PLUG LOADS
Mode of Operation

- Maximum Consumption (W)
  - Weekdays 9am-5pm
- Minimum Consumption (W)
  - All other times
- Reduction during school breaks
System Diagram

Plug load and lighting electricity

- **Other power**
  - Building Standby (139)
  - Emergency (189)
  - Mechanical Equip (190)
  - BNHW (194)

- **Plug load power (west)**
  - 1stFloorWest (197)
  - 2ndFloorWest (199)
  - 3rdFloorWest (201)
  - BasementWest (202)
  - Lab Equip BasementWest (193)

- **Plug load power (east)**
  - 1stFloorEast (196)
  - 2ndFloorEast (198)
  - 3rdFloorEast (200)
  - BasementEast (191)

- **Lighting power**
  - 1stFloor (186)
  - 2ndFloor (187)
  - 3rdFloor (188)
  - Basement (192)
  - Outside (195)

**Plug Loads**

393 Plug Load Current Draw (9000001)
Object Hierarchy
Plug Loads by Floor

3rd Floor:
- Unoccupied: 40,000W
- Occupied: 0 W

2nd Floor:
- Unoccupied: 3,000W
- Occupied: 6,000W

1st Floor:
- Unoccupied: 4,000W
- Occupied: 7,000W

Basement:
- Unoccupied: 10,000W
- Occupied: 15,000W

Does the plug load distribution look correct? **Yes** (with exception to the 3rd floor)

- Basement: Lots of lab equipment running day and night
- 1st floor: Most student activity, meeting rooms & offices
- 2nd floor: Slightly less student activity, meeting rooms & offices
Plug Load Zoom

3rd Floor Plug Loads

Weekend
Closer Look

Why a dip?
Object Hierarchy

Building  →  System  →  Component  →  Zone  →  Zone  →  Floor  →  Building

y2e2  →  Electrical  →  Plug Load Current Draw  →  Room 393  →  Room 393  →  3rd Floor  →  y2e2
Room 393 Plug Loads

Weekend
Group 4

LIGHTING LOADS
Mode of Operation

- Maximum Consumption (W)
  - Weekdays 9am-5pm
- Minimum Consumption (W)
  - All other times
- Reduction during school breaks
System Diagram

Plug load and lighting electricity

Other power
BuildingStandby (139)
Emergency (189)
MechanicalEquip (190)
BNHWD (194)

ServerRoom (218)
Cafe (1140)

Lighting power
1stFloor (186)
2ndFloor (187)
3rdFloor (188)
Basement (192)
Outside (195)

Plug load power (west)
1stFloorWest (197)
2ndFloorWest (199)
3rdFloorWest (201)
BasementWest (202)
LabEquipBasementWest (193)

Plug load power (east)
1stFloorEast (196)
2ndFloorEast (198)
3rdFloorEast (200)
BasementEast (185)
LabEquipBasementEast (191)

393 Lighting LoadCurrentDraw (9000002)
Sensor Malfunction

Floor Lighting Loads
3rd Floor Lighting Load

Minimum Consumption: 5kW (compared to 0kW – 2kW on 1st Floor)
Maximum Consumption: 15kW
Object Hierarchy

Building
System
Component
Zone
Zone
Floor
Building

y2e2
Electrical
393 Lighting Draw
Room 393
Room 393
Third Floor
y2e2
Room 393 Lighting Loads

Weekend
Group 4

Y2E2 ELECTRICITY DEMANDS
Y2E2 Electrical Demand

Building Yearly Demand (kW)
SCADA System Diagram

Power
From Main

Main Meter

MAIN SWBD
"MSBA"
- Mechanical
- Basement Server Room
- Future PV
- Future Fuel Cell
- Spare Lab Equipment
- 3rd Floor Plugs

MAIN SWBD
"MSBB"
- Emergency Loads
- Standby
- Basement West Plugs
- 1st West Plugs
- 2nd West Plugs

BNHWD
- Basement East Plugs
- 1st East Plugs
- 2nd East Plugs
- 3rd East Plugs
- Outside Lights and Fountains
- Basement Misc Lab Equip

BNHD
- Basement Lights
- 1st Floor Lights
- 2nd Floor Lights
- 3rd Floor Lights

1NLW5
- Cafe

Entire Building
Y2E2 Electrical Demand
2009 vs. 2011 Problem #11

• Sum of electrical sub meters << total electricity consumption
• This has been a problem, We are working with Cupertino Electric and Eaton Metering to resolve.
• This is on the Issues list
• Electrical
SCADA 2009 Data

Total Power Demand

Entire Building
SCADA 2011 Data

Total Power Demand

- Jan-2009
- Feb-2009
- Mar-2009
- April-2009

Weekend

Entire Building

kW
Data vs. Performance

Outside Lighting Electrical Demand

(float chart showing outside lighting electrical demand over a period from 1/1/2011 to 5/10/2011)

- **1:** Peak demand points
- **2:** Lower demand points
- **3:** Seasonal variation

(DateTime range: 1/1/2011 12:00:00 AM to 5/10/2011 11:59:00 PM) [60]
Data vs. Performance

Basement and 3rd Floors - Lighting Power

Date/Time
(from 3/28/2011 12:00:00 AM to 4/28/2011 11:59:00 PM) [30]

- M2: Electrical Power-Basement-Lighting Power-(1830)-[BTU/hr]
- M2: Electrical Power-3rd Floor-Lighting Power-(1829)-[BTU/hr]

Weekend Time Period
Data vs. Performance

Café Electrical Demand

Time of Day (hr)

20
15
10
5
0

25-Feb 7-Mar 17-Mar 27-Mar 6-Apr 16-Apr

PointID: 1827 - Unit: W [1] (10^3)

2
1

Café-Power
Mechanical Room Power vs. OAT
Recommendations

• Overall building electrical consumption has increased, why?
• Electrical data gives us a chance to look at overall performance (result of modes, set-points, interventions, etc.).
• Dedicate a team to decipher which loads are on each sub-meter.
• Incorporate the SCADA data into SEEIT database.
Group 4

RADIANT SLAB
Mode of Operation

- Active Components: Pump and valve
- Off if outside air temperature > 78F
- Otherwise
  - Turn on pump
  - To reach steady state:
    - Increase valve position by 10% (every 10 min) until temperature setpoint of 71F is met
    - Decrease valve position by 5% (every 10 min) until temperature setpoint of 71F is met
  - After reaching steady state: Adjust valve position by 1% (every 10 min) only
- During unoccupied hours setpoint = 66F
System Diagram

Figure 11. Schematic on sensor locations for slabs
2009 Recommendations

Problem
Radiant slab valve position is only 0 or 120% open
(should change in 10, 5 or 1% increments)

Comments
We did find problems with radiant slab in April. ISS modified programming. ISS has trended and validated sequence. Should have been identified during commissioning

Status
Completed
2009 Data

DateTime
(from 4/1/2009 12:00:00 AM to 4/13/2009 11:59:00 PM) [1]

M2:Radiant Slab-RadiantSlab-ValvePos-(6640001)-[%]
M2:Radiant Slab-RadiantSlab-SlabTempSetpoint-(1687)-[F]
2011 Data

The graph shows 2011 data from April 1st to April 13th for M2:Radiant Slab-RadiantSlab-ValvePos (new)-(1724)-[%] and M2:Radiant Slab-RadiantSlab-SlabTempSetpoint-(1687)-[F].

- **Occupied Set point** is represented by a green line.
- **Unoccupied Set point** is represented by a dashed green line.

The graph highlights certain dates, marked as "weekend" with red boxes, indicating specific periods for analysis or consideration.
2011 Data

DateTime
(from 4/11/2011 12:00:00 AM to 4/11/2011 11:59:00 PM) [1]

- M2: Radiant Slab-Radiant Slab Valve Pos (new)-(1724)-[%]
- M2: Radiant Slab-Radiant Slab Slab Temp Setpoint-(1687)-[F]

- Occupied Set point
- Unoccupied Set Point
Group 4

NATURAL VENTILATION
Modes of Operation

- Active components: Operable windows, atria damper
- Initial range for natural ventilation outside air temperature 68 – 85°F
- If outdoor temperature is within range & average space temperature > 70°F -> open dampers
  - For each zone where temperature > 70°F open operable windows
  - If zone temperature < 70°F for at least 5 min close windows again
  - If all windows around one atrium are closed also close corresponding atrium damper
- Night purge (if daytime outside air temperature exceeds 75°F)
  - During unoccupied hours open windows if outside air temperature < 65°F and space temperature > 65°F
  - Close windows if space temperature < 63°F
System Diagram

- Window Status (633)
  Window Manual Override (1706)
- Window Status (841)
  Window Manual Override (1718)
- Window Status (1892)
  Window Manual Override (1723)

- Air temp A (8860009)
  Enable Setpoint (1705)
  Disable Setpoint (1704)
- Air temp A (8200009)
  Enable Setpoint (1715)
  Disable Setpoint (1714)
- Air temp A (1720)
  Enable Setpoint (1722)
  Disable Setpoint (1721)

- Static Pressure (8180009)
  Static Pressure Setpoint (1695)

- Machinery (6397 & 840)
  Natural Ventilation

- Louvers (one per side)

- Automatic operable windows for smoke control only

- Horizontal shutters for smoke control only

- Basement

- 1st Floor
  Air temp A (1720)

- 2nd Floor
  Air temp A (8200009)
  Air temp B (837)

- 3rd Floor
  Air temp B (1685)

- Automated operable windows in private offices for smoke control only
Object Hierarchy

Building → System → Component → Zone → Zone → Floor → Building

y2e2 → Natural Ventilation → Operable Windows → Atria A → Atria A → First Floor → y2e2

1st & 2nd Floor Night Purge
Yearly Use of Natural Ventilation
Problem
Night purge on the 1st and 2nd floor seems to be on a regular schedule rather than dependent on outside and inside temperatures

Comments
ISS has modified night flush programming.

Status
Completed
2009 Data

1st & 2nd Floor Night Purge
2009 Data Zoomed In

2009 Natural Ventilation
(Atrium A&B, 1st Floor)

Closed

Open

Date Time
(from 9/9/2009 12:00:00 AM to 9/10/2009 11:59:00 PM) [1]

1st & 2nd Floor Night Purge
2011 Data

2011 Natural Ventilation
(Atrium A&B, 1st Floor)

1. Closed
2. Open
3. 12:00 AM to 31-Mar 00:00
4. 31-Mar 00:00 to 2-Apr 00:00

Date/Time
(from 3/27/2011 12:00:00 AM to 4/2/2011 11:59:00 PM)
2011 Data Zoomed In

2011 Natural Ventilation
(Atrium A&B, 1st Floor)

Date/Time
(from 4/1/2011 12:00:00 AM to 4/2/2011 11:59:00 PM) [1]

1st & 2nd Floor Night Purge
2009 vs. 2011 Problems #22

Problem
Purge on 3rd floor seems random and does not follow control strategy

Comments
ISS has modified night flush programming.

Status
Completed
2009 Data

DateTime
(from 5/5/2009 12:00:00 AM to 5/24/2009 11:59:00 PM) [1]

- M2:Atrium A&B-AtriumA&B (3)-WindowsOpen-(1692)-[]
- M2:Atrium A&B-AtriumA (3)-SpaceTemp-(8880009)-[F]
- M2:AHU1-AHU1-OutsideAirTemp-(1123)-[F]
2009 Data

Graph showing data from 16-May 00:00 to 18-May 00:00 with DateTime (from 5/5/2009 12:00:00 AM to 5/24/2009 11:59:00 PM) [1].

Legend:
- M2:Atrium A&B-AtriumA&B (3)-WindowsOpen-(1692)-[]
- M2:Atrium A&B-AtriumA&B (3)-SpaceTemp-(8880009)-[F]
- M2:AHU1-AHU1-OutsideAirTemp-(1123)-[F]

Annotations:
1. Closed
2. Open

3rd Floor Night Purge
2011 Data

Date Time
(from 3/8/2011 12:00:00 AM to 4/7/2011 11:59:00 PM) [1]

- M2:Atrium A&B-AtriumA&B (3)-WindowsOpen-(1692)-[]
- M2:Atrium A&B-AtriumA (3)-SpaceTemp-(8880009)-[F]
- M2:AHU1-AHU1-OutsideAirTemp-(1123)-[F]
2011 Data

DateTime
(from 3/8/2011 12:00:00 AM to 4/7/2011 11:59:00 PM) [1]

- M2:Atrium A&B-AtriumA&B (3)-WindowsOpen-(1692)-[]
- M2:Atrium A&B-AtriumA (3)-SpaceTemp-(8880009)-[F]
- M2:AHU1-AHU1-OutsideAirTemp-(1123)-[F]

3rd Floor Night Purge
RADIANT SLAB HEATING & NIGHT PURGE COOLING SIMULTANEOUSLY
Warning!

• **Night Purge**
  - During unoccupied hours windows open if outside air temperature < 74°F (not 65) and space temperature > 74°F (not 65).
  - Windows Close when space temperature < 65°F (not 63)

• **Radiant Slab**
  - Radiant Slab is Heating when Temperature drops below 68.5°F (not 66)
  - Sets up possible case for simultaneous Heating and Cooling of the 1st Floor Atrium given daytime outside air temperature exceeds 75°F to activate Night Purge

Data Manual - Design

Current

Recommendation
May 9th

Date Time
(from 5/9/2011 12:00:00 AM to 5/14/2011 11:59:00 PM) [1]

- M2: Radiant Slab-Radiant Slab-Slab Temp Setpoint (1687) [F]
- M2: Atrium A&B-Atrium A (1)-Space Temp (1720) [F]
- M2: AHU1-AHU1-Outside Air Temp (1123) [F]
- M2: Atrium A&B-Atrium A&B-Zone Night Purge Setpoint (1782) [F]
- M2: Radiant Slab-Radiant Slab-Valve Pos (new) (1724) [\%]
- M2: Atrium A&B-Atrium A&B (1)-Windows Open (633) [ ]
May 16th

Date Time
(from 5/16/2011 12:00:00 AM to 5/20/2011 11:59:00 PM) [1]

- M2: Radiant Slab - Radiant Slab Temp Setpoint (1687) [F]
- M2: Atrium A&B - Atrium A (1) Space Temp (1720) [F]
- M2: AHU1 - AHU1 Outside Air Temp (1123) [F]
- M2: Atrium A&B - Atrium A&B Zone Night Purge Setpoint (1782) [F]
- M2: Radiant Slab - Radiant Slab Valve Pos (new) (1724) [%]
Date Time
(from 4/4/2011 12:00:00 AM to 4/4/2011 11:59:00 PM) [1]

- M2: Radiant Slab - RadiantSlab - SlabTempSetpoint - (1687) - [F]
- M2: Atrium A&B - AtriumA (1) - SpaceTemp - (1720) - [F]
- M2: AHU1 - AHU1 - OutsideAirTemp - (1123) - [F]
- M2: Atrium A&B - AtriumA&B - Zone Night Purge Setpoint - (1782) - [F]
- M2: Radiant Slab - RadiantSlab - ValvePos (new) - (1724) - [%]
- M2: Atrium A&B - AtriumA&B (1) - WindowsOpen - (633) - [ ]
Group 4

MAIN CHILLED WATER CONSUMPTION
System Diagram

Chilled Water Consumption
Hierarchy

Building  System  Component  Zone

Y2E2  Chilled Water Loop  Zone

Floor  Building

Atria A  First Floor  y2e2
Chilled Water 9-5

Chilled Water Consumption

- Cooling [BTU]
- Temperature [F]

Graphs showing simulated, measured, and outside air temperature data over a period from 3/31/07 to 4/7/07. Key points marked with circles and arrows.
Difference in Simulated Schedules

Cooling [BTU]

Date
3/31/07 0:00 4/1/07 0:00 4/2/07 0:00 4/3/07 0:00 4/4/07 0:00 4/5/07 0:00 4/6/07 0:00 4/7/07 0:00

Chilled Water Consumption
Chilled Water 24/7 with Higher Set Point
Zoomed In Graph

Chilled Water Consumption
### Carbon Abatement

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/7 (simulated higher setpoint)</td>
<td>42,170,972</td>
<td>BTU</td>
</tr>
<tr>
<td>24/7 (simulated lower setpoint)</td>
<td>41,648,273</td>
<td>BTU</td>
</tr>
<tr>
<td>Energy Use Difference</td>
<td>522,699</td>
<td>BTU/week</td>
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<tr>
<td>Energy Use Difference</td>
<td>153</td>
<td>kwh/week</td>
</tr>
<tr>
<td>Saved Energy Per Year</td>
<td>1,838.33</td>
<td>kwh/yr</td>
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<tr>
<td>CO2/yr</td>
<td>2,389.83</td>
<td>lbs</td>
</tr>
<tr>
<td>Estimated cost</td>
<td>$1,000.00</td>
<td>dollars</td>
</tr>
<tr>
<td>Cost per lb carbon/yr</td>
<td>$0.42</td>
<td>dollars/lb CO2</td>
</tr>
<tr>
<td>Cost per lb carbon/2 yr</td>
<td>$0.21</td>
<td>dollars/lb CO2</td>
</tr>
</tbody>
</table>

- High cost per lb of CO2 savings
  - Probably not worth changing
Carbon Abatement

$0.42/lb CO2 savings
High cost/energy savings = low priority
Teach me how to Wiki

• Purpose of our Wiki:
  • Easily allows multiple users to edit and update data on a webpage
  • Allows us to compile all our work from the quarter in one spot so that future users can easily access what some of our findings
  • Provide a clear understanding of our analysis and findings
Teach me how to Wiki

- Table of Contents
- Quickly choose what you want to explore
Teach me how to Wiki

- Guide for Users
- Tells you how to use wiki
Teach me how to Wiki

**Summary**

**Object Hierarchy**

**System Diagram**
Teach me how to Wiki

- Points, Modes, rationale, set points, etc.,

**Points**
- From Y2E2 Database:
  - UnOccHeatingSetpoint (1734)
  - HeatingSetpoint (17320008)
  - SpaceTemp (8700007)
  - Cooling Setpoint (1735)
  - UnOccCoolingSetpoint (1733)
  - ActiveBeamHeatingValvePos (8710007)
  - HotWaterFlowRate (9000004)
  - HotWaterSupplyTemp (9000005)
  - HotWaterReturnTemp (9000006)

**Rationale**
- Green: Follows expected operational use
- Yellow: Unusual operational use
- Red: Unreasonable operational use

**Latest Data Assessment**
April 21, 2011 - CEE 243 Query 3 analysis

**Status Assessment Rationale**
 Needs work.

**Mode**
Occupied and Unoccupied operational patterns. User override button to extend occupied hours by 2 hours

**Mode Rate of Change**
Change in setpoints, instantaneous

**Units**
Temperature (F), Flowrate (gpm), Valve Position (%)

**Setpoint Values**
- Occupied temperature setpoint is adjustable by user +/- 3F
- Unoccupied setpoints cooling = 78F, heating = 65F

**Deadband**
Temperature deadband of +/- 2F

**Minimum Normal Value**
65F

**Maximum Normal Value**
76F
Teach me how to Wiki

- Graphs
  - Visually explain findings through annotations
- Written explanations
- Color bands around graphs
- Recommendations

**Graph**

*Y2E2 Entire Building Electricity Use*

*Functions:*
1. This data conforms to functional intent, namely that measured demand will be high during occupied hours (roughly 8am-5pm on weekdays) and low during unoccupied hours (other hours and weekends). The date range here represents a typical spring quarter in the building and shows corresponding high levels of use.
2. This date is clearly out of sync with the rest of the graph and is at odds with functional intent.
3. This date is during summer months and still remains high as compared with the spring quarter even though it might be expected that demand levels during the summer would drop.
4. This data represents the fluctuations in demand that occur during winter break when the building is unoccupied, there is almost no pattern and demand levels do not correspond at all to the rest of the year.

*Performance:

The building appears to perform well overall in terms of usage levels conforming to occupancy cycles. The decrease in demand in the red band area was attributable to a failed sensor which was quickly replaced. The yellow band shows summer use which is not noticeably lower than spring or autumn quarter, which may be a result of elevated temperatures but might also be an indication that the building is not performing as well as it should be since one might surmise that overall demand levels would be lower in the summer.*
General Recommendations

• For the Building
  • Identify problems that result from sensing issues
  • Continue monitoring but improve and refine data analysis abilities
  • Link building/construction/operations knowledge with recorded data

• For the Owner (University)
  • Develop a costing approach to prioritize issues
  • Catalogue lessons learned and hire staff (from this class)

• For the Industry
  • Develop soft/hardware to reliably & efficiently do what we did this quarter and make it pay back (easy, right?)

• For Teaching
  • Create a broader reach through information sharing
  • Develop deliverables for public consumption to encourage progress

• For Research
  • Develop a coherent approach to refining the process (measure, analyze, respond) to make it less haphazard (PhD anyone?)

• For Us
  • Continue to find small ways to save the world; they add up