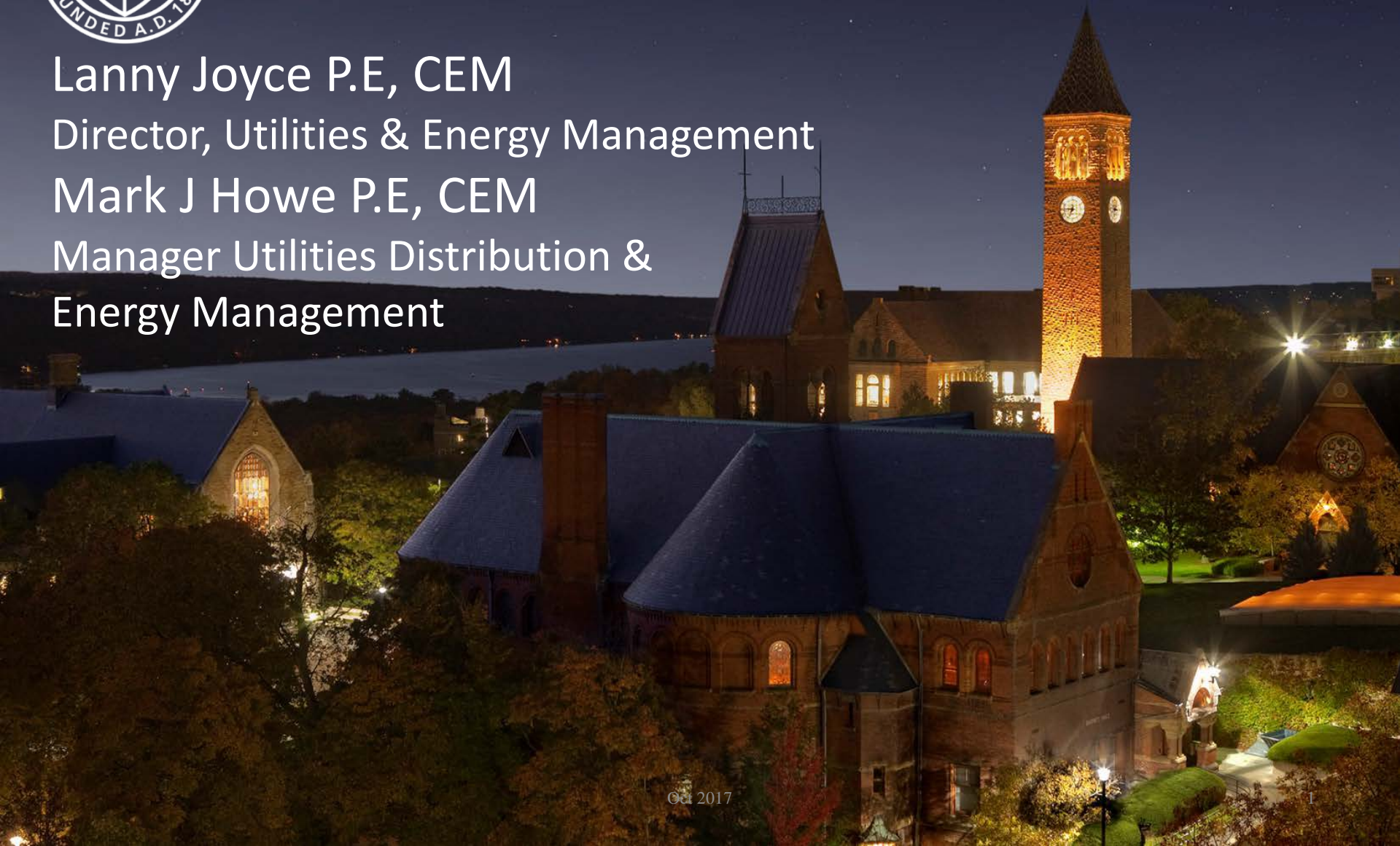# Smart Campus Summit
Energy Management Data Utilization

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Director, Utilities & Energy Management

Mark J Howe P.E, CEM

Manager Utilities Distribution &
Energy Management

Oct 2017

Agenda

- Overview of Cornell energy use

- Forecasting and Tracking Building Energy Use

- Dashboards

- Building Automation

  – Energy Management

  – Controls Systems

- Central Utility Plant

- Questions

Cornell Energy Use

Central Energy
Plant provides

Electric for about
14,000,000 GSF

Steam for
12,800,000 GSF

Cooling for
8,700,000 GSF

Cornell University District Energy

Annual Utility Budget ~ $60 million

Enterprise Units

- Electric
    - 35 MW peak
    - 200 GWh/yr
- Steam
    - 380 kpph peak
    - 1,000,000 klbs/yr
- Chilled Water
    - 25,000 Tons peak
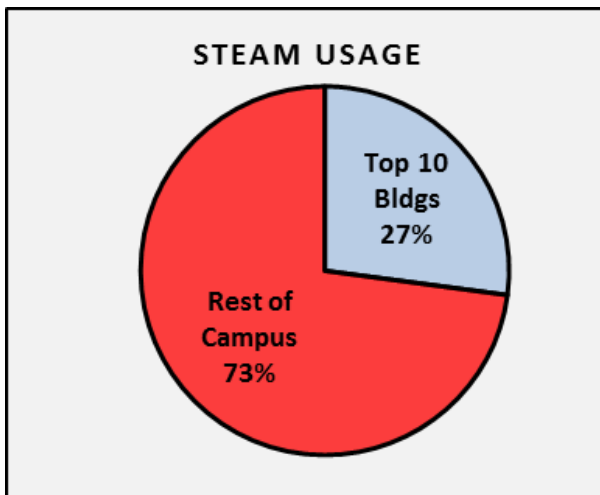   - 45,000,000 ton-hrs/yr
- Water and Sewer

Fully Metered (>1200 meters)
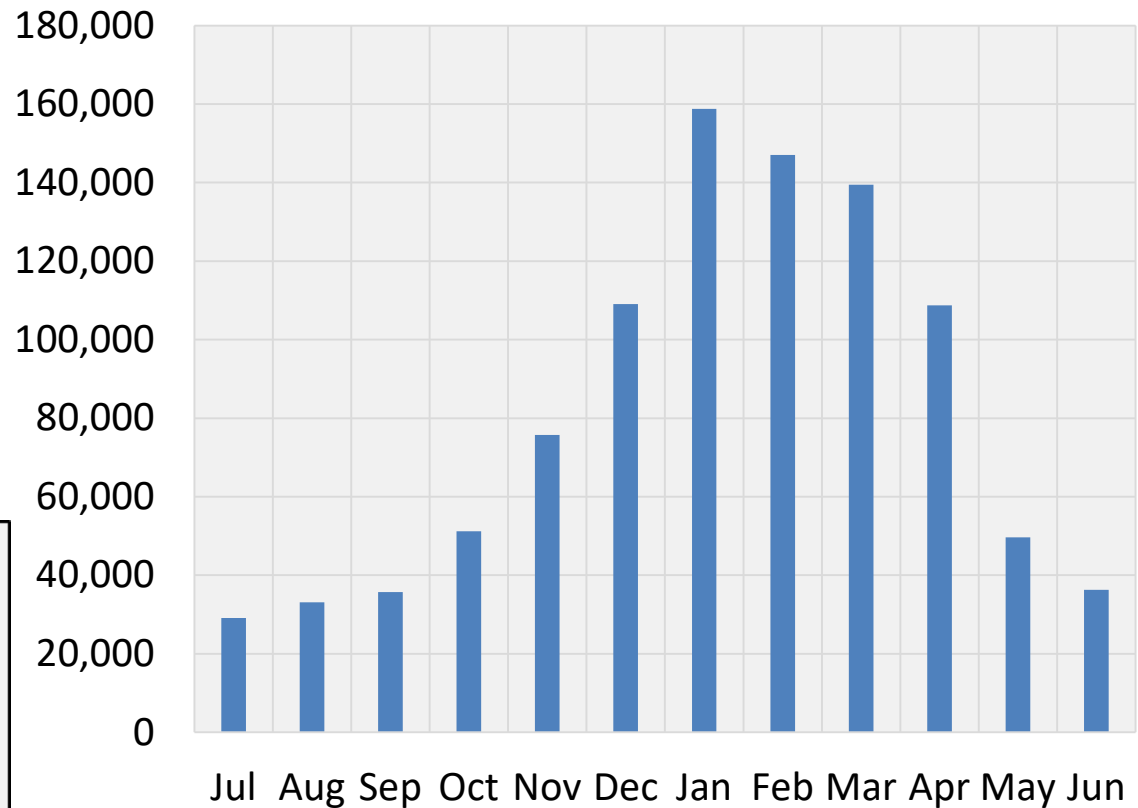
Steam Energy Use

Metered Building sales:
970,000 klbs

Steam use in summer:
Reheat; dehumidification
and process loads

Peak Hourly Steam Load:
380,000 lbs. per hour
(every minute we boil 760
gallons of water)

STEAM USAGE

Top 10 Bldgs 27%

Rest of Campus 73%

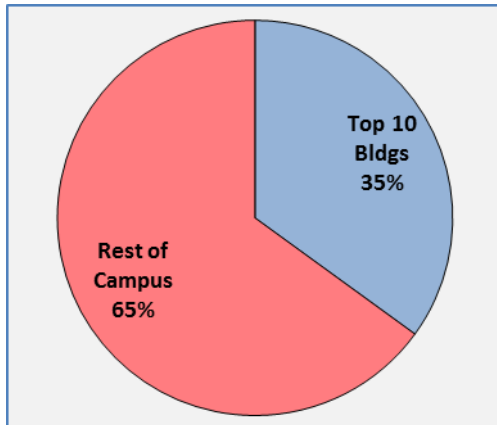Actual Steam Sales (klbs) FY15 by billing month
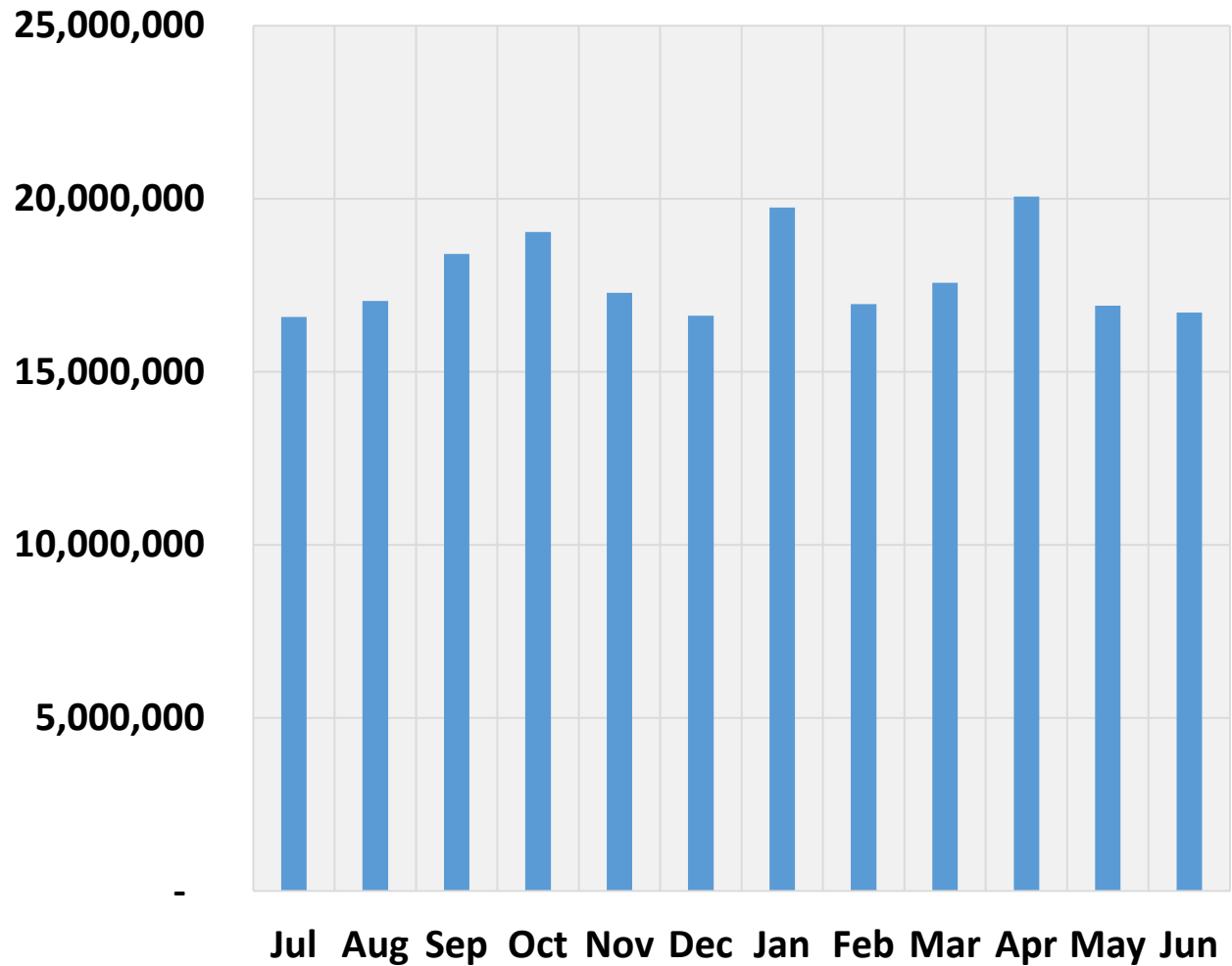
Electric Energy Use

Metered Building sales: 213 million kwh

Usage is quite flat thru out the year, average about 18 million kwh/month

Peak load is 35MW, which is about 1/1000 of the New York State peak

Top 10 Bldgs 35%

Rest of Campus 65%

Actual Electric Sales (kWh) FY15 by billing month

25,000,000

20,000,000

15,000,000

10,000,000

5,000,000

-

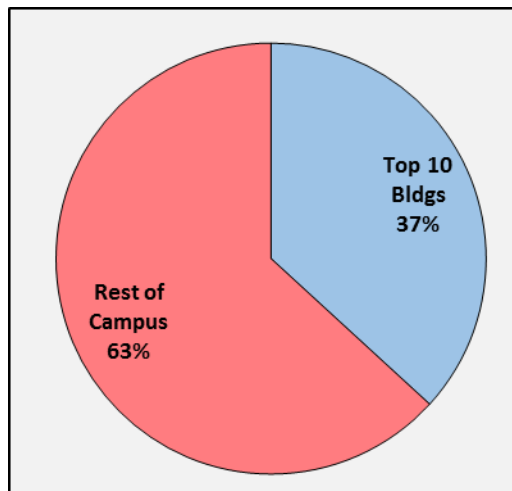Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

Chilled Water Use

Metered Building sales:
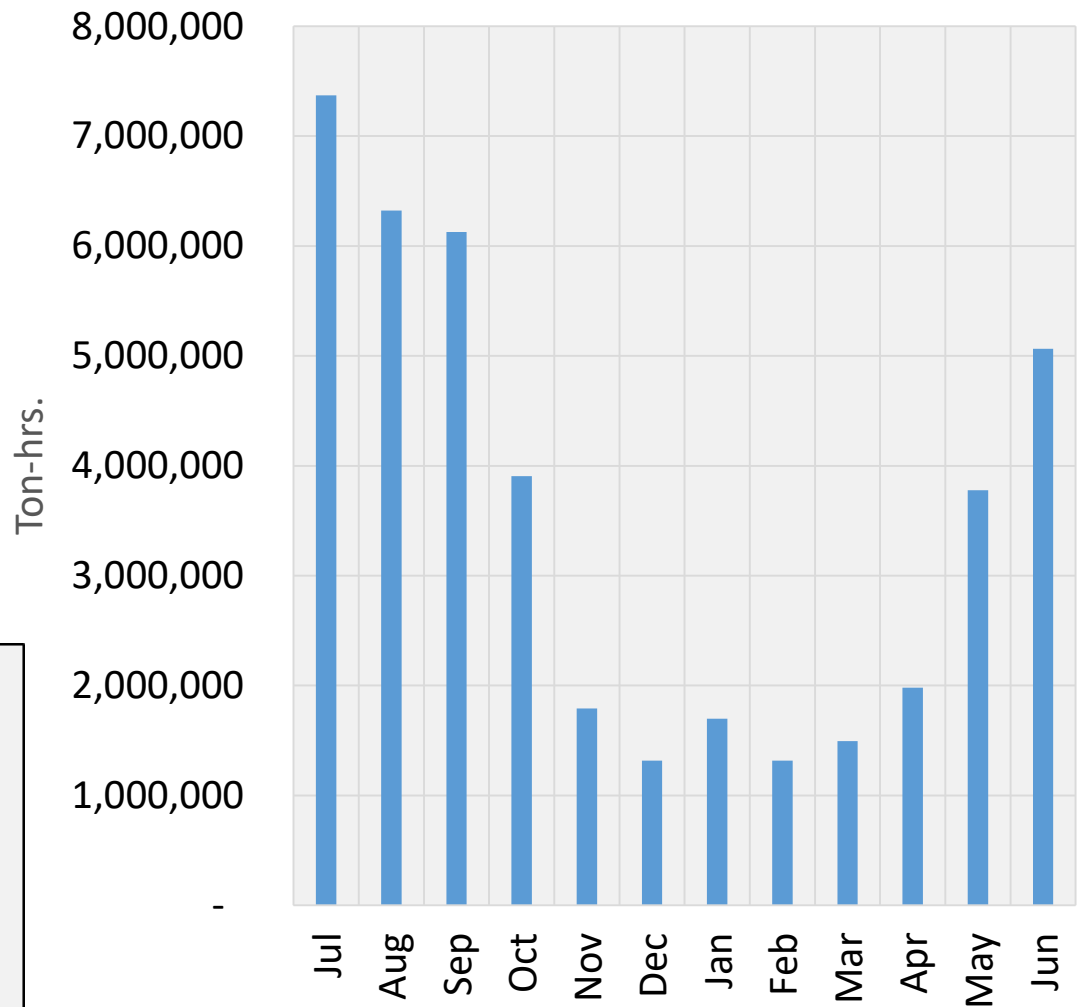42 million ton-hrs.

About 47% of usage occurs in July/Aug/Sept

Winter usage for process cooling and some space cooling

Peak load is 25,000 tons
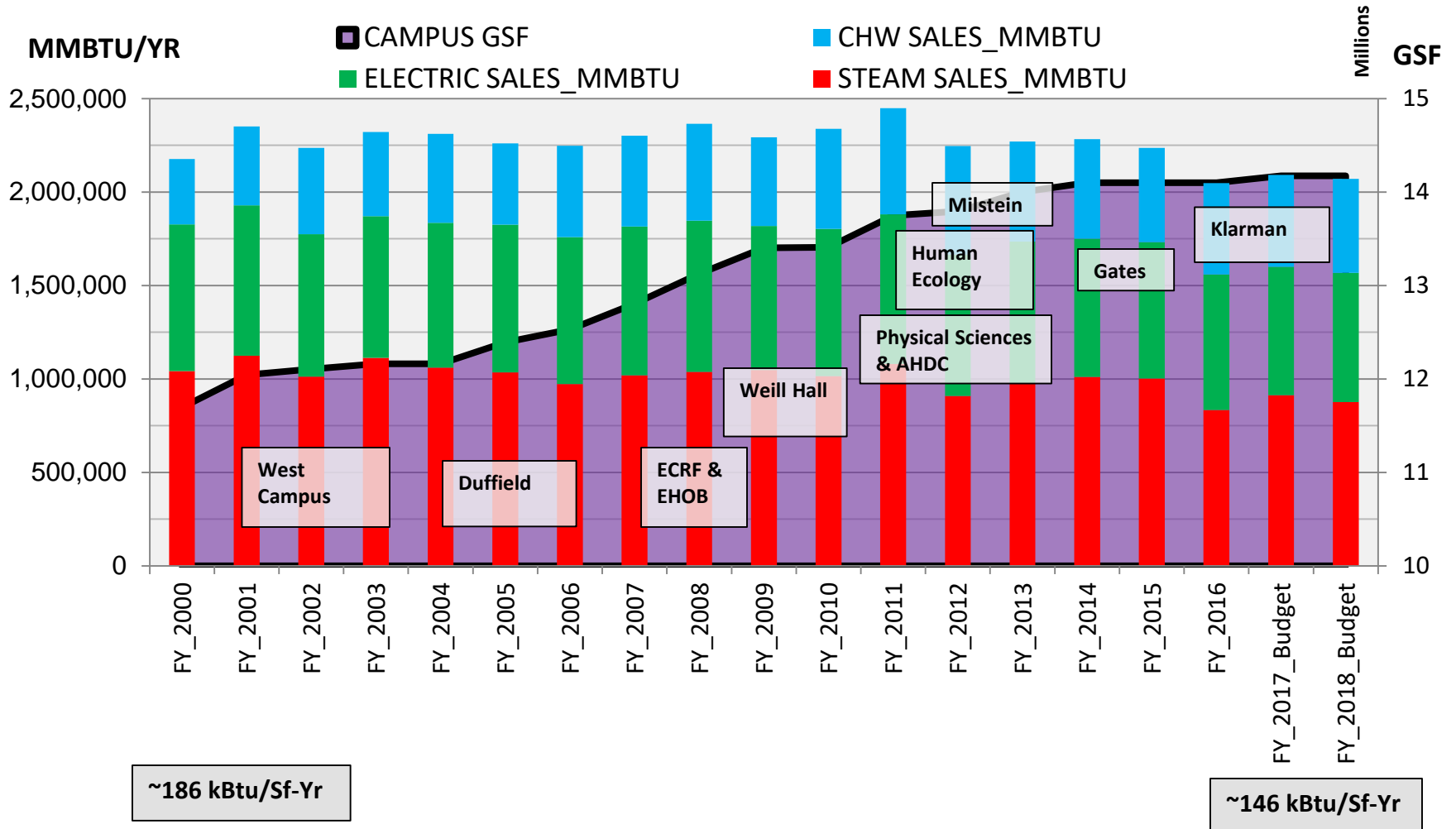(1 ton is the heat rate required to melt one ton of ice in a day)

Actuals Chilled Water Sales FY15 by billing month

Oct 2017

7

Building Energy Sales: History 2000 - 2018

ECI Project Facts:

- **Over 60 Facilities**
- **Over 90 projects**
- **Project Cost $33 million**
- **Project Savings: $6.3 million at billed rates**

ECI project savings	% energy savings from ECI project
Steam: 126,000 klbs	21%
Chilled Water: 5,000,000 ton-hrs	25%
Electric: 19,000,000 kwh	17%

Post ECI Project Billed Savings: $6.3 million

Stacked bar chart. Millions on y-axis ($- to $35).

Pre_ECI Project: Total Billed, $31.3 — Chilled Water, $5; Electric, $9; Steam, $18.

Post_ECI Project: Total Billed, $25.0 — Chilled Water, $4; Electric, $7; Steam, $14.

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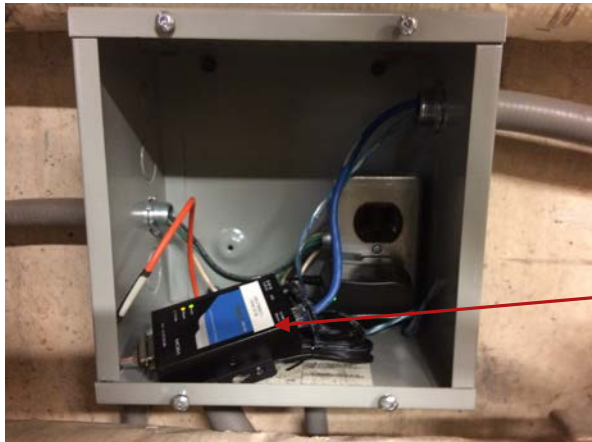
- Questions

Facility Metering
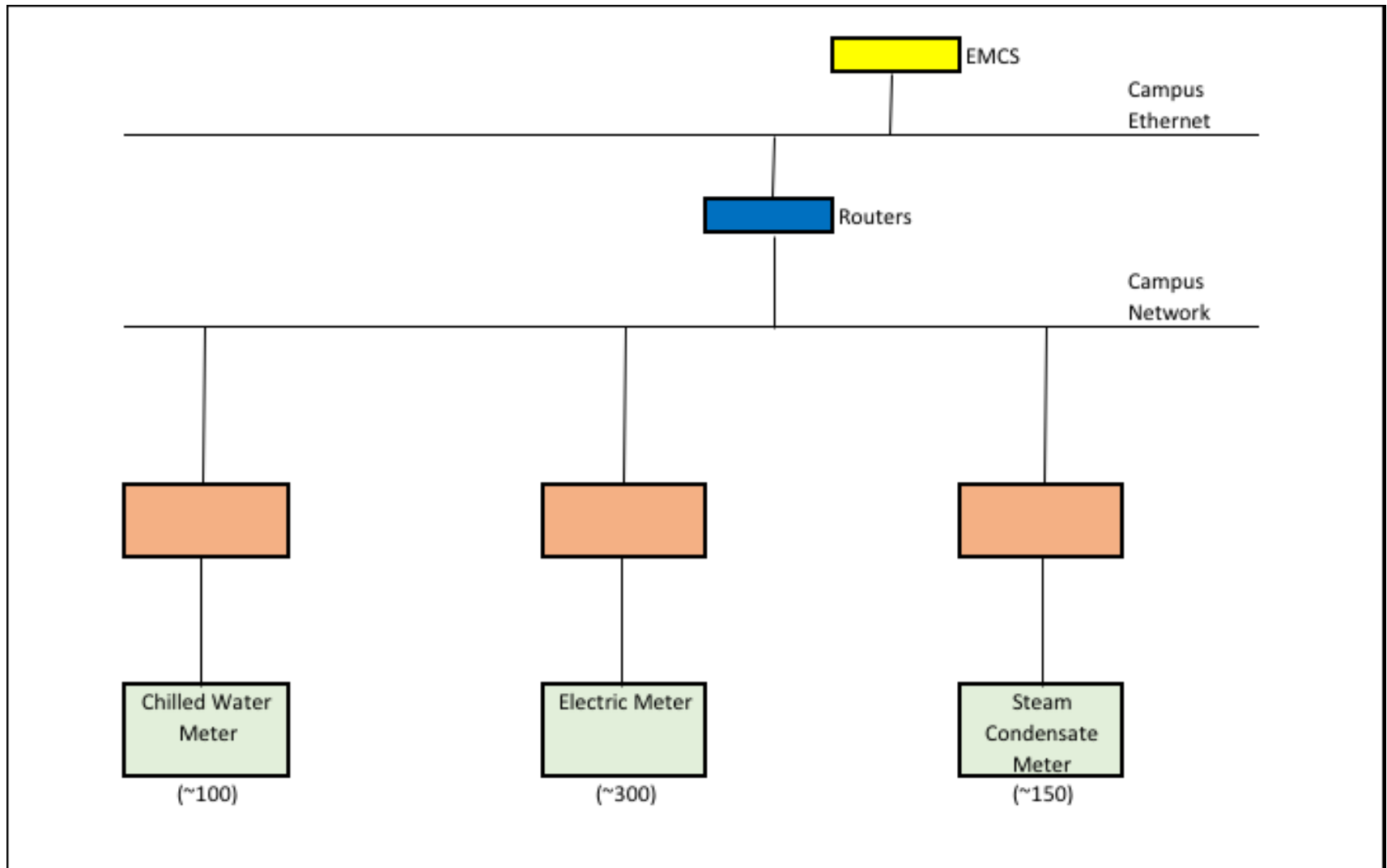
Steam Condensate Metering

Vortek Shedding Meter

Condensate meter with
Duplex pumps

MOXA Serial to
Ethernet Convertor

Chilled Water Metering

Electromagnetic Flow Element

Supply and Return temperature Sensors

Mag Flow Meter

FP93 Energy Computer

Electric Metering

PowerScout BacNet – Modbus power meter

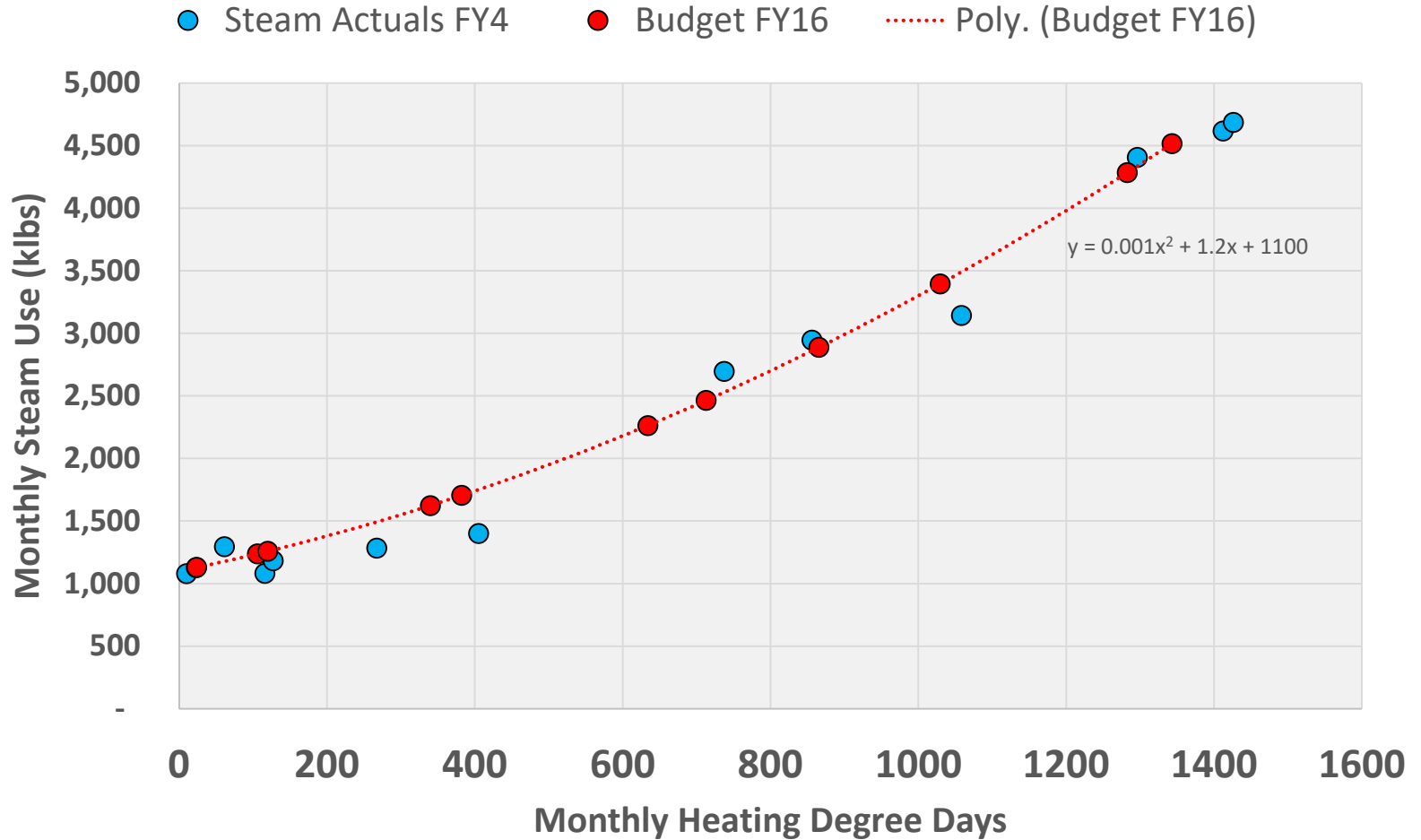MOXA Serial to Ethernet Convertor

Facility Metering

- Meters Used For:
  - Billing: eDNA, EBS, KUALI
  - Tracking Performance
  - Forecasting
  - Real Time Usage Analysis
    - Load Growth
    - Outage performance
  - Engagement
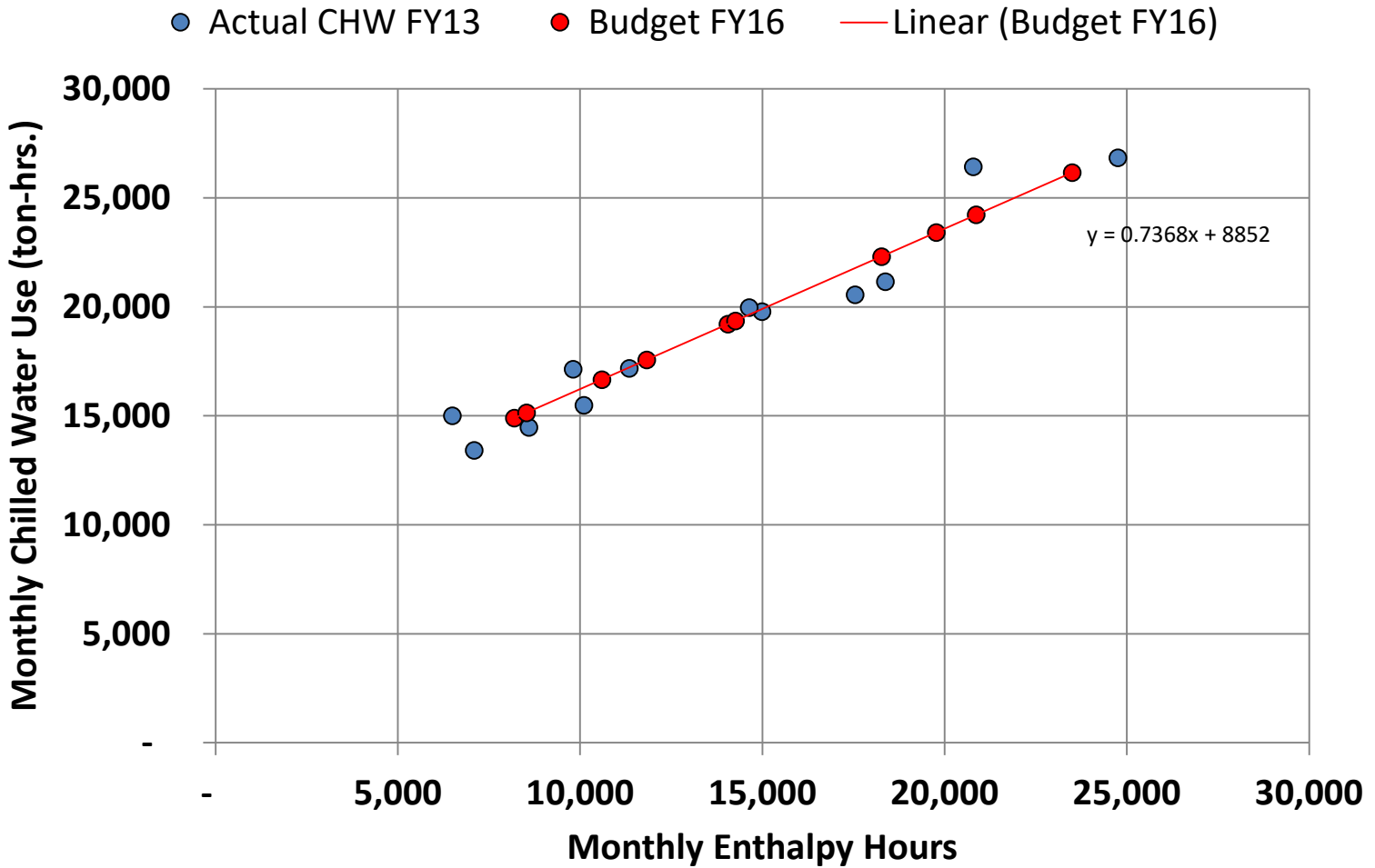
Forecasting

- Forecast is developed for each meter
  - 100 chilled water, 150 steam, 300 electric
  - Steam and chilled water require weather regression
- Reviewed / Updated each budget year based on performance.
- Track performance quarterly
- Building and Campus EUI is tracked and managed
- EUI reporting is part of online IPP metrics
- Accounts for: conservation, projects, utilization

An Example: Duffield Steam forecasting
Use FY14 to develop formula to forecast FY16

Legend: ● Steam Actuals FY4   ● Budget FY16   ⋯⋯ Poly. (Budget FY16)

X-axis: Monthly Heating Degree Days
Y-axis: Monthly Steam Use (klbs)

$y = 0.001x^2 + 1.2x + 1100$

An Example: Day Hall Chilled Water
Use FY13 to develop FY16 forecast

● Actual CHW FY13   ● Budget FY16   —— Linear (Budget FY16)

y = 0.7368x + 8852

Monthly Chilled Water Use (ton-hrs.)

Monthly Enthalpy Hours

Example – Mann Library after ECI

Chilled water:
Tracking the building performance for Mann Library, ECI efforts have significantly reduced overall building consumption

Forecasting was updated based on this new building performance, which is reflected in the FY17 budget
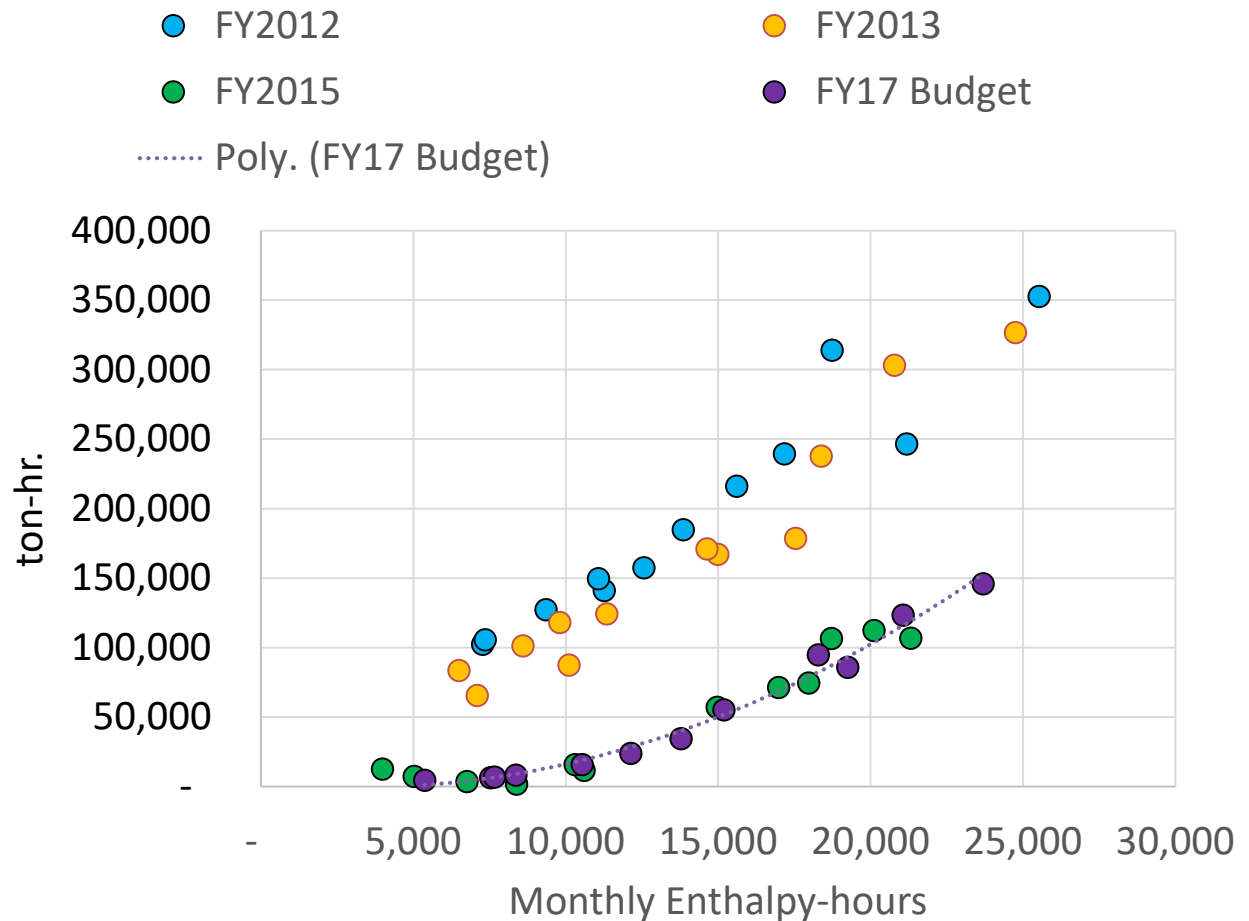
Example – Mann Library after ECI

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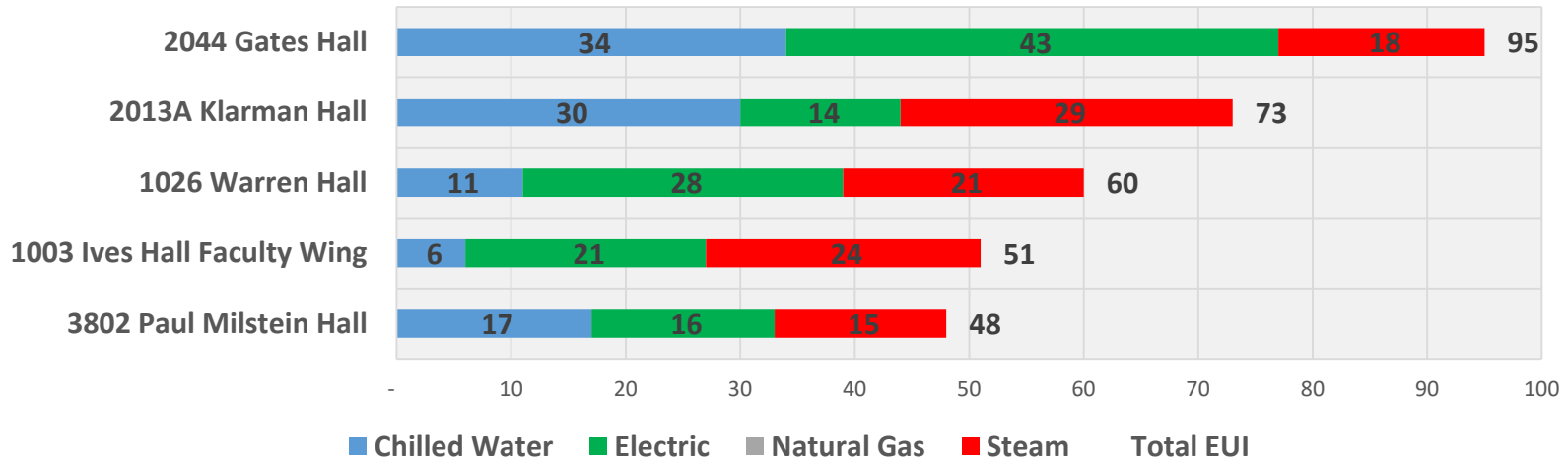
Forecasting was updated based on this new building performance, which is reflected in the FY17 budget
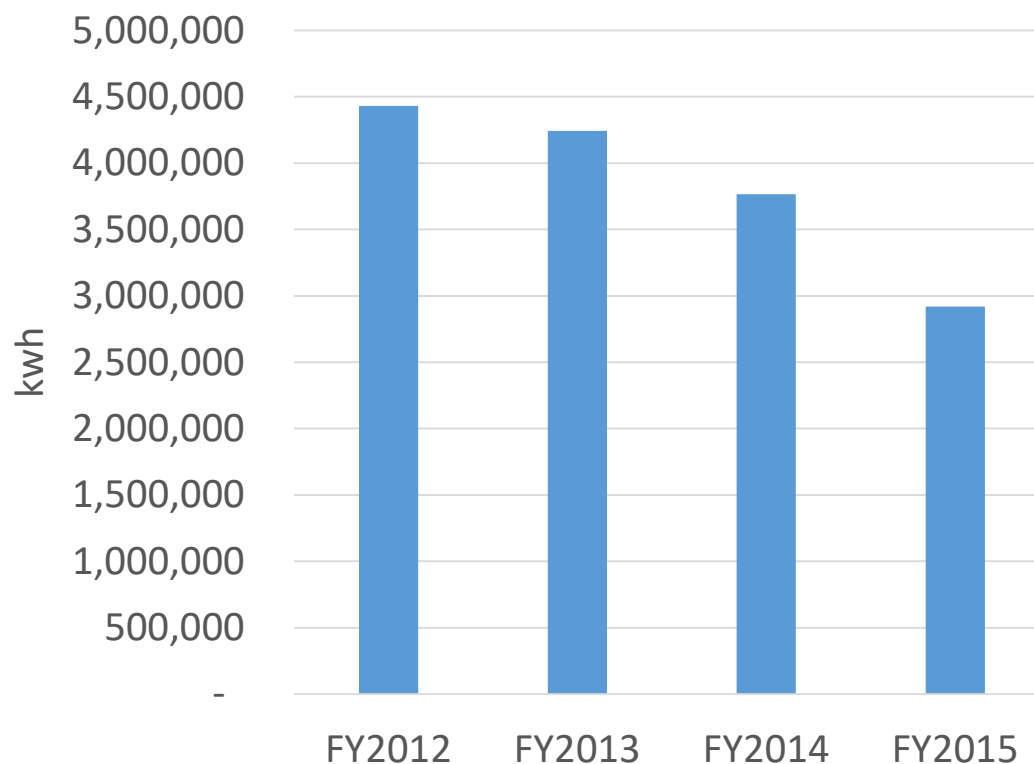
Tracking and Updating

- For Budget Forecast:
  - Review Building Performance
  - Compare actuals versus Forecasting based on the actual weather versus "typical" weather
  - Update accordingly --- Mann Library example

- During the fiscal year:
  - Review quarterly performance, comparing actuals with the original budget and the weather adjusted budget (using current year's weather).
  - Note performance outliers
  - Determine course of action:
    - Active Management
    - Have ECCT (Energy Conservation Controls Team) visit building and check set-points / schedules

New Buildings/Renovations EUI (kBTU/GSF) Office-like

Building	Chilled Water	Electric	Steam	Total EUI
2044 Gates Hall	34	43	18	95
2013A Klarman Hall	30	14	29	73
1026 Warren Hall	11	28	21	60
1003 Ives Hall Faculty Wing	6	21	24	51
3802 Paul Milstein Hall	17	16	15	48

■ Chilled Water ■ Electric ■ Natural Gas ■ Steam Total EUI

New Buildings/Renovations EUI (kBTU/GSF) Lab-like

Building	Chilled Water	Electric	Natural Gas	Steam	Total EUI
1014 Weill Hall	80	81	55	89	305
1166 NY State Vet Diagnostic Cntr	70	89		82	241
2076 Physical Sciences Building	57	59		71	187
1011 Human Ecology Building	30	49		56	135
2045 Upson Hall	7	22		62	91

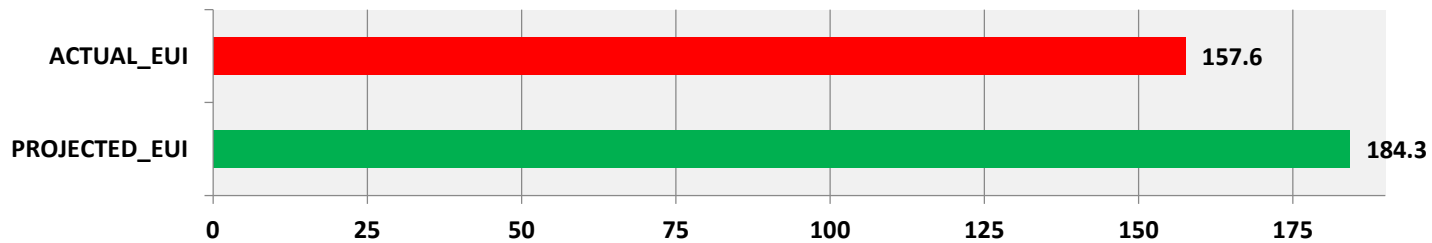■ Chilled Water ■ Electric ■ Natural Gas ■ Steam Total EUI
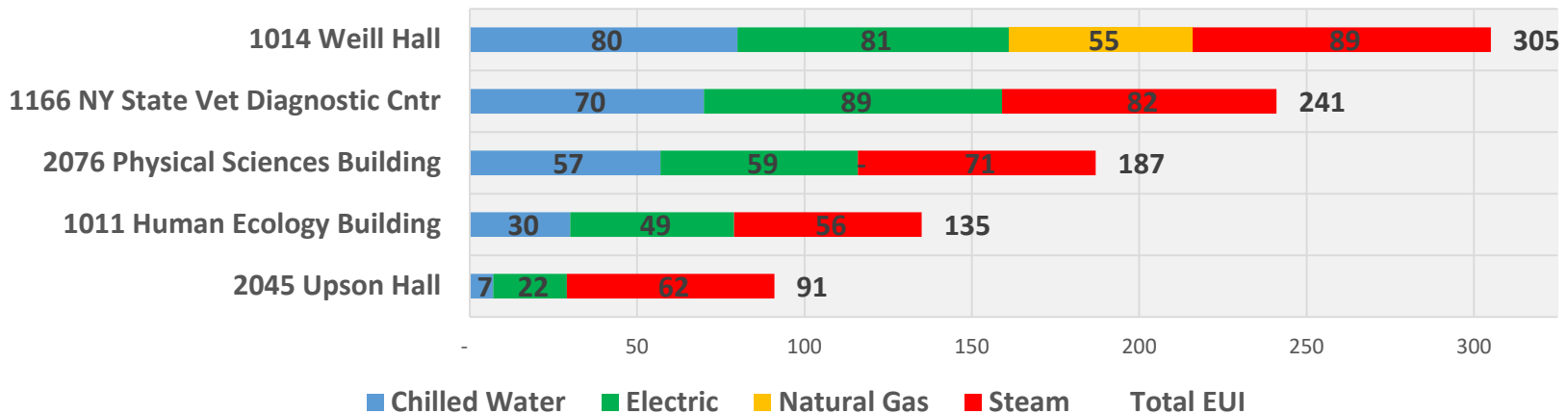
Campus EUI (kBtu/GSF)

Track performance multiple ways:

(1) pre-ECI performance versus post-ECI performance

FY15 CEP - ITHACA CAMPUS KBTU/GSF

ACTUAL_EUI	157.6
PROJECTED_EUI	184.3

0   25   50   75   100   125   150   175

(2) Actual performance versus Budget (weather adjusted)

FY15 CEP - ITHACA CAMPUS KBTU/GSF

ACTUAL_EUI	157.9
PROJECTED_EUI	165.4

0   25   50   75   100   125   150   175
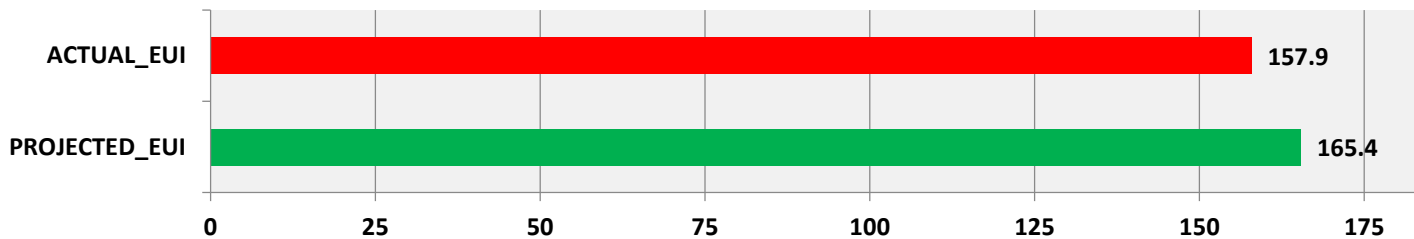
Review

- Forecast is developed for each meter
  - 100 chilled water, 150 steam, 300 electric
  - Steam and chilled water require weather regression
- Forecasts include ECI, ECCT and renovation impacts
- Reviewed / Updated each budget year based on performance.
- Track performance quarterly
- Building and Campus EUI is tracked and managed
- EUI reporting is part of online IPP metrics

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Dashboards

- Non-Techie, Eye Friendly
  - Easy to set up competitions
  - Quick look at building usage
  - Social media
  - Open to all
- SAS application
- Began 2011, converting to HTML5 in 2017

http://buildingdashboard.net/cornell/#/cornell
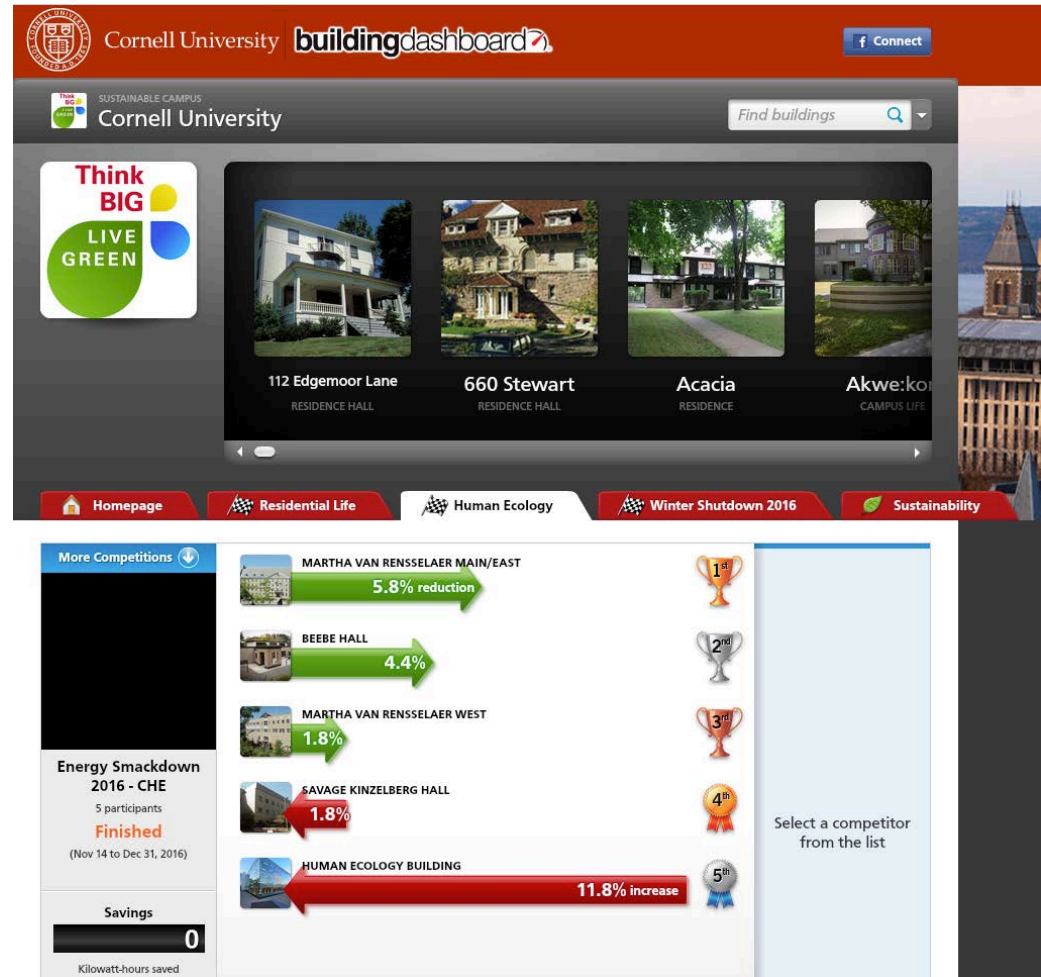
Dashboards

- EMCS Portal
  - Techie
    - Real time energy use by facility/ Utility
    - Download to CSV/Excel
    - Cornell created
    - Includes weather data
    - Open to all

http://portal.emcs.cornell.edu/
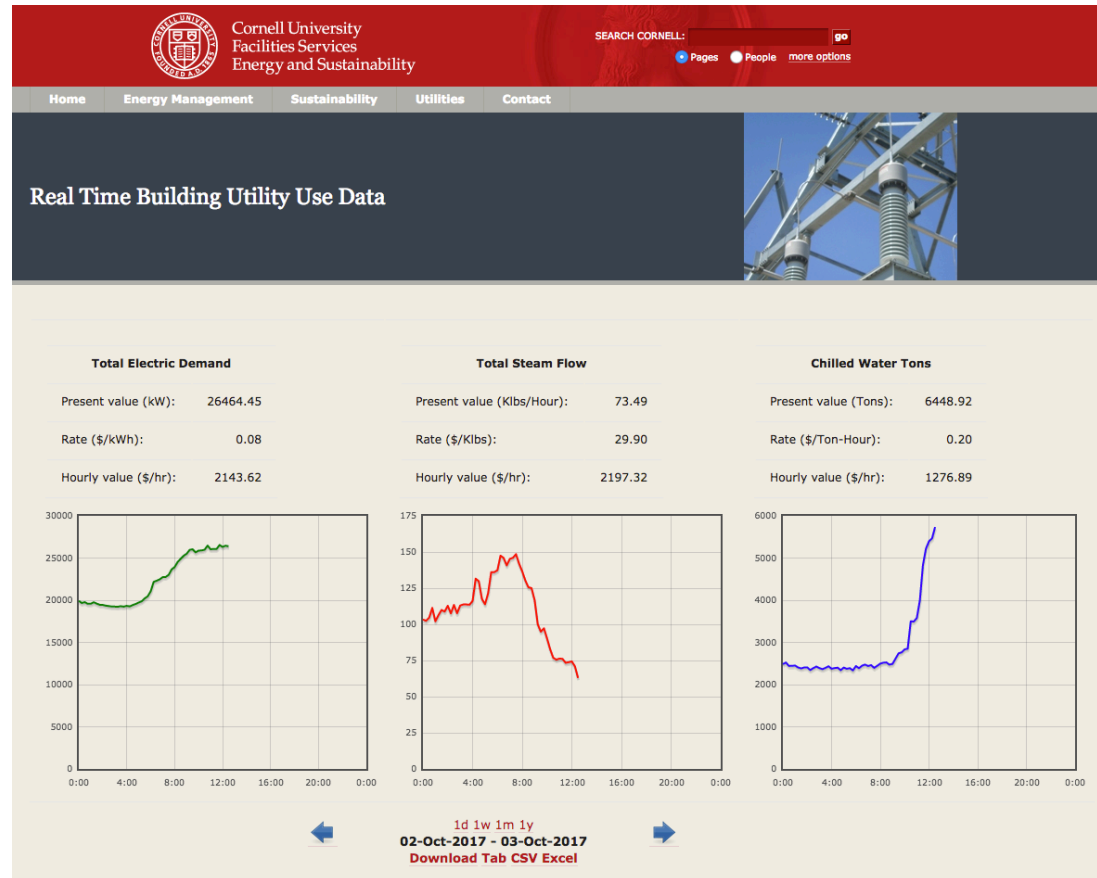
Available Campus Resources

- Electronic Billing System (EBS): instep-ebs.fs.cornell.edu/

- Real-time building energy usage via the **Energy Management Control System** (EMCS): portal.emcs.cornell.edu

- Cornell Building Dashboard: buildingdashboard.cornell.edu

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Building Automation and Control Systems

- 225 buildings with digital/microprocessor based controls
- Vendor and custom head-end databases/graphics/trends
- EMCS central alarm monitoring and response team, 24/7
- 12,500 controllers with over 1.3 million points connected
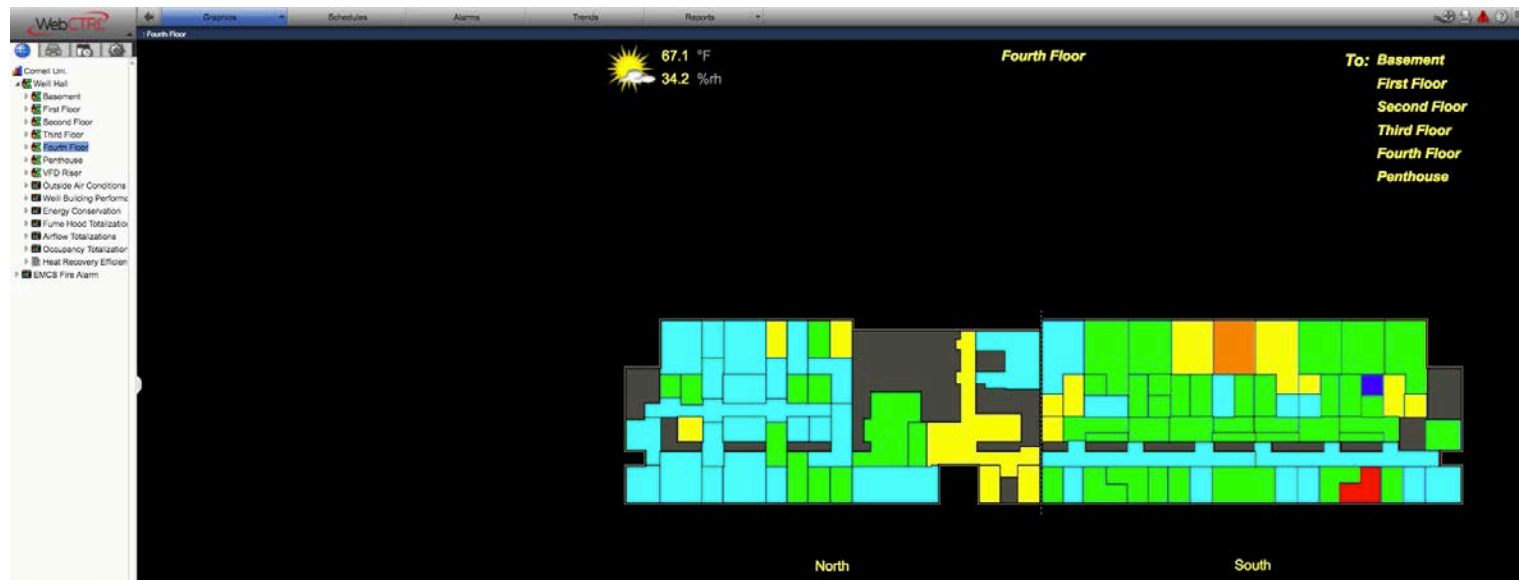
Building Automation and Control Systems

- 15 virtual servers in a redundant VM cluster with storage array

- Dedicated systems integration and development team (BACSI)

- Utility plant and building systems collaboration
  - Ability to back up each operation
  - IT and Controls staff shared resources

- Historian databases dedicated to business functions, plant ops, building controls, metering, public access

ECCT Staffing and Cost

- 10 million sq ft, 100 buildings
- 9 technicians, 1 working supervisor, .5 engineer oversight
- Highly skilled controls techs
- $1.5 million annual shop expense
- 5-15 % savings, budgeted at 8 %
- Billed cost annual savings is ~ twice cost
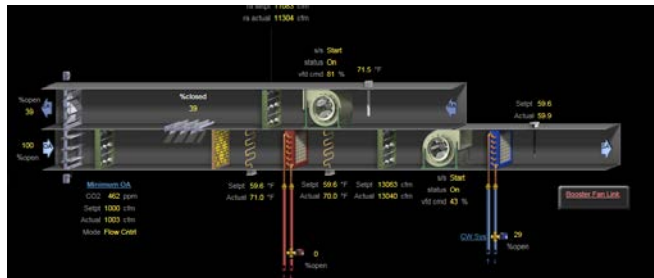
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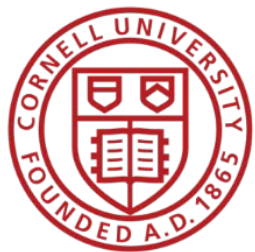
- Questions

Central Utility Plants Controls

- Central Utility Plants
  - 10 Facilities
  - PLC's
    - 20 Allen Bradly
    - 4 Square D
  - Remote I/O
    - Pressure, temperature, flow, valve position
  - Remote Devices
    - Meters
    - Transmitters w/ analog to IP conversion
  - Servers
    - 2@ water filter plant
    - 2 @ maple ave substation
    - 6 @ central energy plant
  - ~20 Workstation screens

Central Utility Plants Controls

- History and Evolution
  - Prior to 1990- Proprietary vendor, first gen
  - 1991 upgrade to second gen
  - Ethernet and PLC's introduced in 2000
  - PLC's took off ~2010 with CCHPP project, dramatically expanding the Ethernet infrastructure
  - 2010-2017 continuing evolution of network architecture and security
  - Where will we be in 2020-2030?

Questions