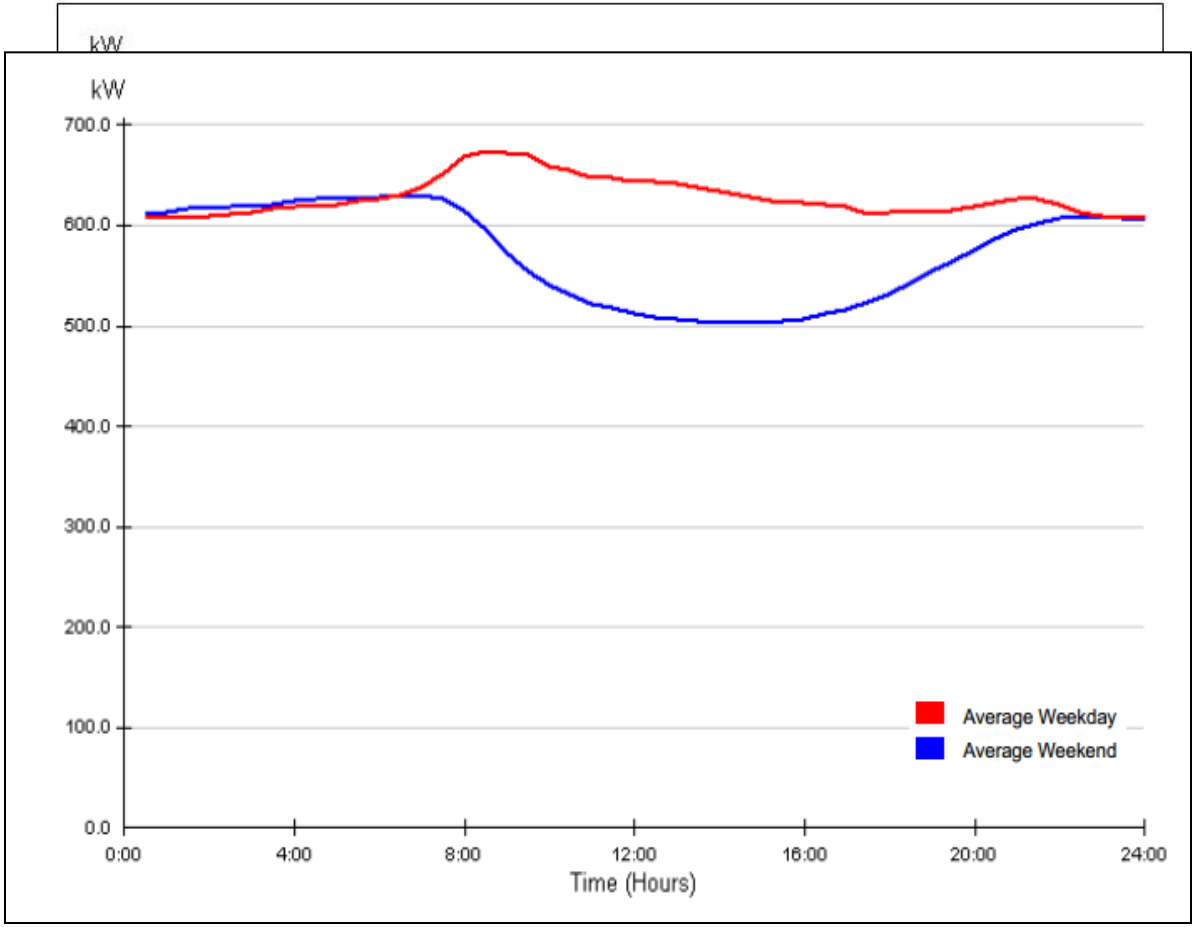
Data Logging



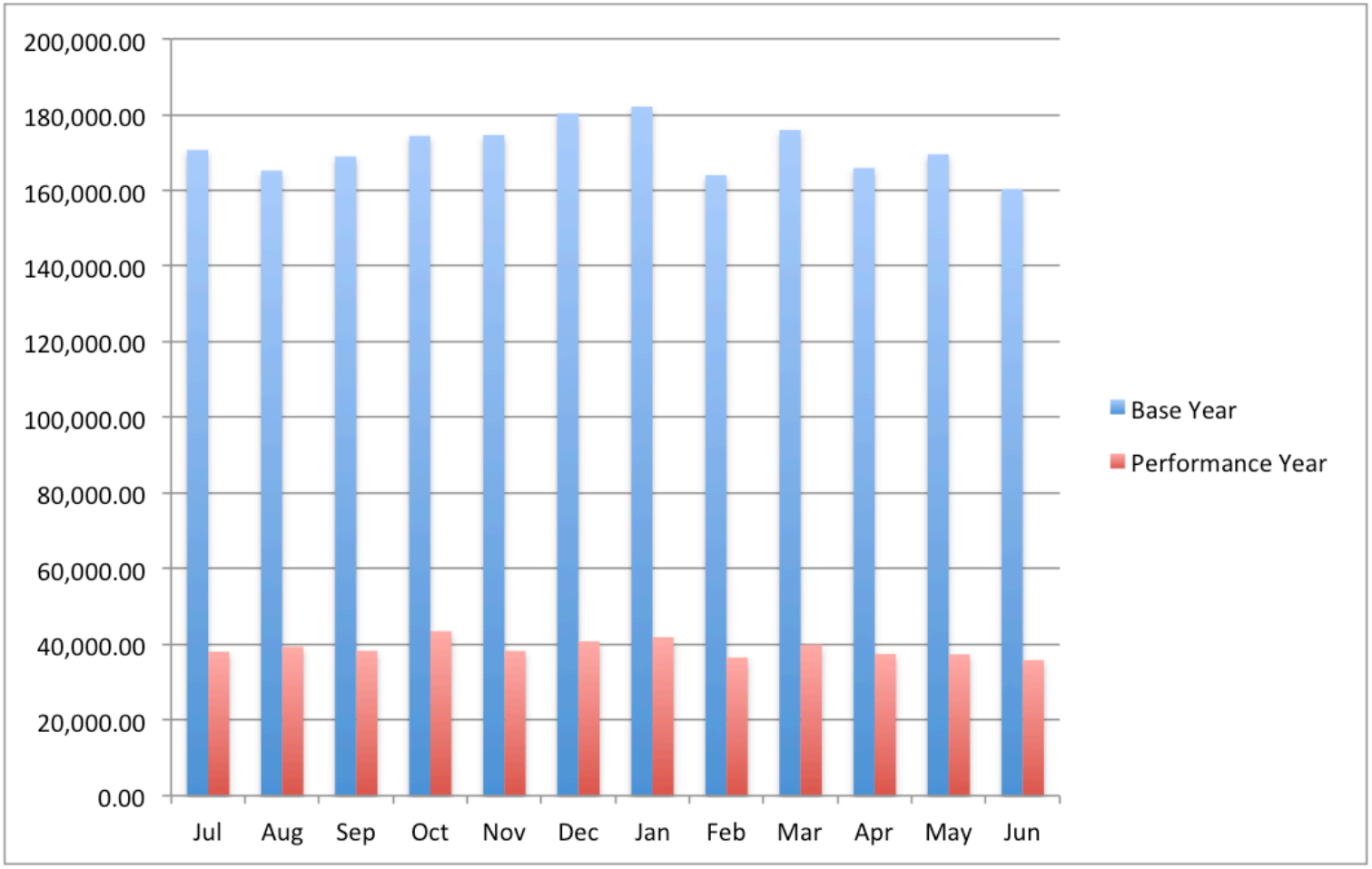
Data Logging



Meter Analysis



Meter and Excel



Getting Owner Buy In

BUILDING INTELLIGENCE GROUP LLC

- Need to make it simple and believable
- Put results in both engineering and financial terms
- Work high level with management
- Bring utility incentives, tax credits, grants, and other financial tools to the table

What Does an HPBT Need to Know?

- Systems
- Troubleshooting
- Data, Knowledge, Action
- Summarize data
- Build a business case
- Facilitate improvements

Case Study

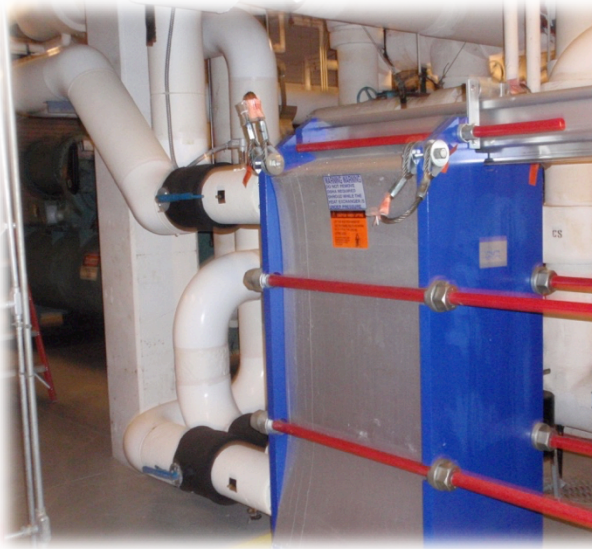
- Hospital project
- Constructed in early 1990’s

PHM Overview

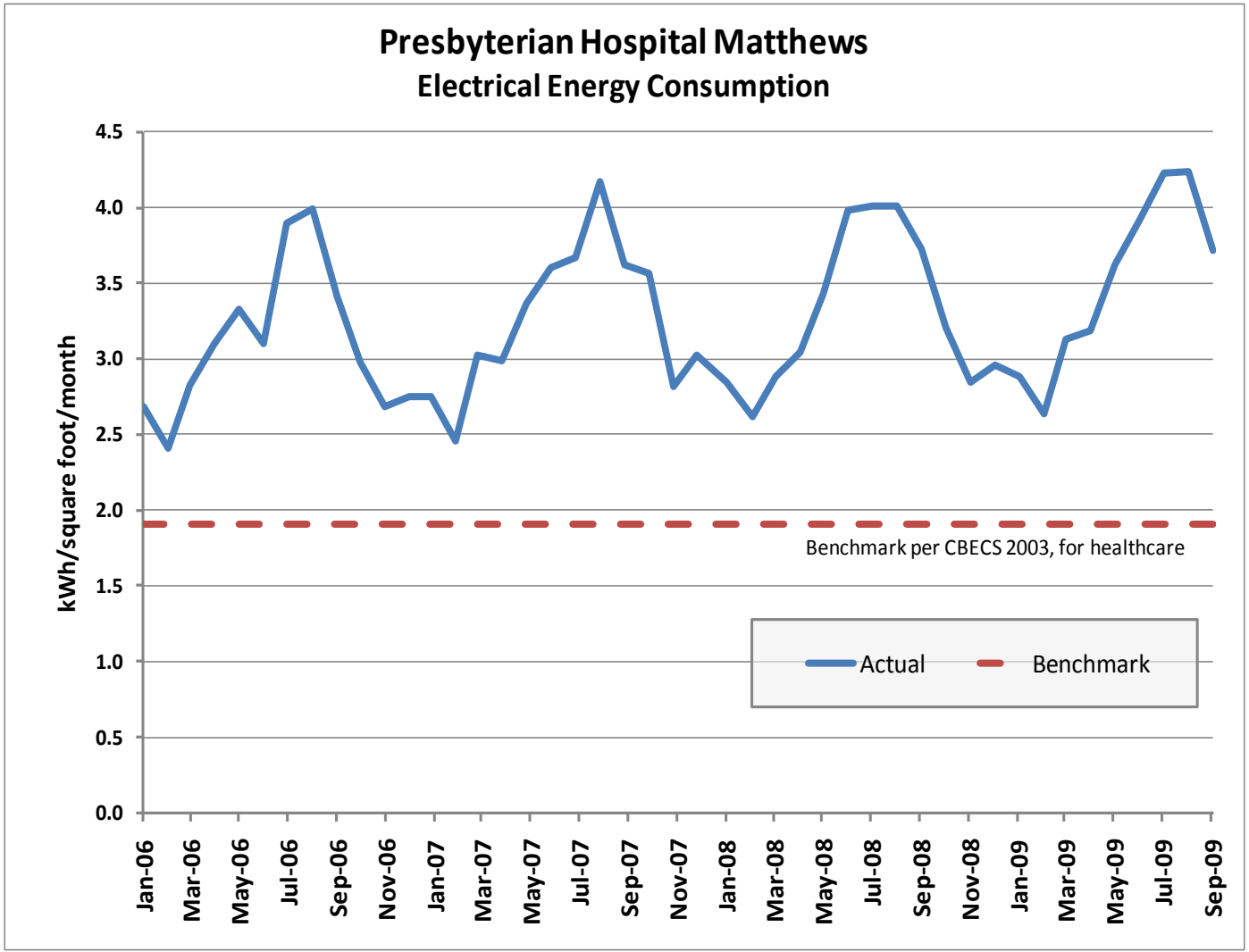
- High energy usage (gas and electric)
- Pneumatic controls are contaminated with oil
- Calibration and control issues
- Systems are designed to operate as VAV, but are running as constant volume reheat
- All areas are conditioned 24x7 even those that have scheduled occupancy
- Study focused on air handling and chiller plant

Site Observations

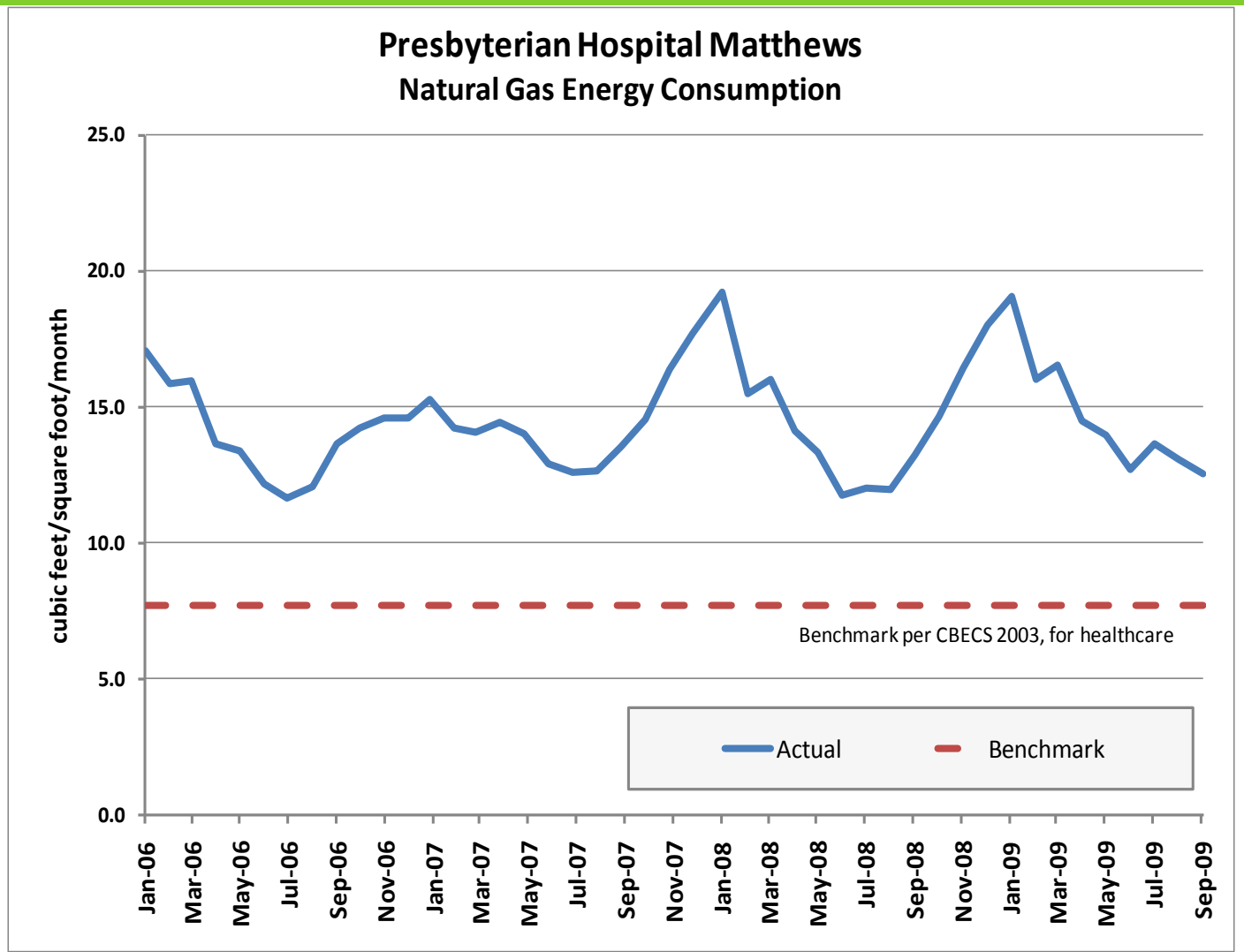
BUILDING INTELLIGENCE GROUP LLC



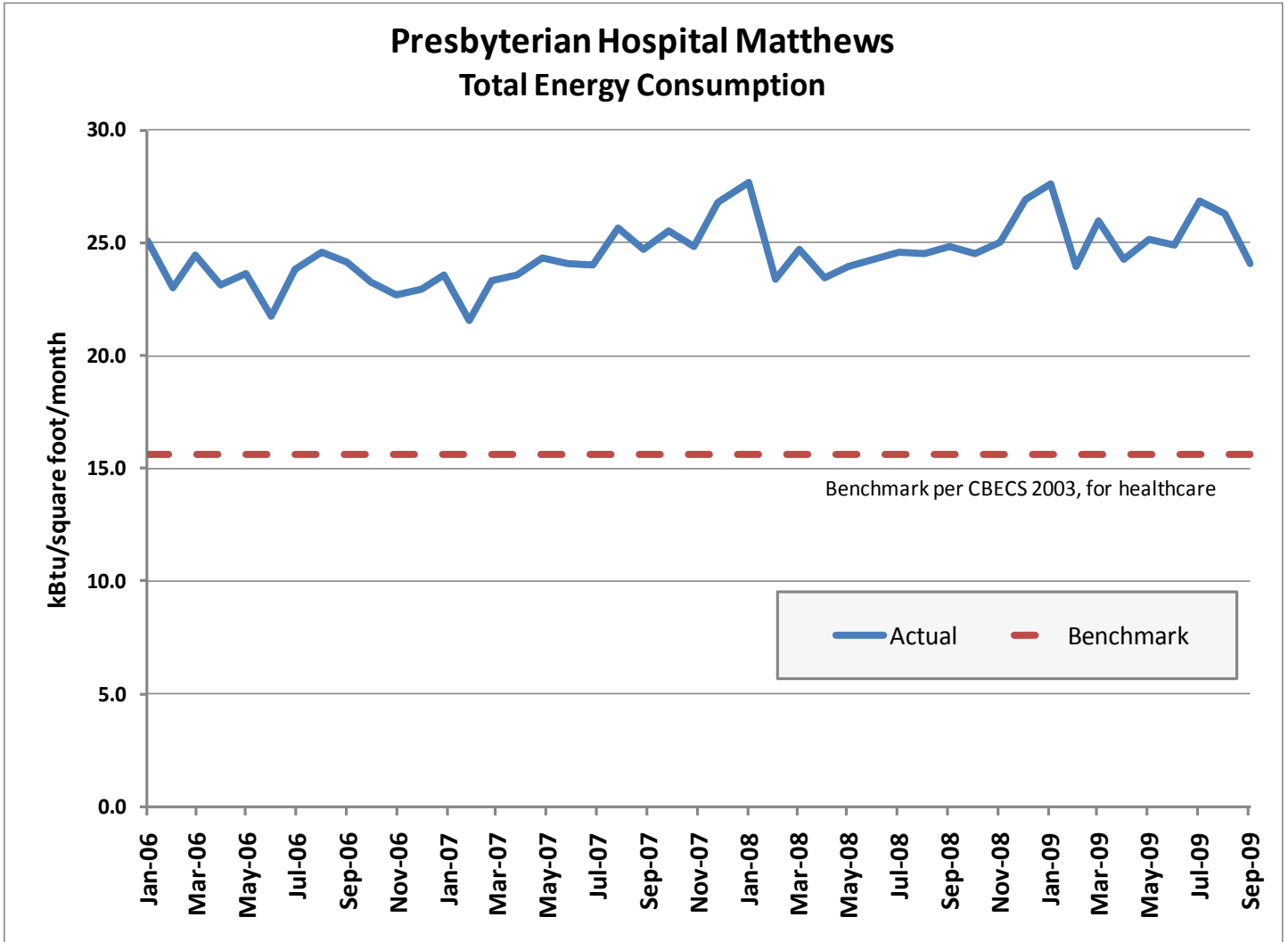
Electric Power Usage



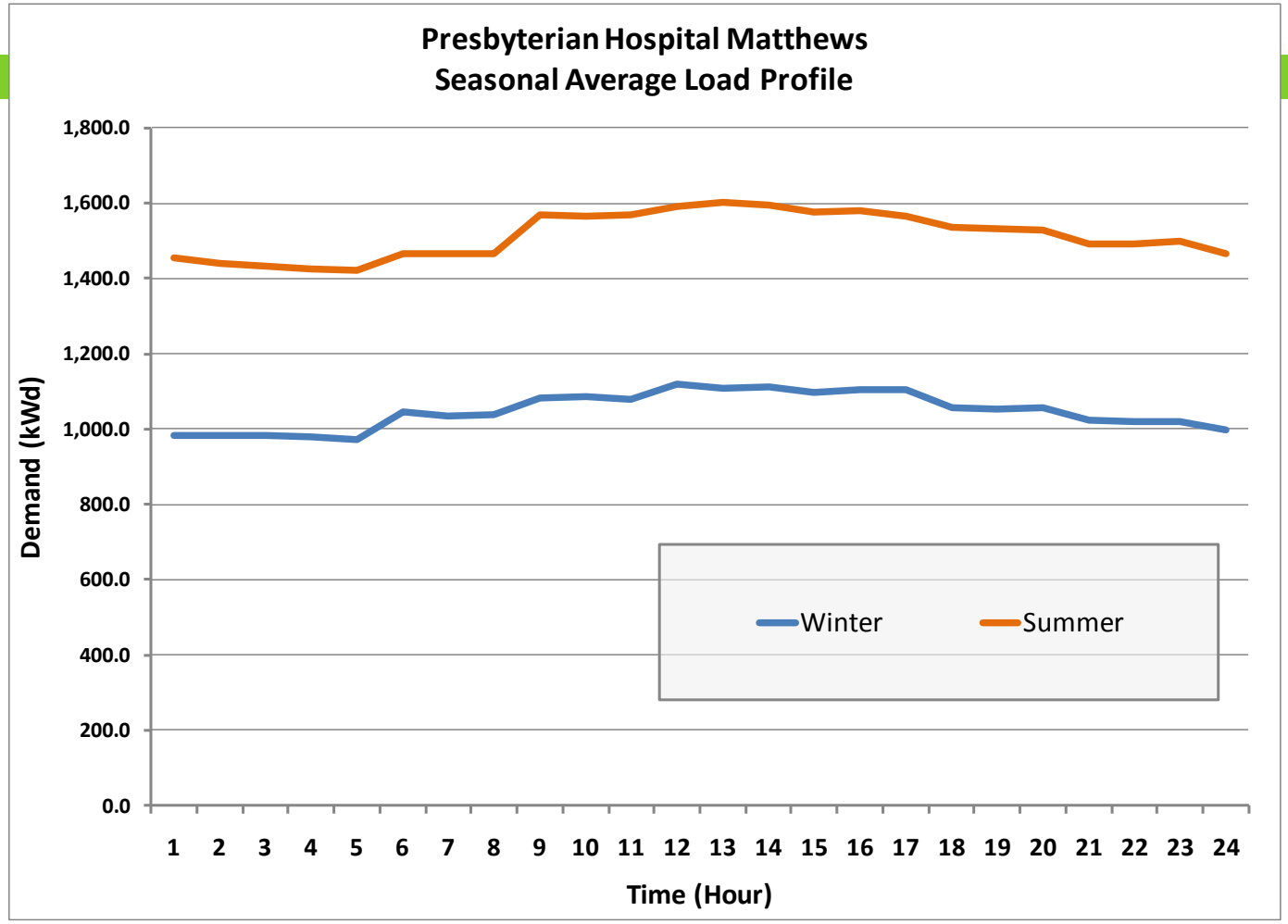
Natural Gas Usage



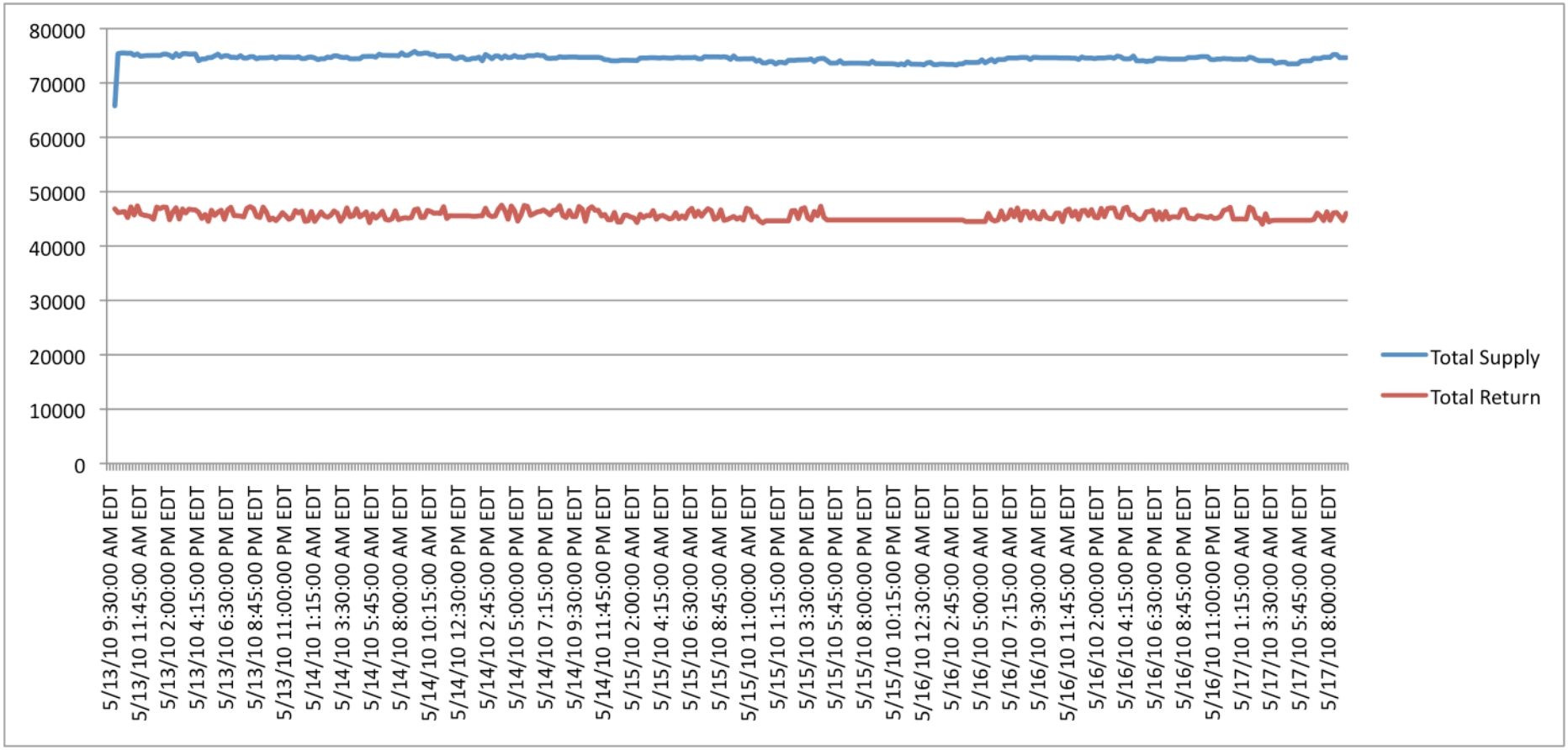
Total Energy Usage



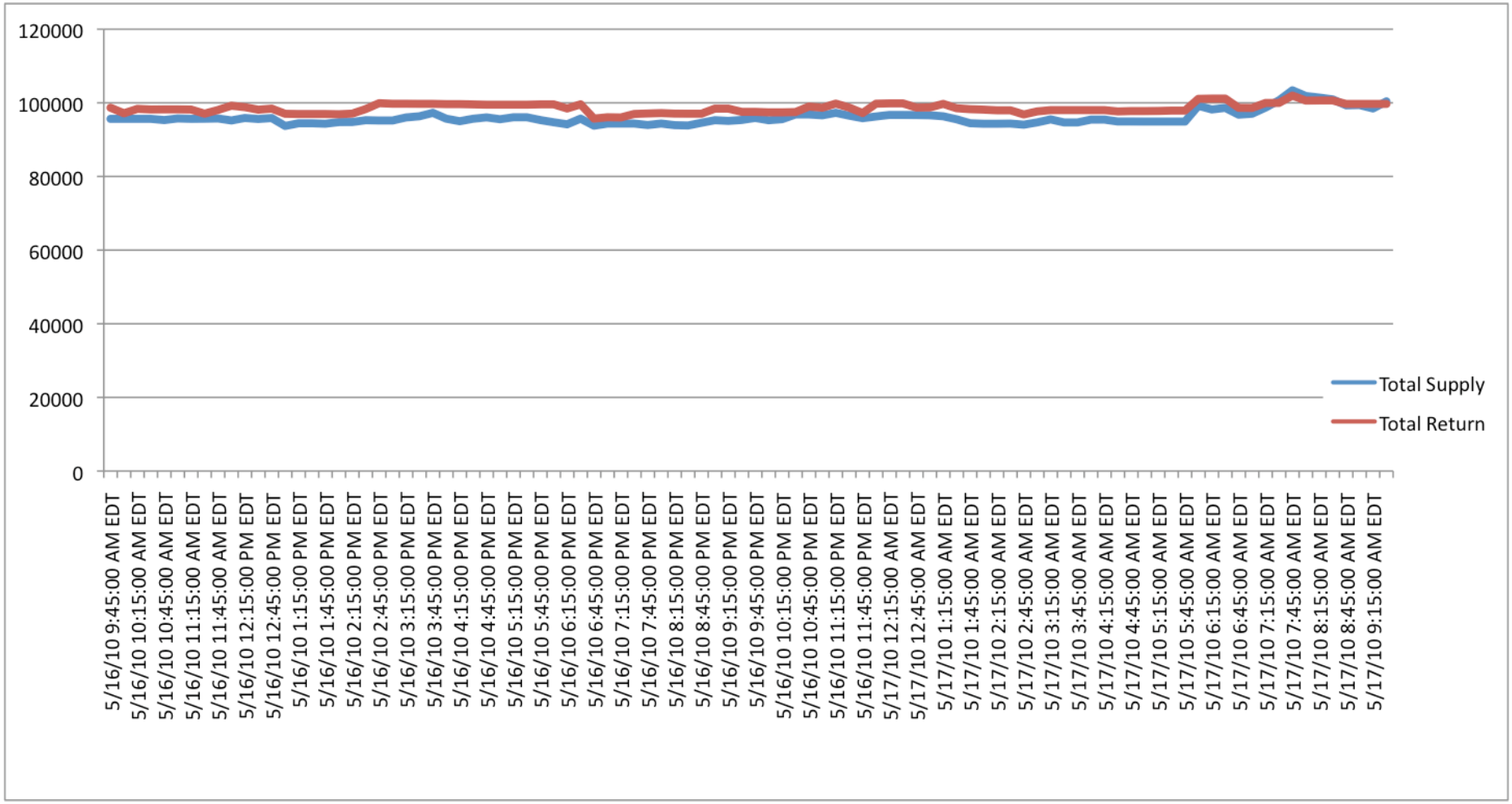
Electrical Load Profile



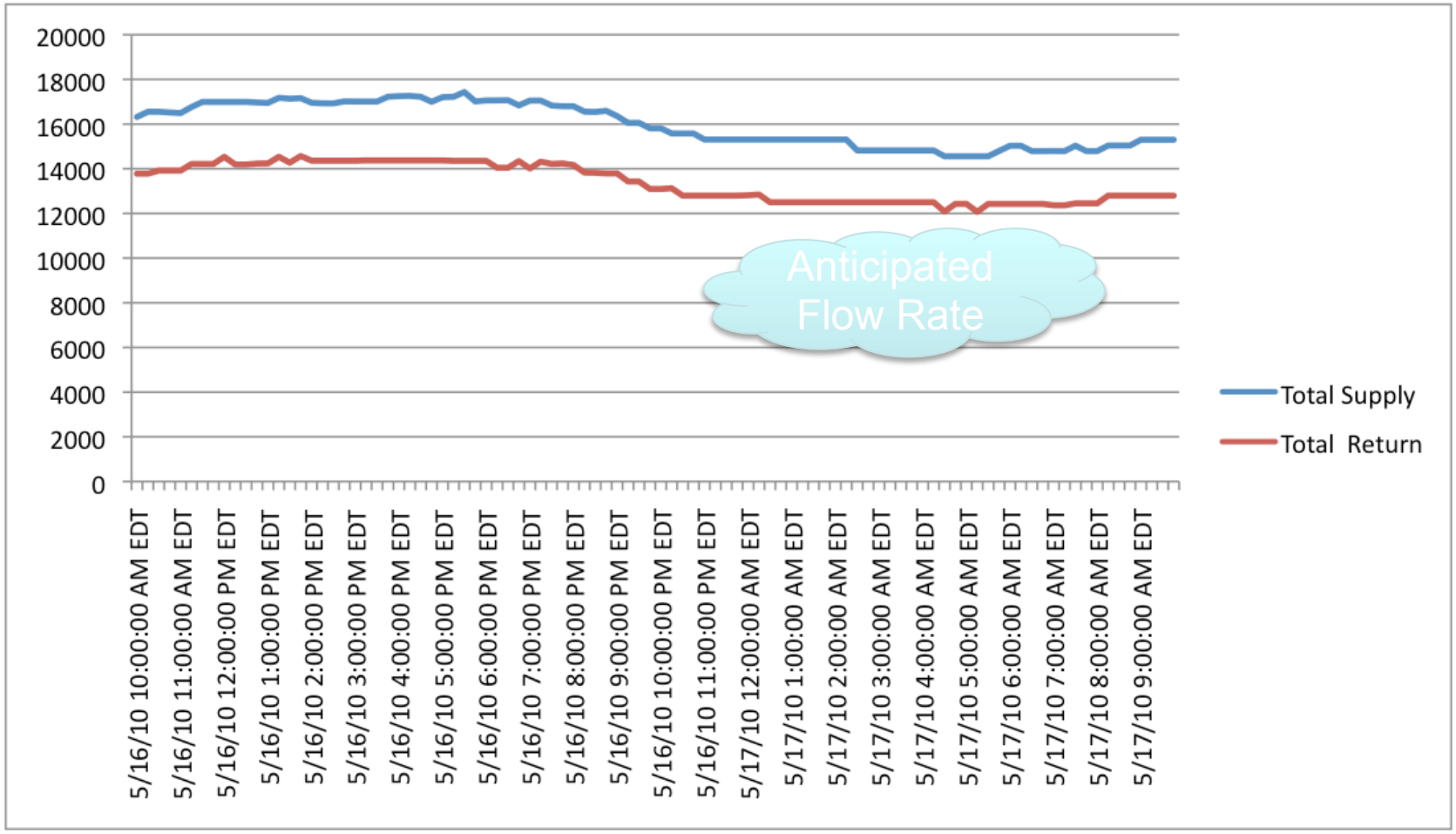
PHM AHU 1
76,320 CFM – max
57,725 CFM - min



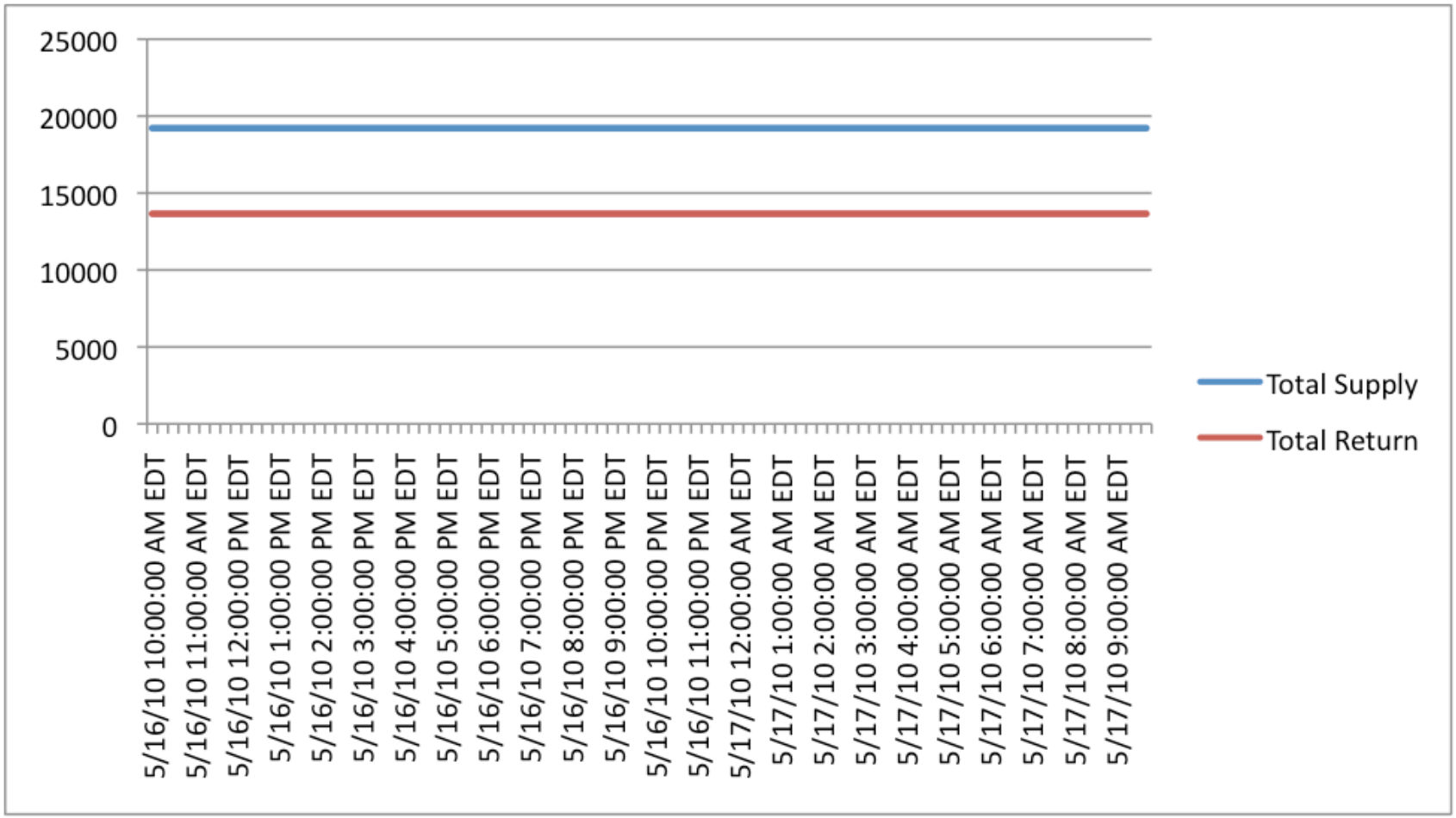
PHM AHU 2
132,850 CFM – max
82,040 – min



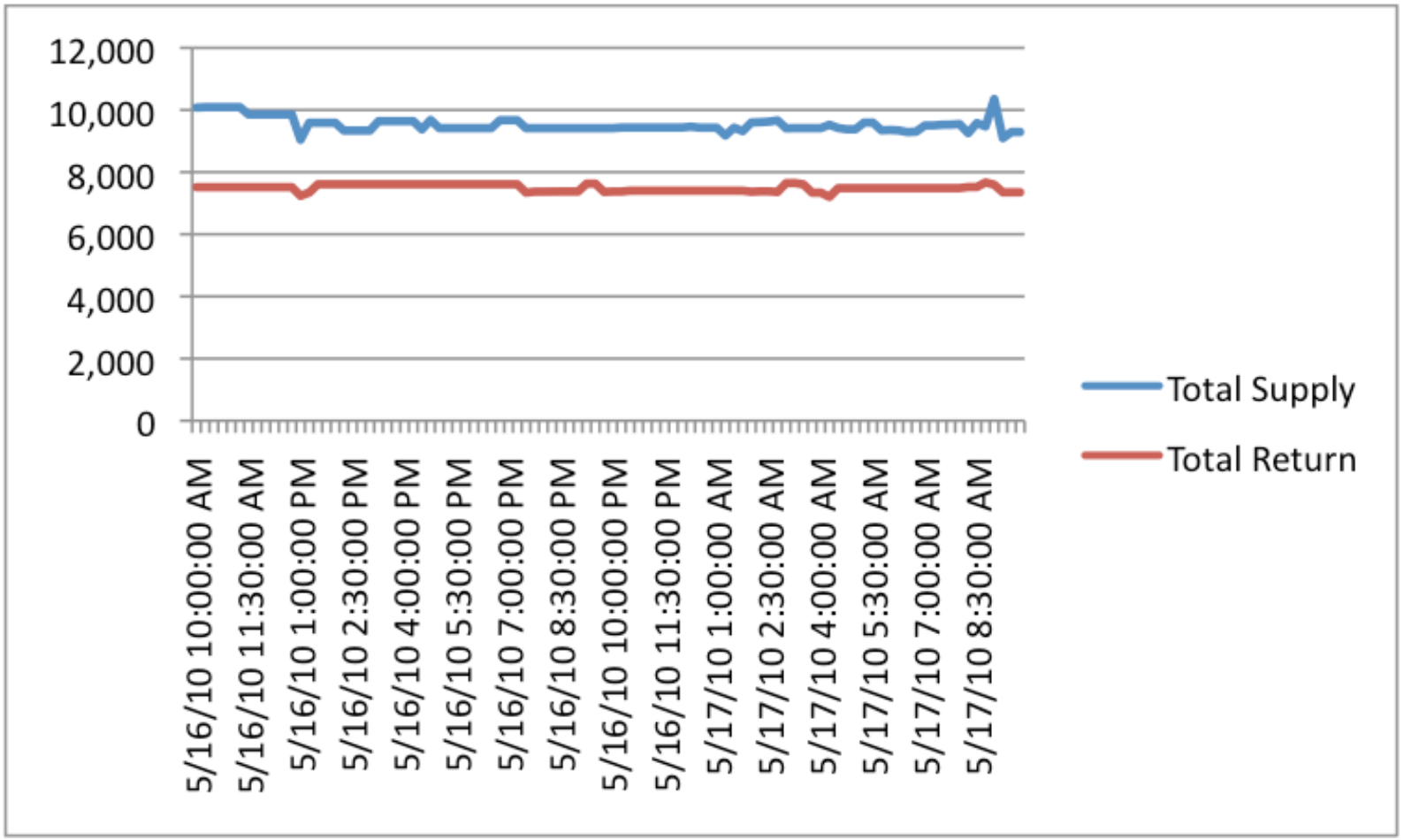
PHM AHU 3 (lobby)
20,500 CFM – max
6,800 CFM - min



PHM AHU 4 (Dietary)
20,000 CFM - max
1,485 CFM – min



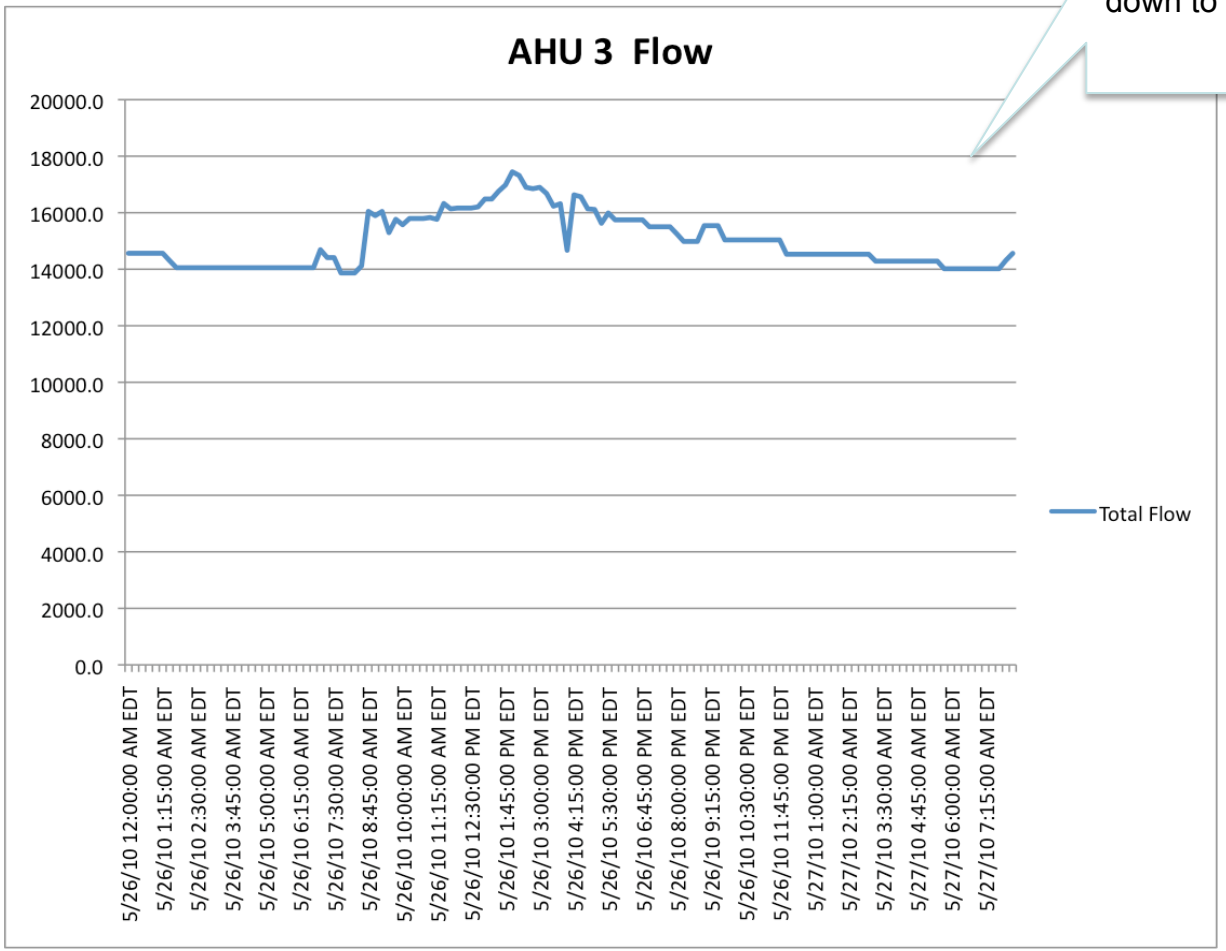
PHM AHU 6 (Administration)
16,855 CFM – max
5,500 CFM - min



RcX Study

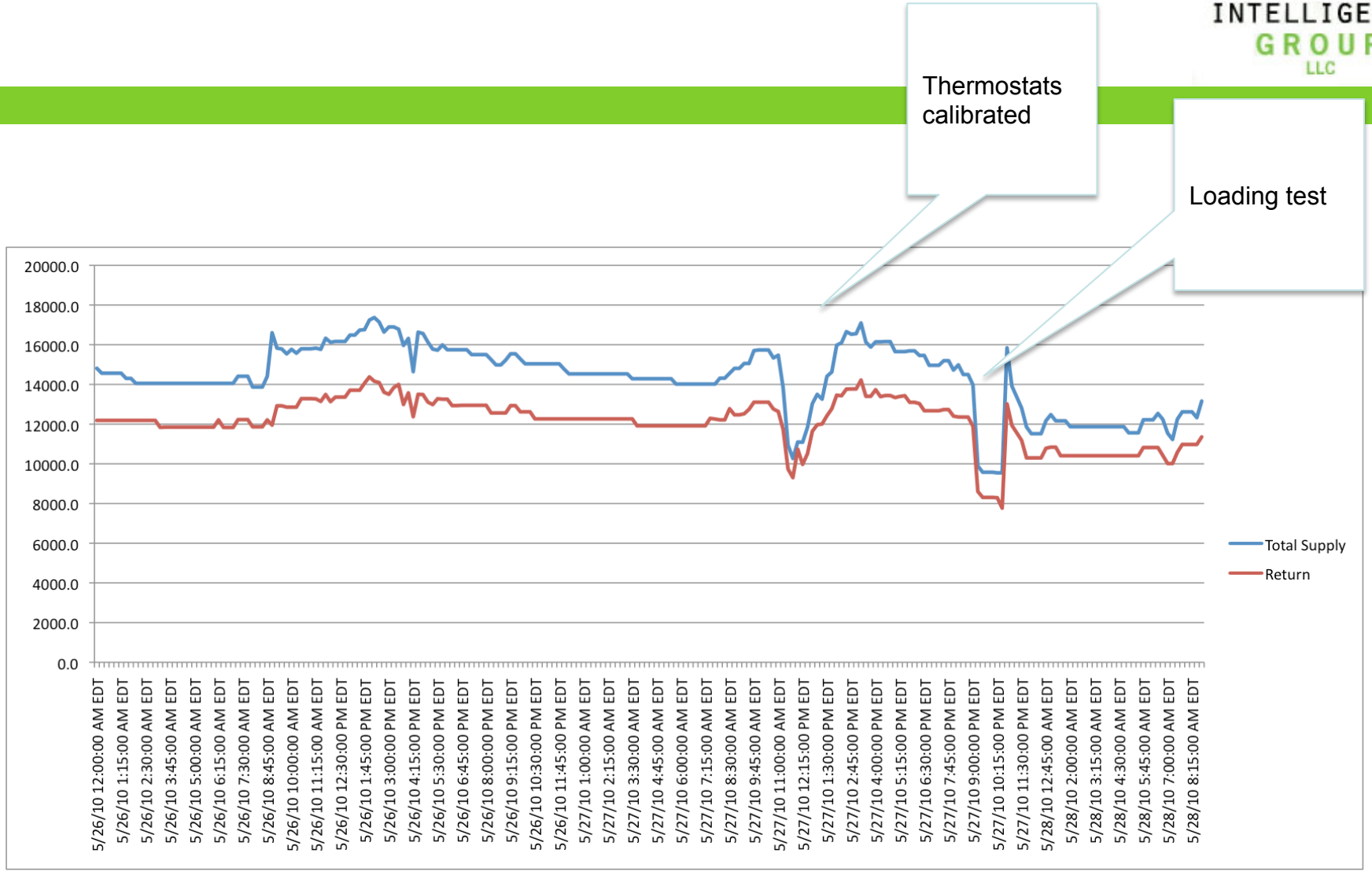
- Focus on AHU 3 (lobby unit)
  - Read all box flows
  - Re-calibrated box flow
  - Re-Calibrated pneumatic thermostats
  - Ran after hours tests to simulate light loads

AHU 3 Before Calibration



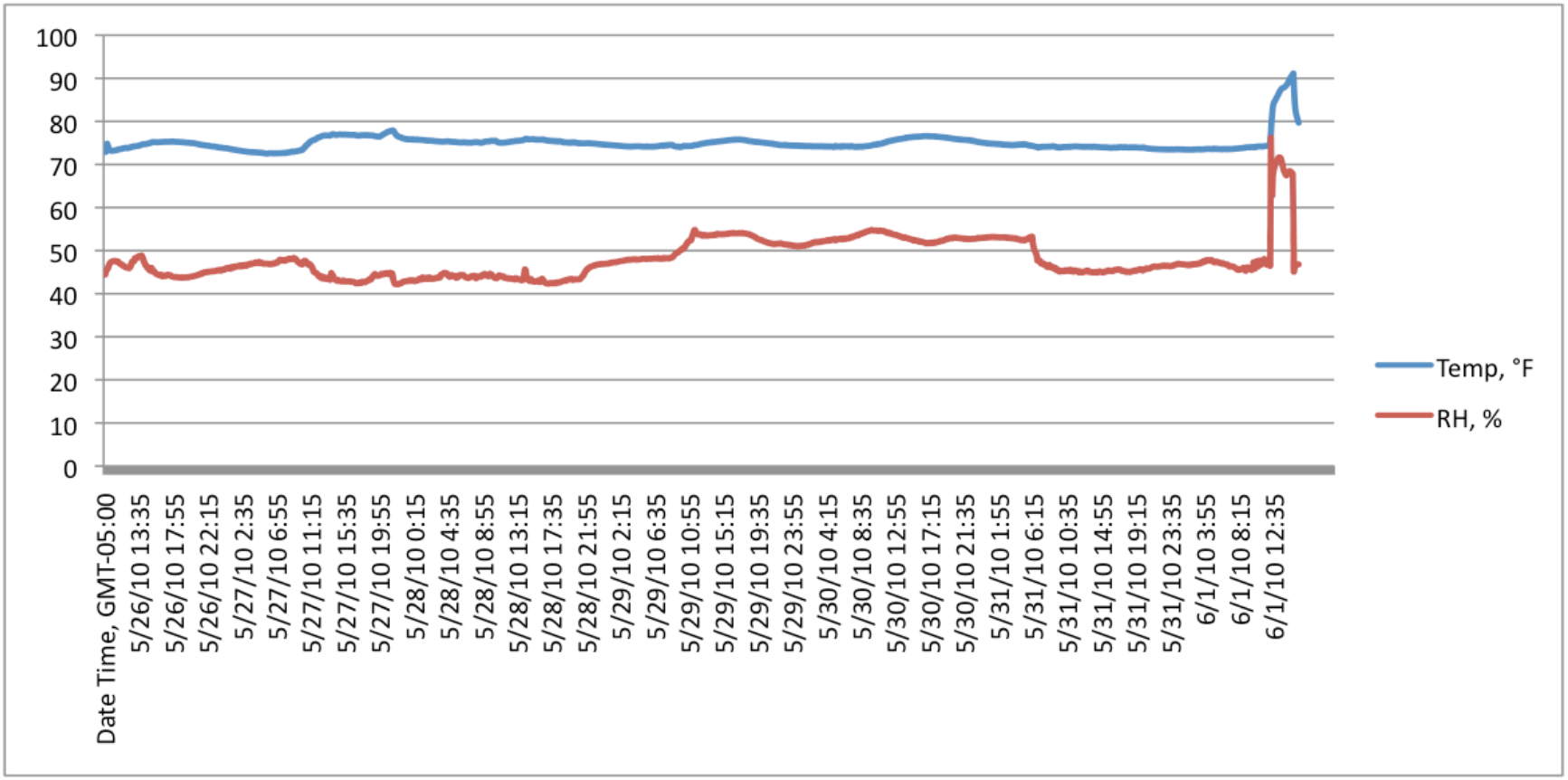
Never drops below 14,000 CFM. Design is for unit to modulate down to 6,800 CFM.

AHU 3 After Calibration

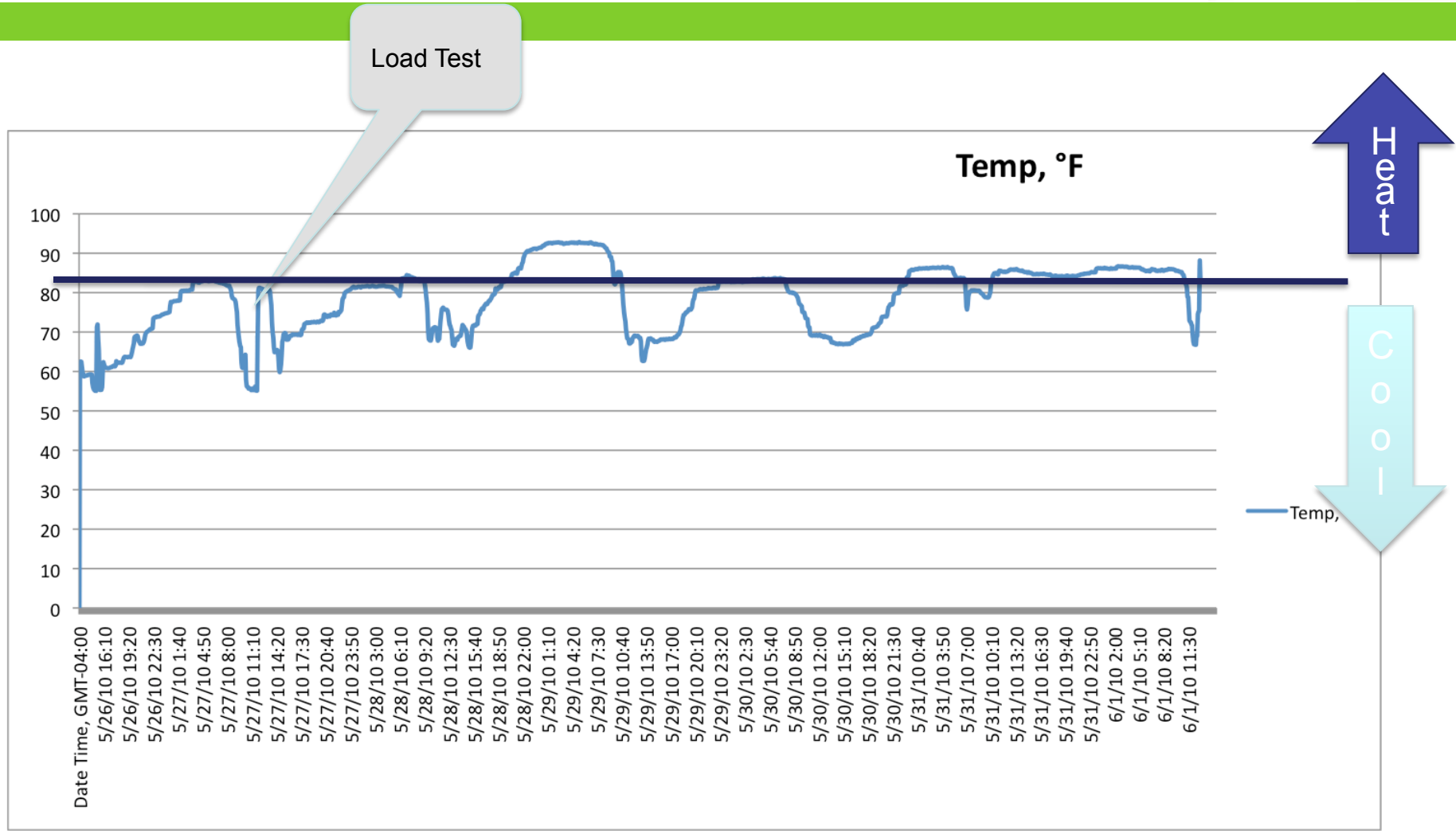


Current Trend

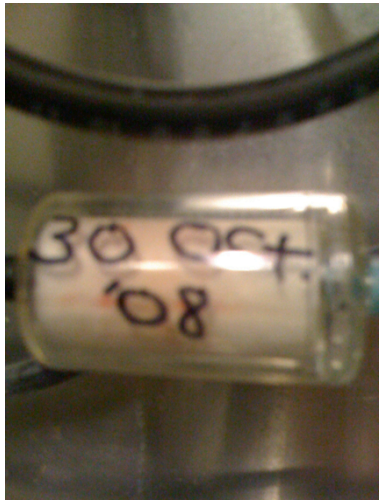
Temperature Trend

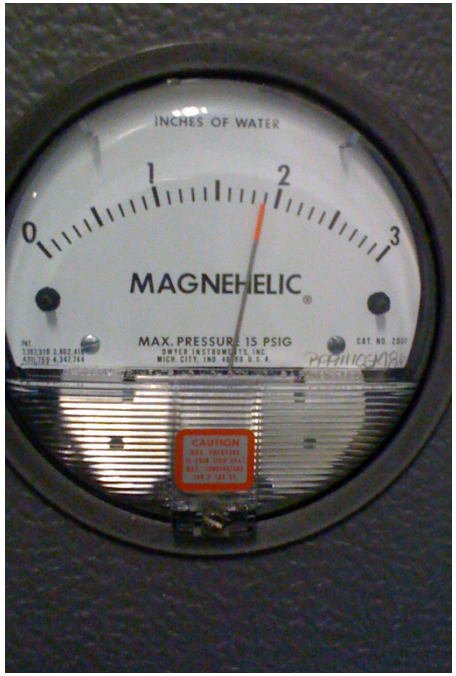


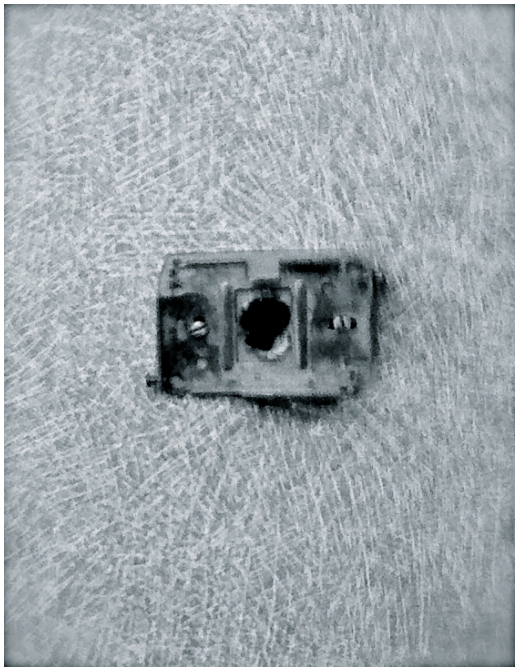
Diffuser Discharge Temp



Conditions


30 Oct
'08


INCHES OF WATER
0
1
2
3
MAGNEHELIC
MAX. PRESSURE 15 PSIG
CAUTION



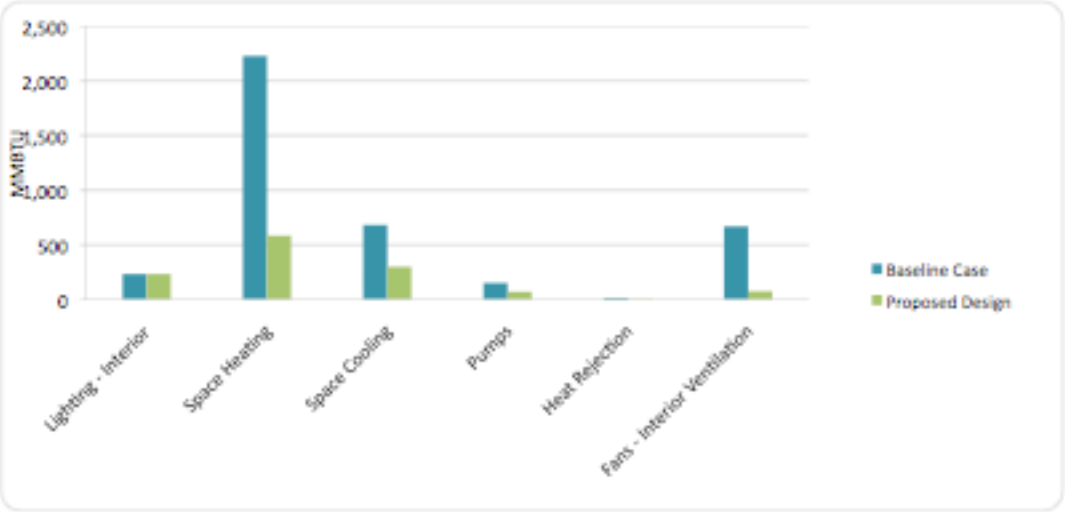
General Recommendations

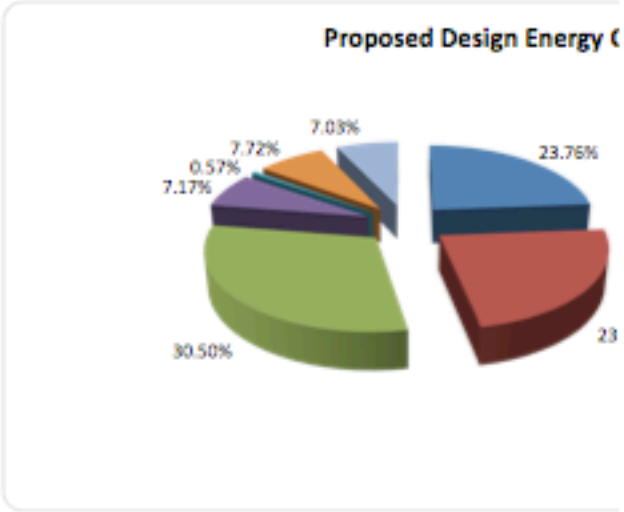
- Replace pneumatic controls with DDC
  - Contamination and calibration problems
  - Can't be optimized (reheat control, static, temperature)
  - Doesn't provide feedback to operations
  - Use of drives instead of inlet vanes
- Schedule zones or units
- Optimization

[redacted]

Presbyterian Hospital Matthew - AHU-3 Analysis
Energy Saving Measure Comparison Study

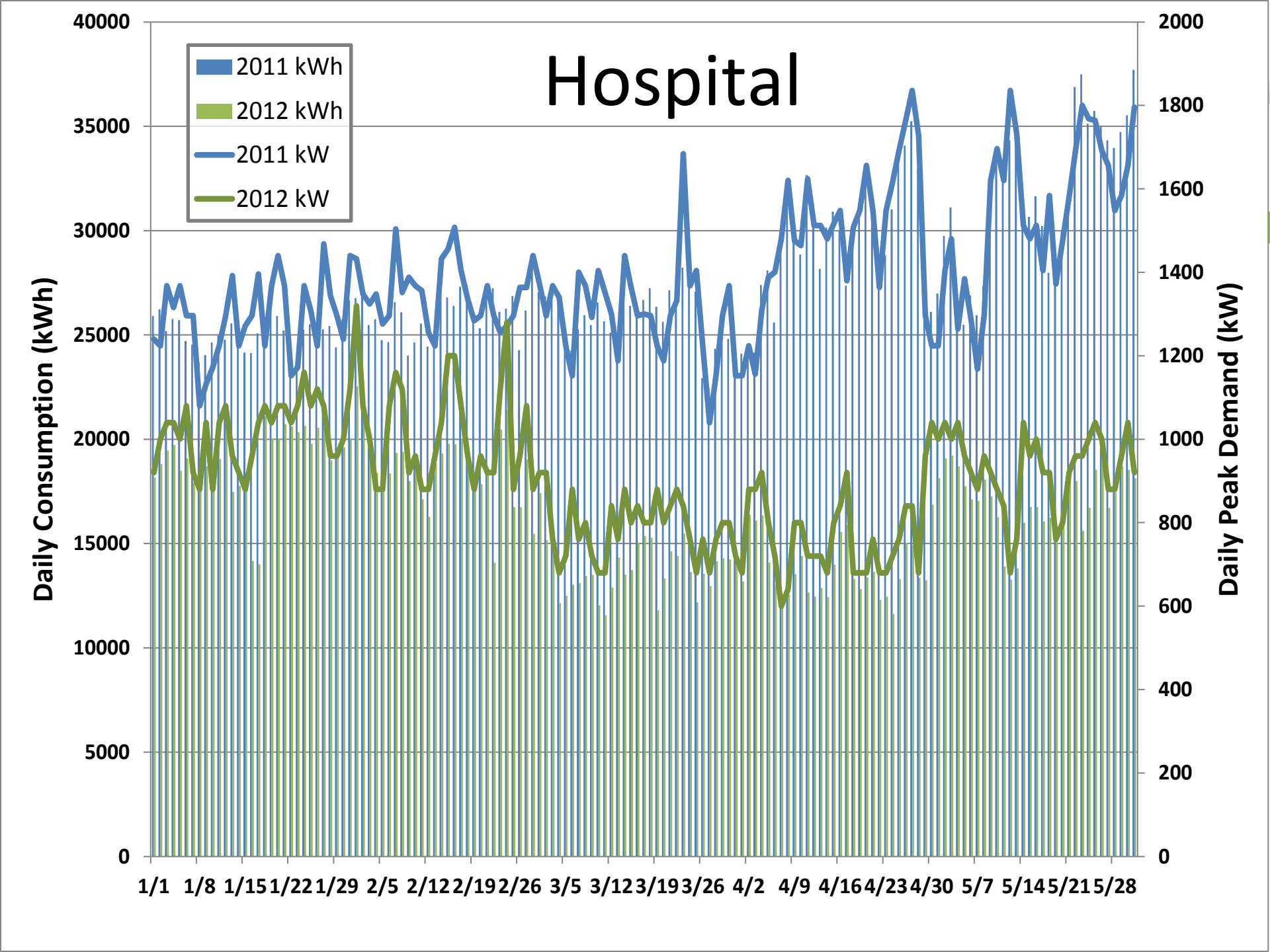
Number	Measure	Annual Electric Use kWh	Annual Electric Cost $	Annual Natural Gas Use Therms	Annual Natural Gas Cost $	Total Annual Energy Cost $	Cost Savings vs Average Base $	Percentage of Cost Savings vs Average Base %
0.00	**Baseline Case**	532,904	$30,506	22263	$19,213	**$49,719**		
	Proposed Design - All ECMs engaged	220,129	$16,626	5834	$5,035	**$21,661**	$28,058	**56.43%**
1.10	*ECM 1: Reduced Fan Operating Schedule*	366,364	$24,846	12252	$10,574	$35,420	$14,299	28.76%
1.20	*ECM 2: AHU-3 Supply Fan w/ VSD control + VAV Box Modulation*	365,426	$21,822	11393	$9,832	$31,654	$18,065	36.33%
1.30	*ECM 3: Enthalpy-based Economizer Control*	464,665	$27,872	22556	$19,465	$47,337	$2,382	4.79%





Budget

- Total controls retrofit approximately $1.6 million
- Consider a multi-year approach with a focus on energy savings for the first year
- Initial project approximately $590,000 – net after incentive $490,000


Hospital
2011 kWh
2012 kWh
2011 kW
2012 kW
Daily Consumption (kWh)
Daily Peak Demand (kW)
40000
35000
30000
25000
20000
15000
10000
5000
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/1
1/8
1/15
1/22
1/29
2/5
2/12
2/19
2/26
3/5
3/12
3/19
3/26
4/2
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28

Questions