Smart Campus Summit
Energy Management Data Utilization

Lanny Joyce P.E, CEM
Director, Utilities & Energy Management
Mark J Howe P.E, CEM
Manager Utilities Distribution & Energy Management
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)
Metered Building sales: 213 million kWh

Usage is quite flat throughout the year, average about 18 million kWh/month

Peak load is 35MW, which is about 1/1000 of the New York State peak
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)
ECI Project Facts:
- Over 60 Facilities
- Over 90 projects
- Project Cost $33 million
- Project Savings: $6.3 million at billed rates

<table>
<thead>
<tr>
<th>ECI Project Savings</th>
<th>% Energy Savings from ECI Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam: 126,000 klbs</td>
<td>21%</td>
</tr>
<tr>
<td>Chilled Water: 5,000,000 ton-hrs</td>
<td>25%</td>
</tr>
<tr>
<td>Electric: 19,000,000 kwh</td>
<td>17%</td>
</tr>
</tbody>
</table>

Post ECI Project Billed Savings: $6.3 million

- Total Billed, $31.3
- Total Billed, $25.0

Bar chart showing:
- Pre_ECI Project
  - Steam, $18
  - Chilled Water, $5
  - Electric, $9
- Post_ECI Project
  - Steam, $14
  - Chilled Water, $4
  - Electric, $7
Agenda

• Overview of Cornell energy use
• **Forecasting and Tracking Building Energy Use**
• Dashboards
• Building Automation
  – Energy Management
  – Controls Systems
• Central Utility Plant
• Questions
Facility Metering

Diagram showing the relationship between EMCS, Routers, and various meters such as Chilled Water Meter (~100), Electric Meter (~300), and Steam Condensate Meter (~150) through Campus Ethernet and Campus Network.
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

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

Steam Actuals FY4  Budget FY16  Poly. (Budget FY16)

Oct 2017
An Example: Day Hall Chilled Water Use FY13 to develop FY16 forecast

\[ y = 0.7368x + 8852 \]
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.
Electric:
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.
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

<table>
<thead>
<tr>
<th>Building</th>
<th>Chilled Water</th>
<th>Electric</th>
<th>Natural Gas</th>
<th>Steam</th>
<th>Total EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2044 Gates Hall</td>
<td>34</td>
<td></td>
<td>43</td>
<td>18</td>
<td>95</td>
</tr>
<tr>
<td>2013A Klarman Hall</td>
<td>30</td>
<td>14</td>
<td>29</td>
<td></td>
<td>73</td>
</tr>
<tr>
<td>1026 Warren Hall</td>
<td>11</td>
<td>28</td>
<td>21</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>1003 Ives Hall Faculty Wing</td>
<td>6</td>
<td>21</td>
<td>24</td>
<td></td>
<td>51</td>
</tr>
<tr>
<td>3802 Paul Milstein Hall</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td></td>
<td>48</td>
</tr>
</tbody>
</table>

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

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

Oct 2017
Campus EUI (kBtu/GSF)

Track performance multiple ways:

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

FY15 CEP - ITHACA CAMPUS KBTU/GSF

<table>
<thead>
<tr>
<th>Actual EUI</th>
<th>Projected EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>157.6</td>
<td>184.3</td>
</tr>
</tbody>
</table>

(2) Actual performance versus Budget (weather adjusted)

FY15 CEP - ITHACA CAMPUS KBTU/GSF

<table>
<thead>
<tr>
<th>Actual EUI</th>
<th>Projected EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>157.9</td>
<td>165.4</td>
</tr>
</tbody>
</table>
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
Agenda

• Overview of Cornell energy use
• Forecasting and Tracking Building Energy Use
• Dashboards
• Building Automation
  — Energy Management
  — Controls Systems
• Central Utility Plant
• Questions
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
Agenda

• Overview of Cornell energy use
• Forecasting and Tracking Building Energy Use
• Dashboards
• Building Automation
  – Energy Management
  – Controls Systems
• Central Utility Plant
• Questions
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
Agenda

• Overview of Cornell energy use
• Forecasting and Tracking Building Energy Use
• Dashboards
• Building Automation
  – Energy Management
  – Controls Systems
• Central Utility Plant
• 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