Lessons Learned and the Future of Plug Load Controls

Rois Langner, NREL

Technical Lead, Plug & Process Load Technical Solutions Team

Lessons Learned & The Future of Plug Load Controls

- Introduction: Plug & Process Loads. Where are we now and where are we headed?
- Presentations:
  - Kinga Porst, Sustainability and Green Buildings Program Advisor at the U.S. General Services Administration
  - Matt Baldassano, Technical Director at CommScope
  - Jason Page, Director of the Alliance Center, Alliance for Sustainable Colorado
- Discussion and Q & A

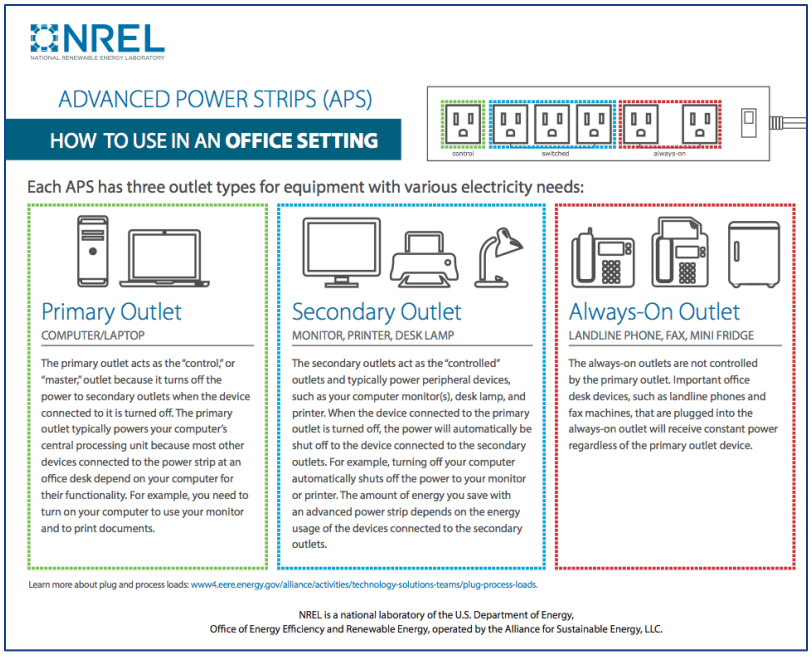
BBA PPL Membership

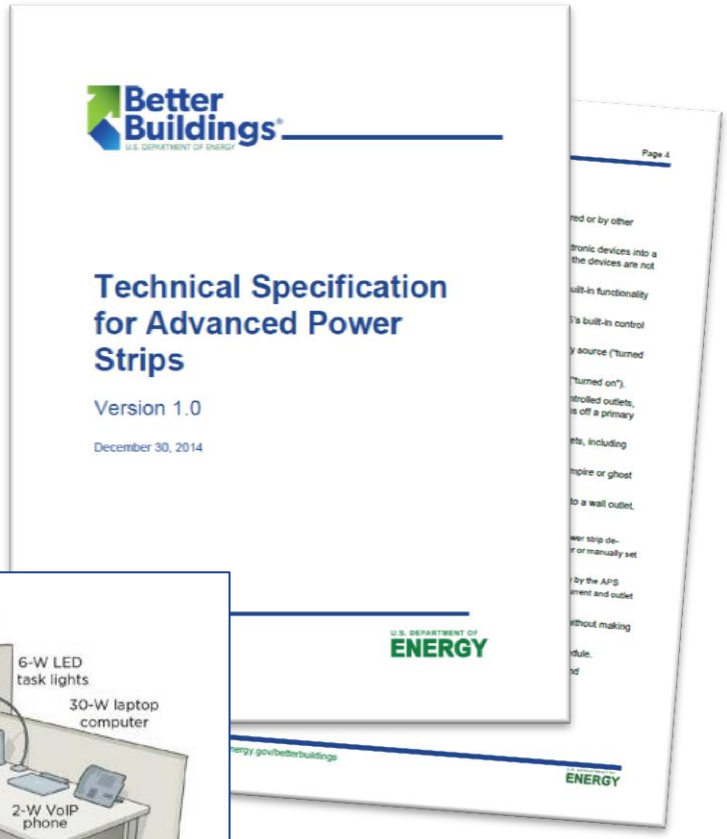
https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/plug-process-loads

BBA PPL Resources

Utility Incentives for Purchasing Advanced Power Strips

Incentive Sponsor	State	Utility/ State/City Incentive	Rebate/ Incentive Amount	Limit	Fund	Application	Termination Date	Type of Incentive
Pacific Gas and Electric Company	CA	Utility	$15	NA	NA	Residential, Commercial	12/31/13	Incentive
Ameren Illinois	IL	Utility	$10	NA	Less than $250K	NA	5/31/2014	Rebate





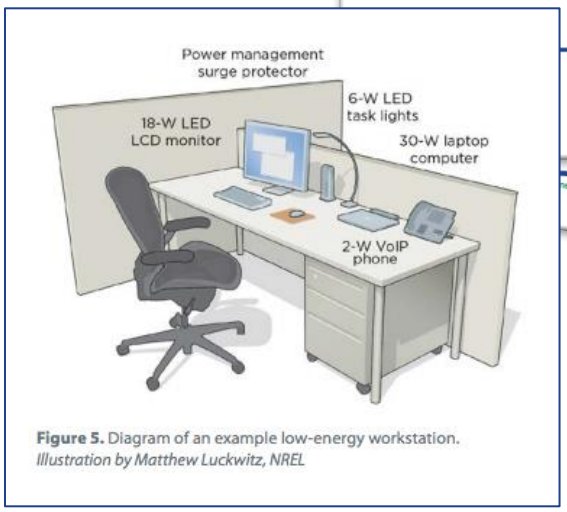


Figure 5. Diagram of an example low-energy workstation.
Illustration by Matthew Luckwitz, NREL

Thank you!

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U.S. DEPARTMENT OF ENERGY

U.S. General Services Administration

High Performance Buildings

Submetering

presented by
Kinga Porst, GSA

OFHPGB PPL & SUBMETERING STUDIES

- **Submetering framework and decision making tool SFTool**
- **Green Proving Ground**
- **Submetering pilot w/ GSA Leasing, NCR, Vornado**
  - Test the costs and savings achievable from sub-metering fully serviced leased buildings through a landlord/tenant pilot partnership.
- **Low cost wireless meter testing w/DOE/BTO**
  - DOE will conduct a performance test of two working prototypes at the GSA HQ.
- **Plug and Process Load Study in Leased Buildings w/ GSA PBS Leasing, NREL, Hines**
  - The project helps stakeholders make more effective design decisions, enabling benefits such as: (1) reduced capital costs, (2) more energy-efficient system operation, and (3) improved ability of designers to model and optimize multiple interacting systems to achieve aggressive whole-building energy performance goals.

GSA PORTFOLIO

- **376 million square feet**
  - 182 million owned
  - 194 million leased
- **Average age of inventory is 48**
- **Functional Replacement Value $70B**
- **Fair Market Value equal to $32.4B**
- **Reinvestment needs:**
  - $3.1 B (short term)
  - $4.6 B (long term)

- Over 9,100 assets
  - 1,500 Owned
  - 7,600 Leased
- Almost 22,000 assignments to agencies/business units

- 2,200 cities, 50 states, 6 U.S. Territories and the District of Columbia

- Housing over 1.1 million federal employees for 65 agencies

Why is Submetering Important?

Submetering is an important tool for reducing energy in buildings; it provides information at a local level, enabling building occupants and tenant agencies to identify energy intense systems and adjust their behaviors to achieve energy performance goals.

Promotes energy savings:

- ✓ Benchmarking – accurate knowledge of where energy is being consumed is the first step in creating energy savings.
- ✓ Continuous commissioning – Constant monitoring allows the user to gauge the results of an energy savings program.

What Type Of Submetering Is Right For Me?

What Kind of Submeter Do I Need?

This simple guide allows you to compare the strengths and limitations of available low-to-moderate cost submeter types so you can match tool capabilities to your project goals. The variety and capability of device-oriented electrical submeters is expanding. But increased options make it more challenging to choose the most effective tool.

When Might Submeters Be Helpful?

Submeters help Facility Managers, energy managers and tenant organizations identify:

1) inefficient equipment;
2) use and configuration alternatives; and
3) equipment and user profile management opportunities.

Submetering Comparison Chart

Simple

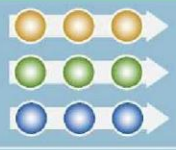
A device able to measure instantaneous power and cumulative energy data but requires manual reading and recording.

Enhanced

A device able to measure and record interval data but requires manual data file download.

Advanced

A device able to measure and record time-series interval data, communicate data to a remote location, and integrated into an energy management or building automation system.

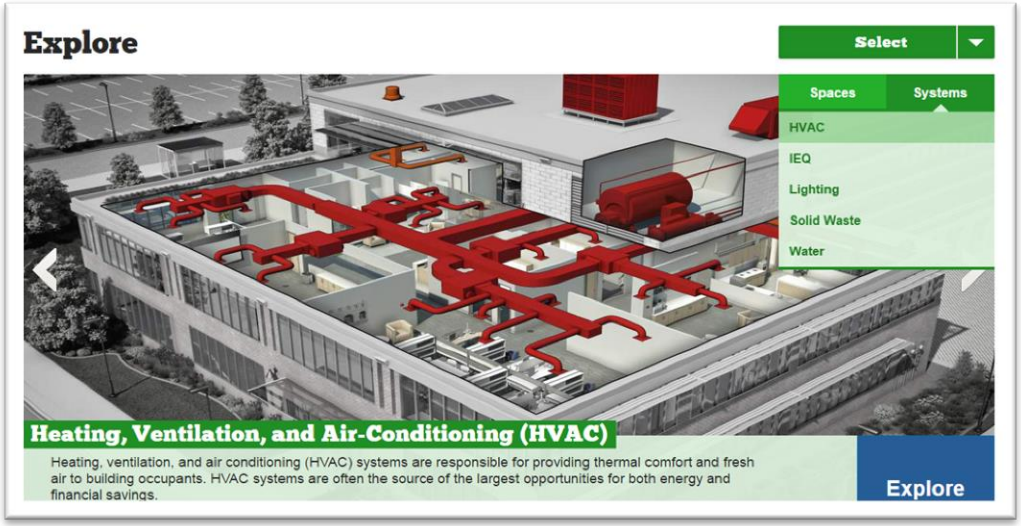
	Simple	Enhanced	Advanced
Data Unprocessed power and energy information collected by the submeters.			
Cost Submetering equipment and installation cost.	$	$ $	$ $ $
Labor The labor required to operate and maintain the submetering effort, such as data recording.			
Analysis Expertise required to utilize the data and apply it to energy management decisions.			

Submeter Data Framework Design

A Submeter Framework is needed to guide project planning, identify data needs, inform objectives and model cost savings. The Framework is currently designed to collect data that capture comprehensive system benefits.

Submeter Type	Functionalities	Benefits	Unit and Monetary Value
Electrical: • Circuit • System • End-Use Device **Natural Gas** **Water**	• Frequency of data and storage • Visualization, Data Feedback and Dashboards • Resulting Capabilities for Fault, Detection Theft, Power Monitoring • Resource Measurement	**Building Level:** • Reduced Resources Demand & Cost • Reduces O&M Costs **Portfolio Level:** • Capital Savings • O&M Savings	**Data points and formulas to calculate costs saved or avoided from identified benefits.** ***Energy Waste Reduction Value ($)*** = [energy rate ($/kwh)] * [total energy consumption at level (kwh)] * [estimated % of consumption reduction with roll-out]

EXPLORE: SUBMETERING

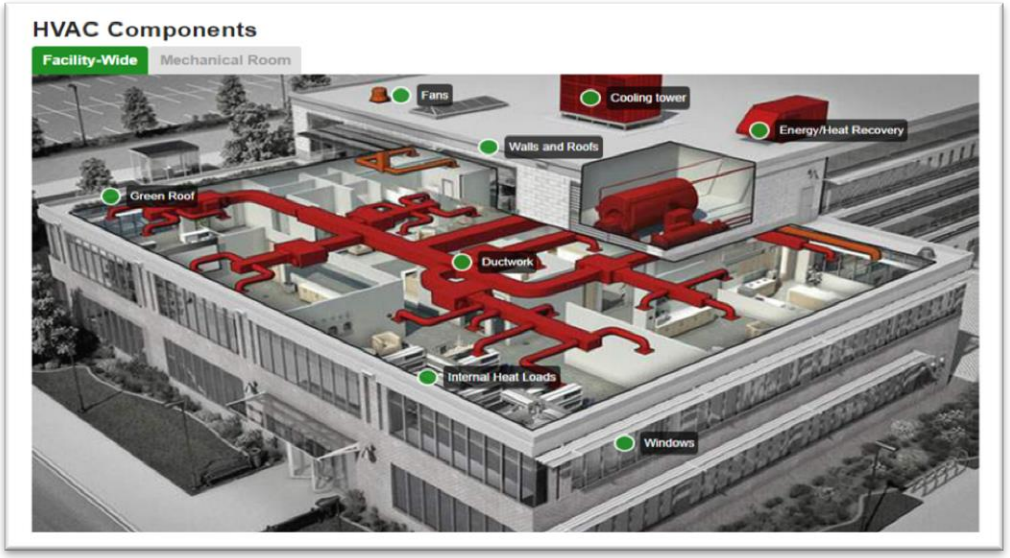


Recent industry trends show that, in addition to the primary utility meter, installation of metering devices after the primary utility meter that measure actual resource consumption provides multiple benefits to building performance. These submetering systems could allow building owners, designers and managers to monitor energy usage for individual tenants, departments, whole floors, pieces of equipment or other loads individually to account for their actual energy usage. This finer-grained facility data could be used to inform strategies for future cost-savings and sustainability projects and initiatives. Achieving sustainability goals will reduce capital investment and operating costs and potentially significantly decrease resource use and environmental footprint.

System Overview

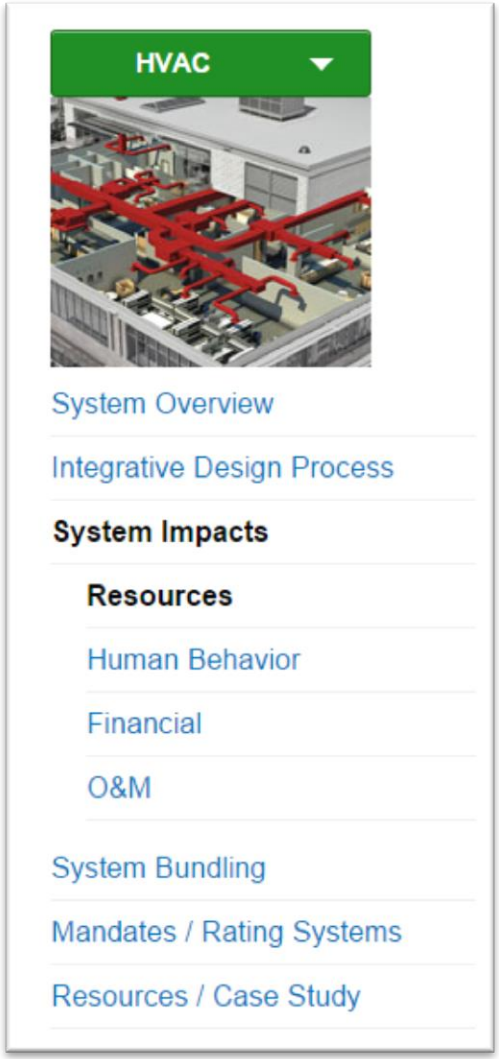
Visualizing submetering systems is helpful for users to understand the differences in submeter types. Define and examine submeter types within the building:

- Electrical – Circuit
- Electrical – System
- Electrical – End Use Device
- Natural Gas
- Water



Similar to the HVAC components diagram, display submeter installations and data roll over points. This page is intended to educate the user with a general understanding of submeter types to enable proper selection of meter type, followed by corresponding functionalities and benefits shown in the framework.

System Impacts



Using the data from submetering systems to better manage building operations and maintenance can have a significant impact on a building's overall resource use.

Use of submetering data:
-Enabling monitor-based commissioning
-Identifying and monitoring efficiency retrofits
-Aligning incentives and enabling behavioral conservation
-Demand response

Based on the knowledge compiled in the framework, submetering system benefits are:
-Economic Benefits
-Reliability Benefits
-Environmental Benefits
-Security Benefits
-Behavioral Benefits

GREEN PROVING GROUND

- **Plug Load Controls**
- **Integrated Daylighting Systems**
- **Occupant Responsive Lighting**
- **Wireless Sensor Networks**

Energy Management : Adoption

Advanced Power Strips

- Schedule-based control, where users determine the day and time when a circuit is energized, found to be most effective.
- 26% energy reduction at workstations with advanced computer management already in place, 50% energy reduction in kitchens and printer rooms
- Over 16,000 units deployed at 80 federal facilities across the country
- On GSA Schedule
- www.gsa.gov/gpg

GPG

GPG FINDINGS 01

MARCH 2012

WIRELESS SENSOR NETWORKS FOR DATA CENTERS

OPPORTUNITY

How much energy is used by data centers in the U.S.?

2% OF ALL U.S. ENERGY IS CONSUMED BY DATA CENTERS[1]

~50% GOES TO NON-IT LOADS[2]

TECHNOLOGY

How do Wireless Sensor Networks save energy?

CAPTURE & DISPLAY CRITICAL INFORMATION IN REAL-TIME

OPERATORS IDENTIFY WAYS TO INCREASE ENERGY- EFFICIENCY

M&V

Where did Measurement and Verification occur?

LAWRENCE BERKELEY NATIONAL LABORATORY assessed the effectiveness of collecting real-time information to optimize data-center energy efficiency at the USDA National Information Technology Center in St. Louis, Missouri

RESULTS

How did Wireless Sensor Networks perform in M&V?

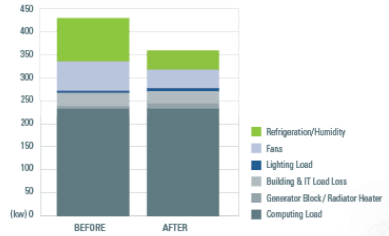
17% ENERGY SAVINGS
48% REDUCTION IN COOLING LOAD[3]

EFFECTIVE TOOL
FOR ON-GOING OPTIMIZATION OF DATA CENTERS[4]

3.4 YEARS
PAYBACK AT $0.045 kWh
< 50% of national average $0.11 kWh[5]

Data Center Power Usage Distribution

48% Cooling Load Reduction, 17% Overall Data Center Energy Reduction



DEPLOYMENT

Where does M&V recommend deploying Wireless Sensor Networks?

ALL DATA CENTERS

Estimated $61 million in annual savings and annual decrease of 532,000 metric tons of CO2, if implemented by tenant agencies throughout the GSA portfolio

Data center assessment kit developed during study reduces deployment time and power interruptions during installation

[1]McKinsey & Company, "Revolutionizing Data Center Efficiency", 2008 [2]Wireless Sensor Network for Improving the Energy Efficiency of Data Centers. Rod Mahdavi, William Tschudi (LBNL), March 2012, p.27 [3]Ibid, p.29 [4]Ibid, p.7 [5]Ibid, p.29

GSA GPG Green Proving Ground Program

The Green Proving Ground program leverages GSA's real estate portfolio to evaluate innovative sustainable building technologies.
www.gsa.gov/gpg | gpg@gsa.gov

Energy Management : Translation

Wireless Network Sensors

- Dense network of wireless sensors provides real-time information enabling facility operator to better manage HVAC.
- 48% reduction in facility cooling load
- 3.4 years simple payback (@ $0.045 kWh < 50% of national average $0.11 kWh)
- Deploying at two GSA-operated data centers
- On GSA Schedule

GPG

VORNADO PILOT

One Skyline Tower
Address: 5107 Leesburg Pike, Falls Church, VA
100% occupied by GSA via two leases (SSA, DOJ)
Number of Floors: 26
Building Size: 517,656 total RSF
130 meter points installed
Detailed Project Approach:
Phase 1: Metering Architecture & System Technical Design
Phase 2: Project Management, Coordination & Installation Oversight
Phase 3: System Commissioning, Testing and Startup Services
Phase 4: Baseline 11/01/14 – 10/31/15

The Energy Issue in Leased Space

- 95% of PBS's leases are done on a full service basis with utilities included in the rent
- Lack of current utility consumption information requires extrapolation and projection of estimated consumption and associated (scope 3) Green House Gas emissions.
- Disconnect between the user of utilities and the party paying for them (landlord/tenant) does not encourage reductions in energy use.
- Better measurement of utilities being consumed in leased space.
  - –Costs and challenges
  - –Impact on utility reductions
- Better understanding of cost implications to landlords when considering opportunities for policy shift from full service leases to leases net of utilities.

Sub-metering Pilot Goals

1. Acquire a better understanding of energy use and costs in leased facilities where the landlord is paying for utilities;
2. Develop replicable processes for implementation of sub-metering in leased facilities, including an understanding of costs of equipment and installation;
3. Develop duplicable standardized tracking processes for analyzing and reporting energy usage data in sub-metered leased facilities;
4. Explore and test for a method of automated GHG reporting in leased facilities;
5. Develop a thorough understanding of the cost-benefit analysis of sub-metering; and
6. Test alternative approaches to motivating more energy efficient landlord and occupant behaviors and identify factors that encourage or hinder behavioral change.

PLUG AND PROCESS LOAD STUDY

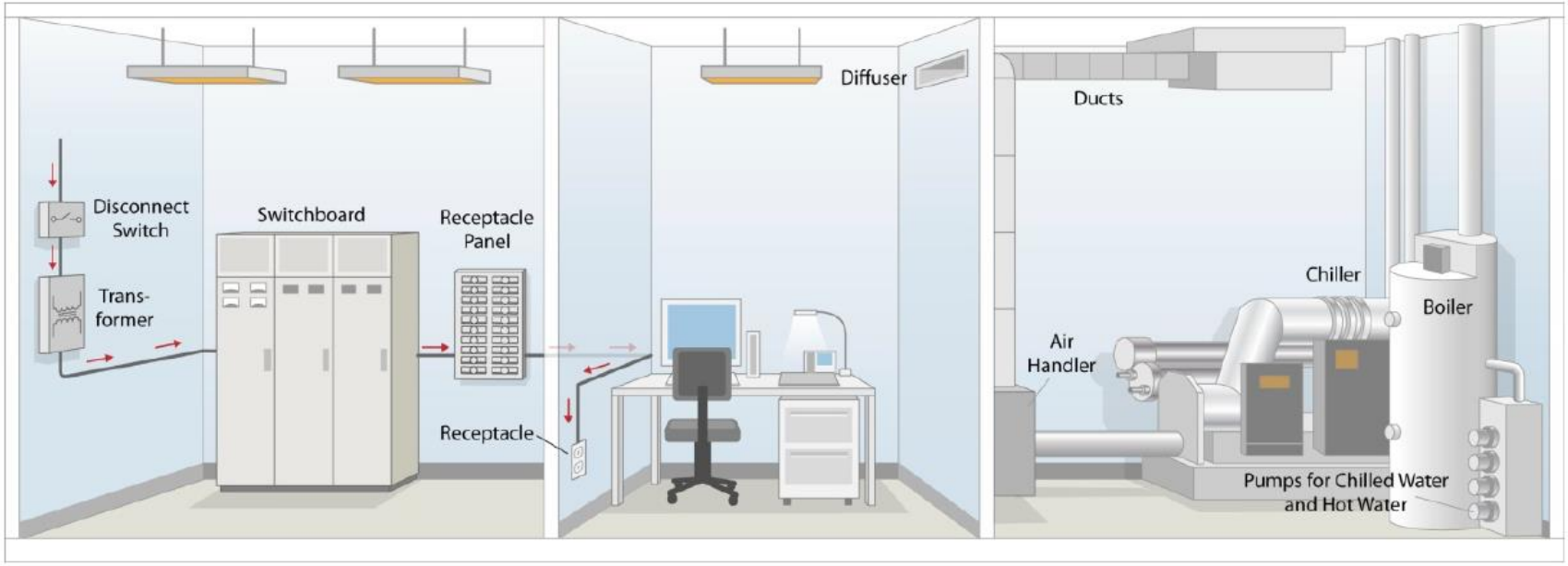


Figure 1–1 Systems that are affected by plug and process load densities specified in lease agreements
(Photo credit: Alfred Hicks/NREL)

- Peak PPL energy use intensity for offices with data centers is 0.88 W/ft2.
-On average, the typical PPL energy use intensity for offices is around 0.28 W/ft2
- Right-sizing HVAC system components led to an average 14% reduction in upfront capital costs and a 3–4% reduction in energy costs.

RESOURCES

- **Sustainable Facilities Tool https://sftool.gov**
- **GSA Green Proving Ground www.gsa.gov/gpg**
- **GSA Office of Federal High Performance Green Buildings www.gsa.gov/hpgb**
- **NREL Plug and Process Load www.nrel.gov/docs/fy14osti/60266.pdf**

Kinga Porst

GSA, Office of Federal High Performance Green Buildings

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The Connected and Efficient Intelligent Building Sensor Based Network Systems

Matt Baldassano
Technical Director – Enterprise Solutions
May, 2015

An Intelligent Building is Connected and Efficient

Connected:

Efficient:

The Connected and Efficient Building

An integrated infrastructure that supports building intelligence applications

Addressing space, energy and productivity challenges

Office Space is Changing

Smart Power Management ENERGY

Monitor building occupancy and link to Elevator, Lighting, HVAC and Plug Loads bringing floors online as occupancy demands.

Efficient Building Operation PRODUCTIVITY

Understand if spaces were/are occupied and for how long… Does the cleaning crew need to clean every room when they weren't even used?

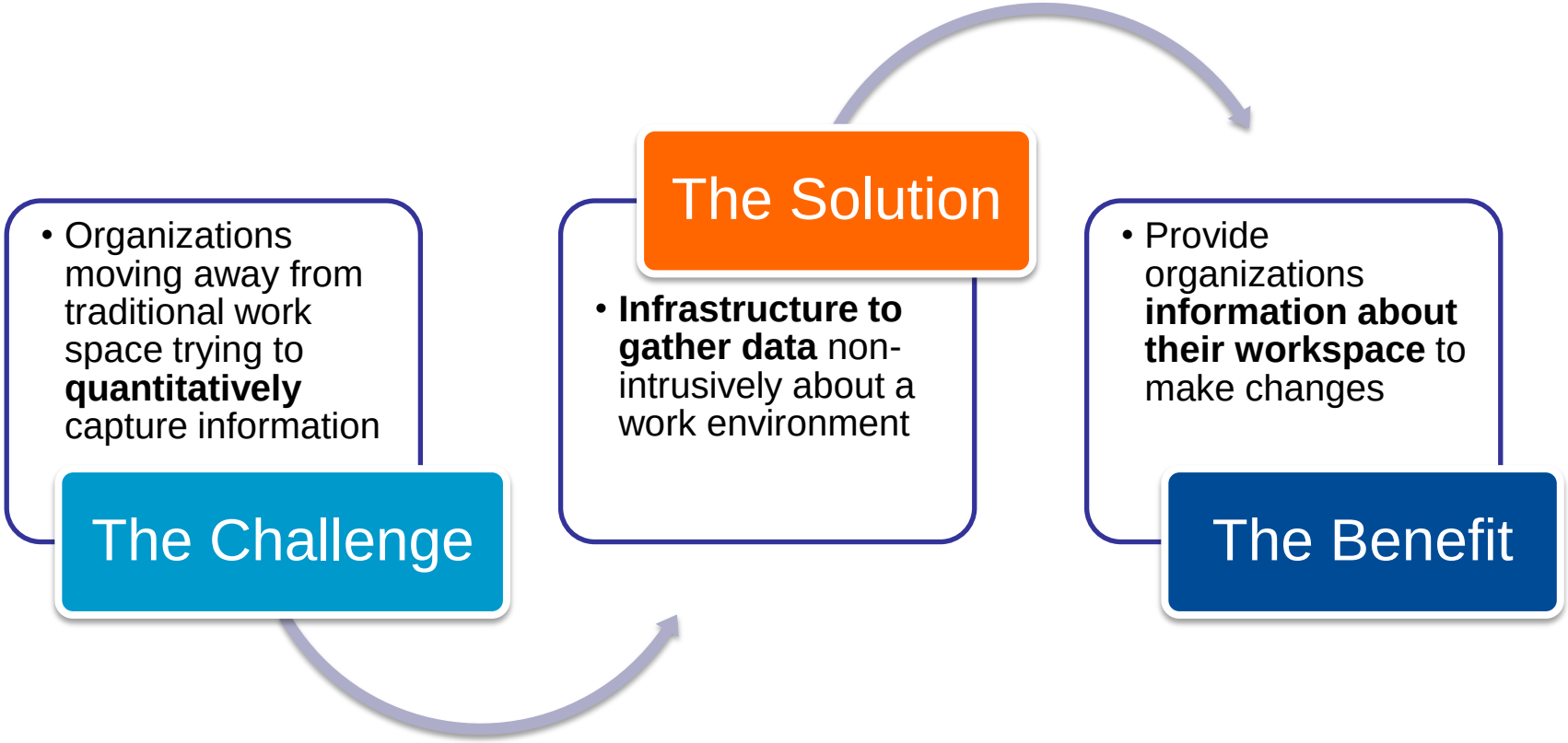
Maximize Real Estate SPACE

Data collected provides real-time and historical information on how efficiently space was occupied

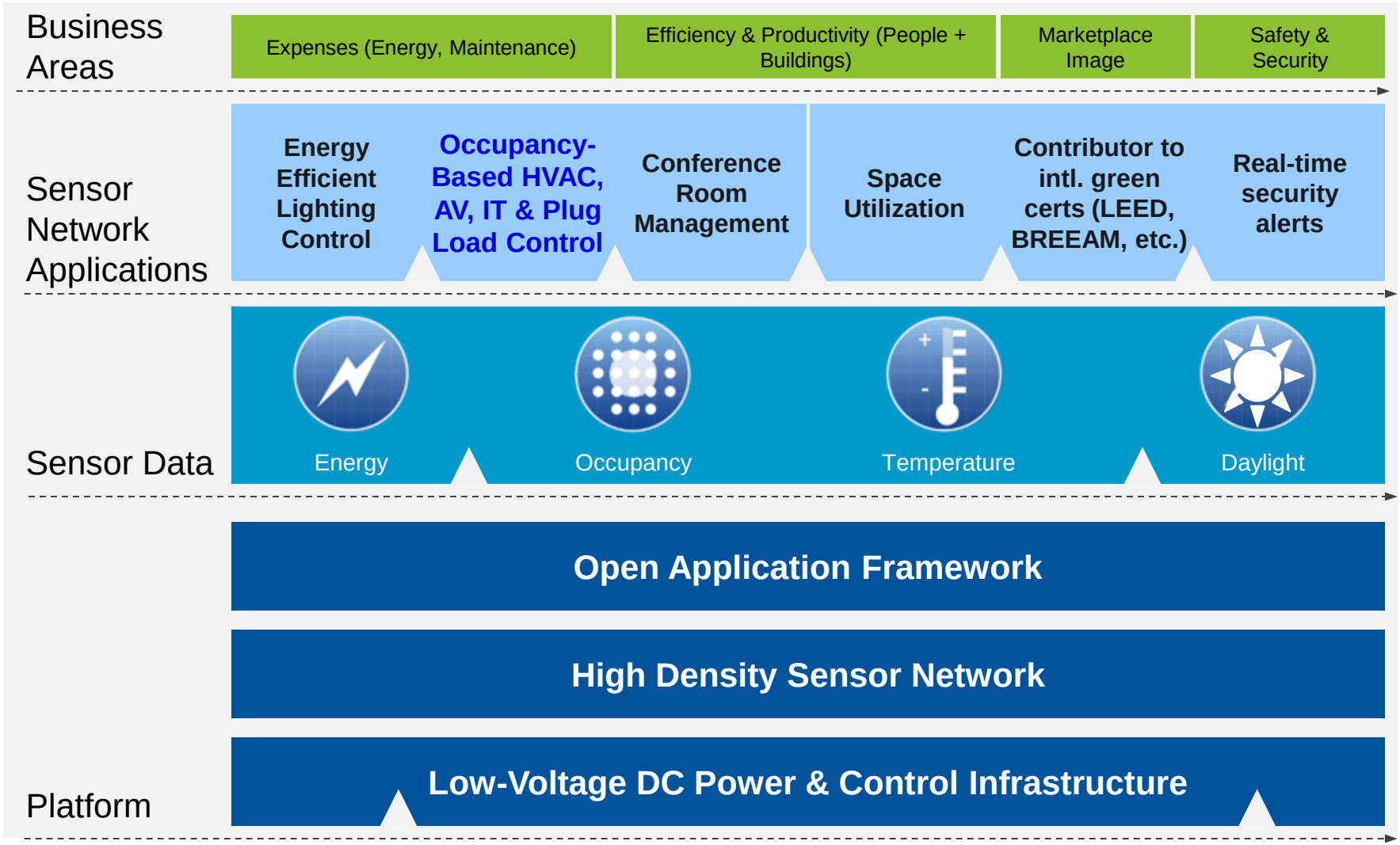
Security Assist VALIDATION

Identify occupancy areas and confirmation during evacuation flashing lights to escape routes

What we've noticed: The Opportunity

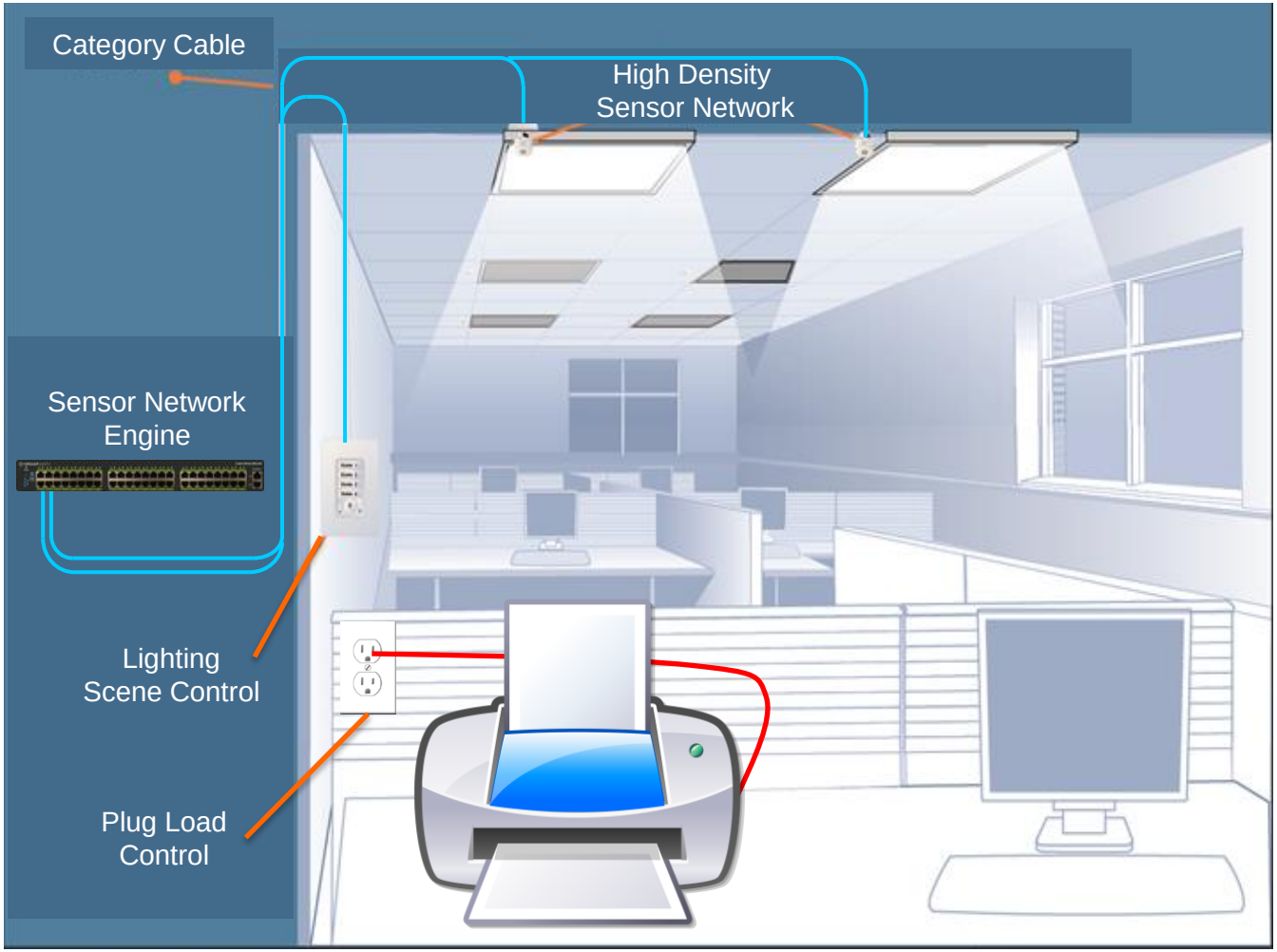


Sensor Network – Data from High Density Coverage



Sensor Network – Centralized Power and Control

- Traditional category cabling (RJ45)
  - Power
  - Control
  - Measurement
- High-Density Sensor Network
  - Data Collection
- Centralized Management
  - Dashboards
  - Reporting
  - Easy re-provisioning

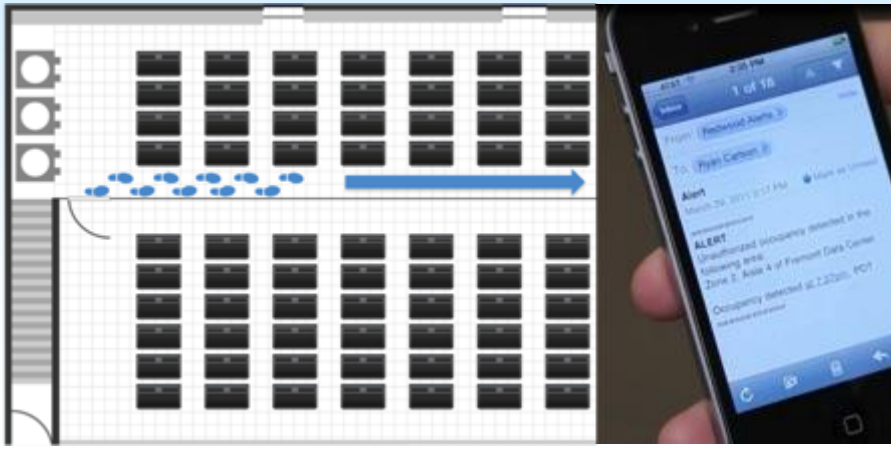


Connected and Efficient – System & Application Integration

Conf. Room Scheduling
REAL TIME OCCUPANCY

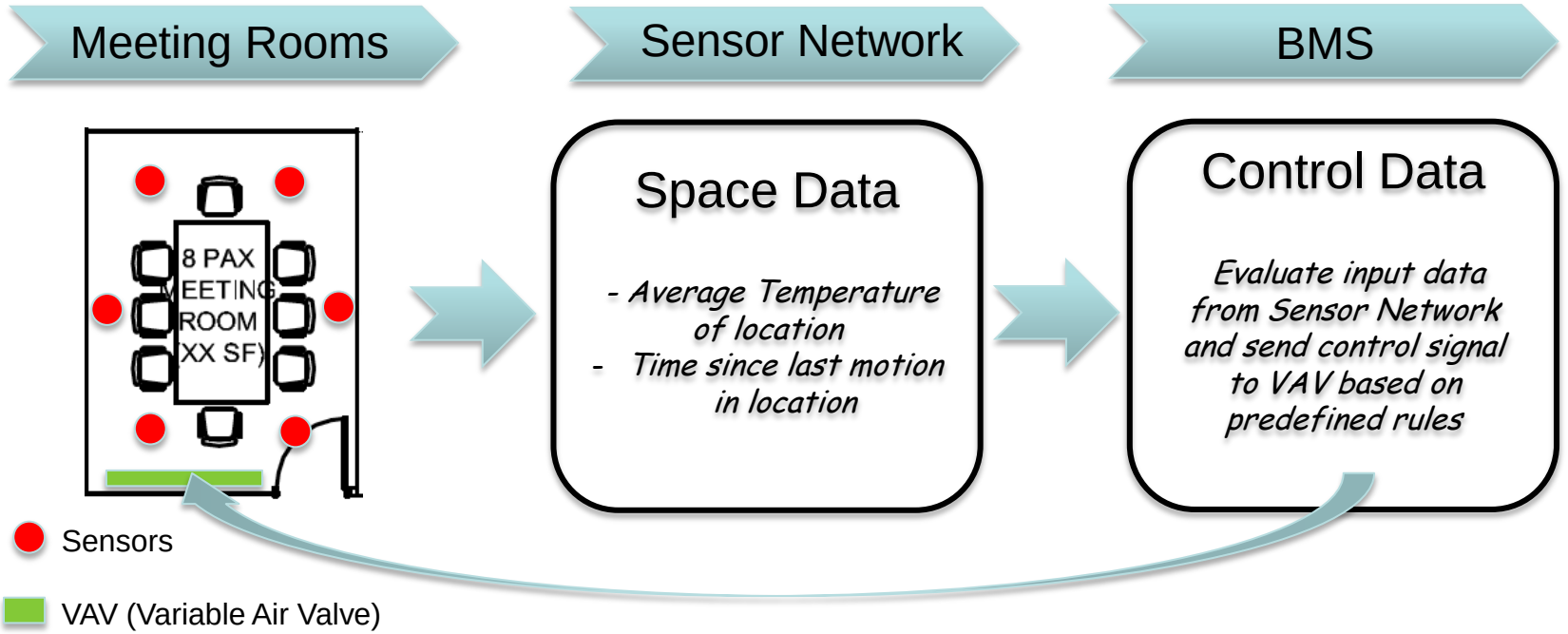
Occupancy-Based Lighting, HVAC & Plug Load Control

Smart LED Lighting



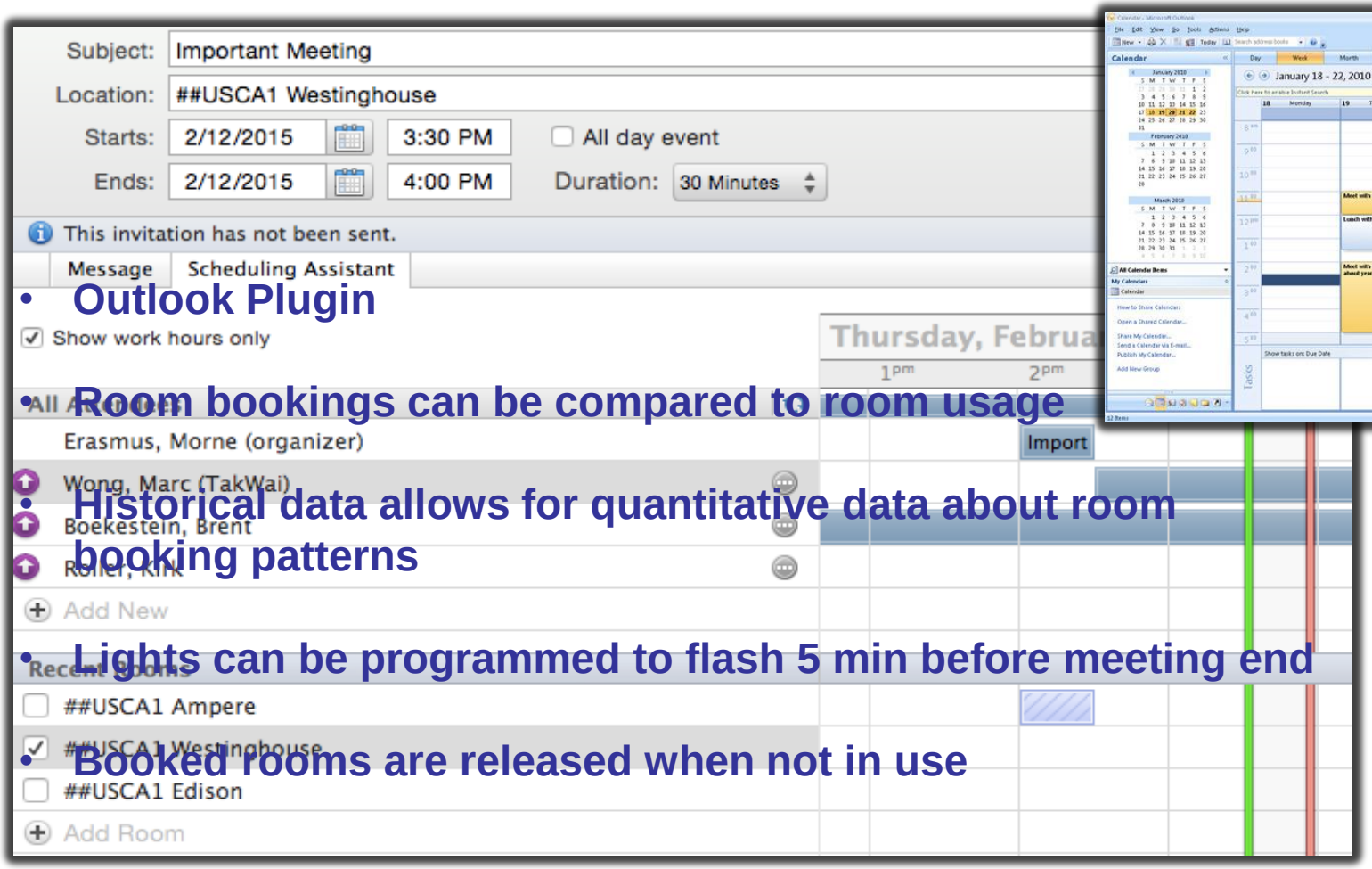
Motion Detection – Security & Safety

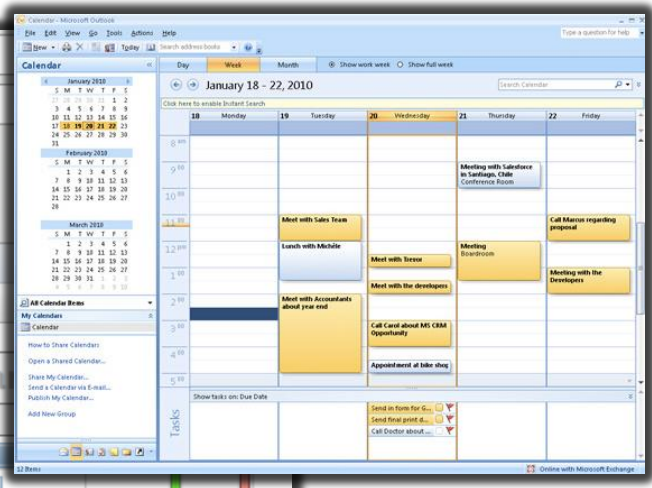
HVAC Integration



- Sensors in every room feed information (**Temperature, Motion and Light** levels) to the Sensor Network Control System
- **Open API or BACnet**, 3rd party BMS control systems can talk directly (or through a translator appliance) to the Sensor Network System and gather information about the space
- BMS will then **evaluate data** against predefined rules and send a control signal to the VAV to either open or close.
- Save energy by increasing the tolerance band for **rooms that are not occupied.**

Calendaring Integration

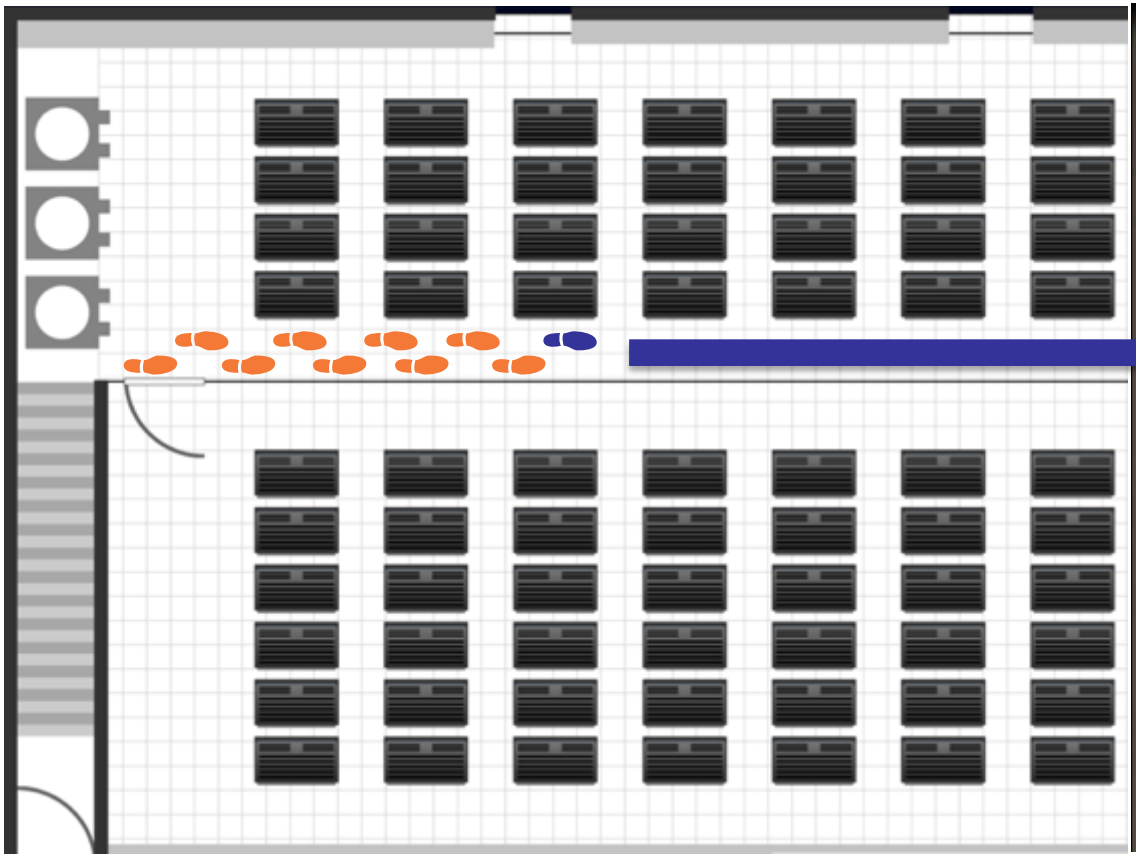


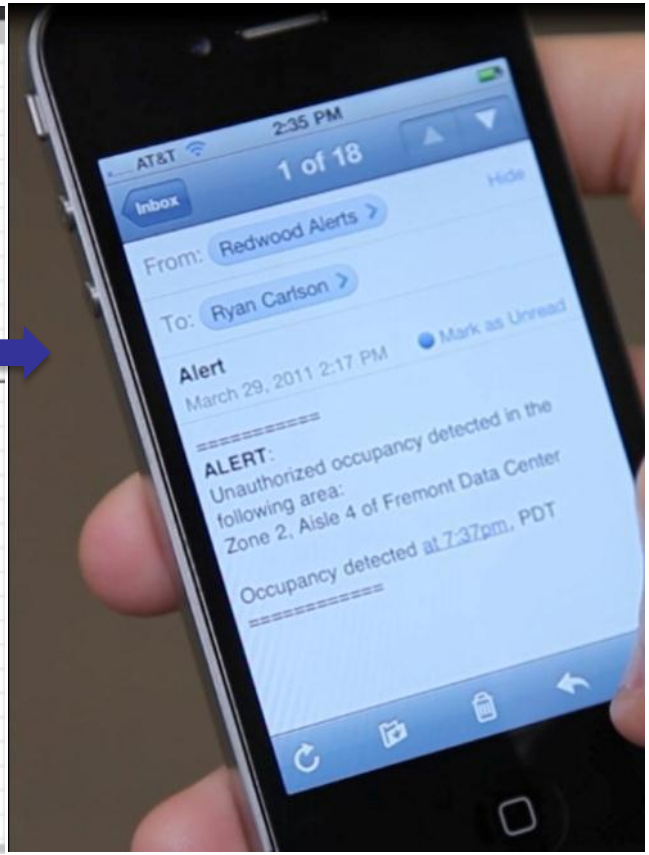


- **Outlook Plugin**
- **Room bookings can be compared to room usage**
- **Historical data allows for quantitative data about room booking patterns**
- **Lights can be programmed to flash 5 min before meeting end**
- **Booked rooms are released when not in use**

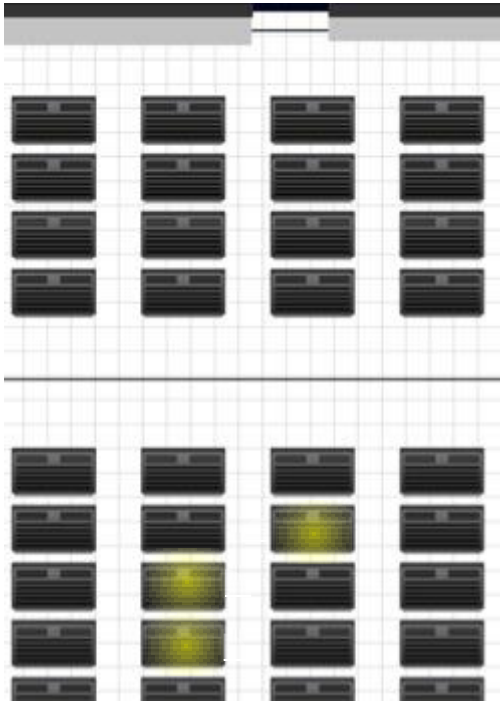
Safety and Security Systems Integration

Alert to unexpected presence, validate security walkthroughs, or to identify occupants in an emergency



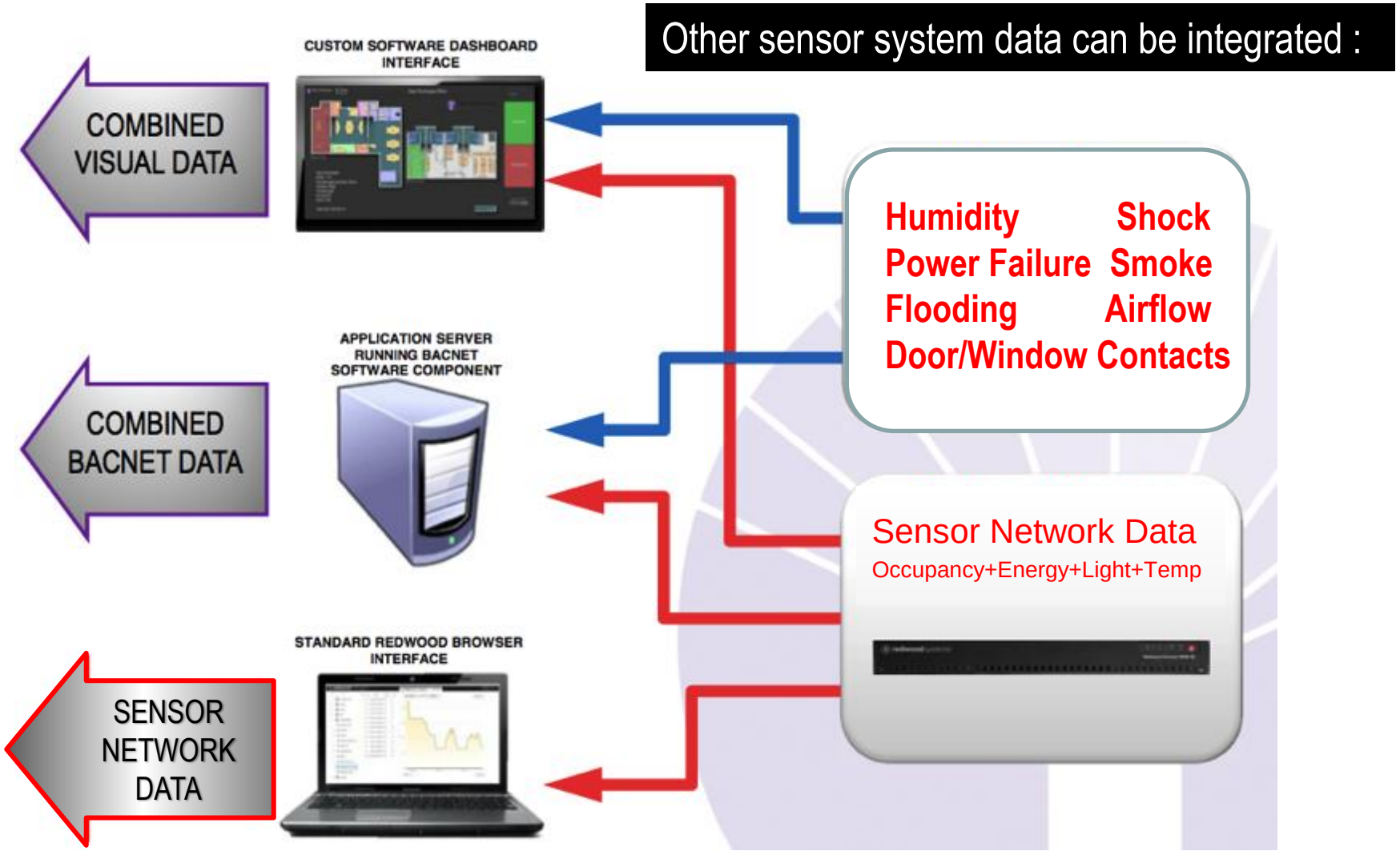


Visual Alerts



Flashing lights over open doors help prevent radical temperature changes or security breaches.

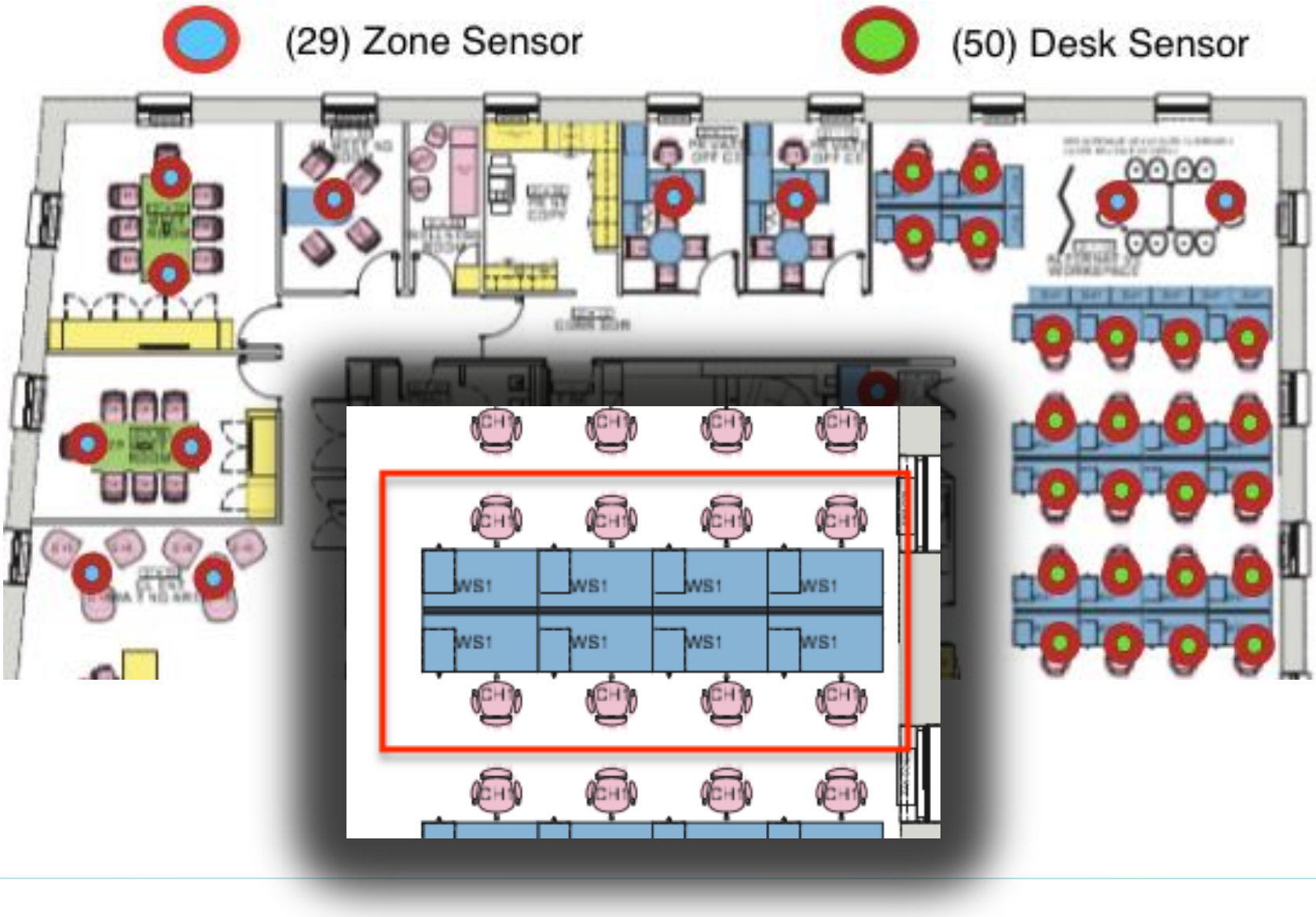
Connected and Efficient – Multi-System Data Integration



What Facilities/Operations Management wants to know?

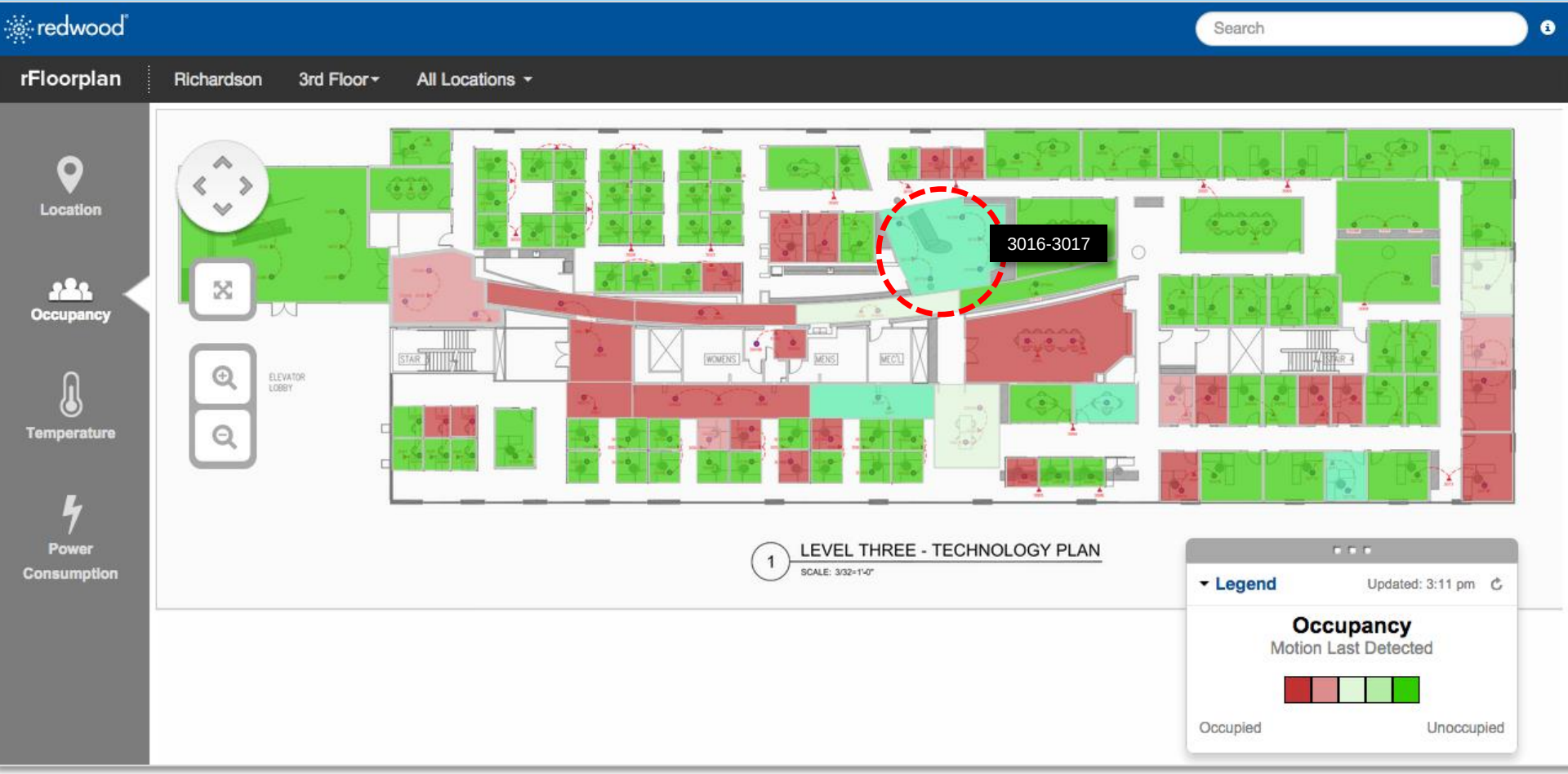
- Which rooms show the highest usage?
- Are the rooms fully occupied?
- Which areas are under-utilized and when?
- How does the occupancy pattern change over the course of that day, hour by hour?

Desk vs. Zone Sensor Placement



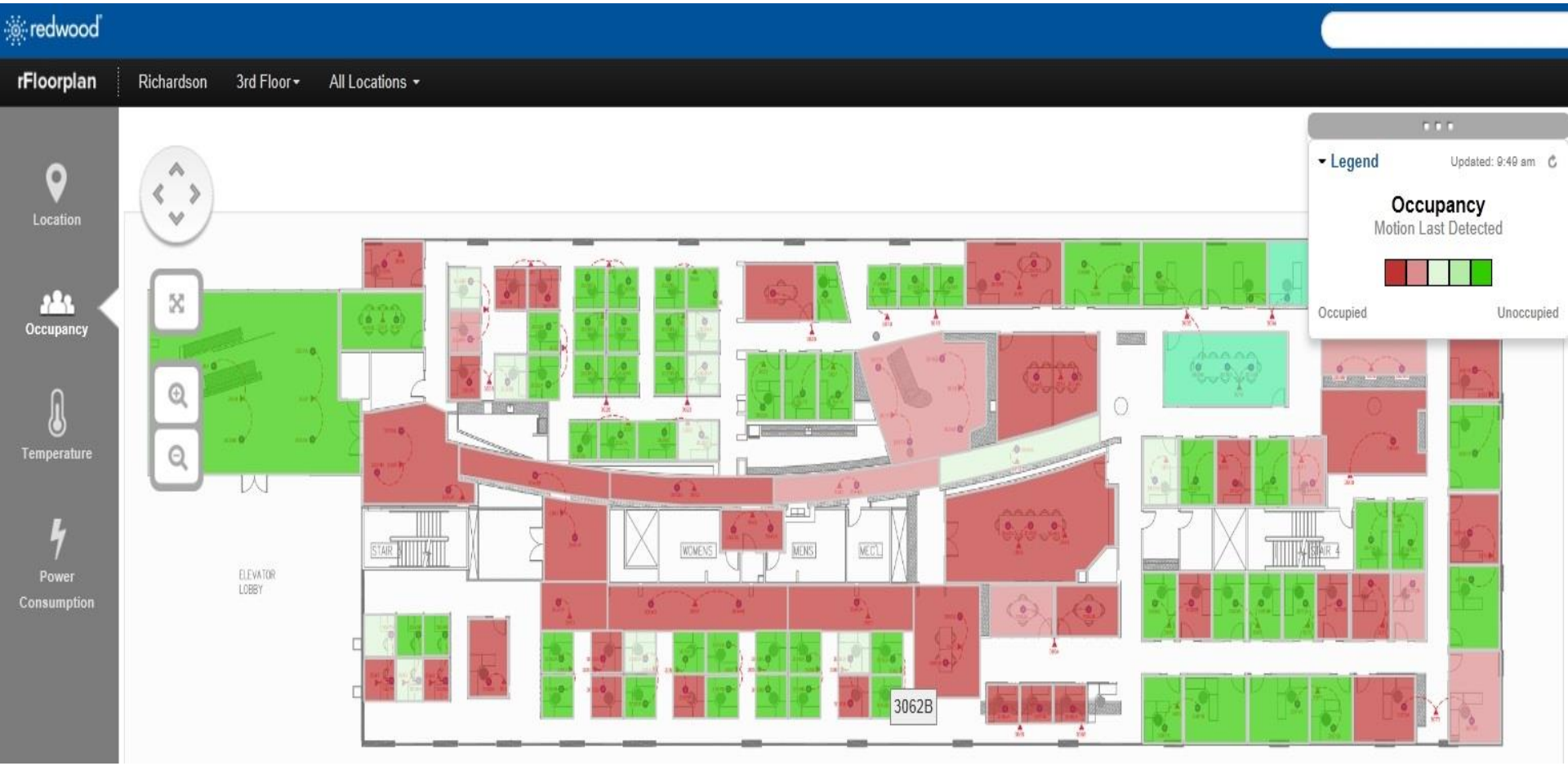
CommScope Office (Normal Day)

- Analyzing various spaces for three floors



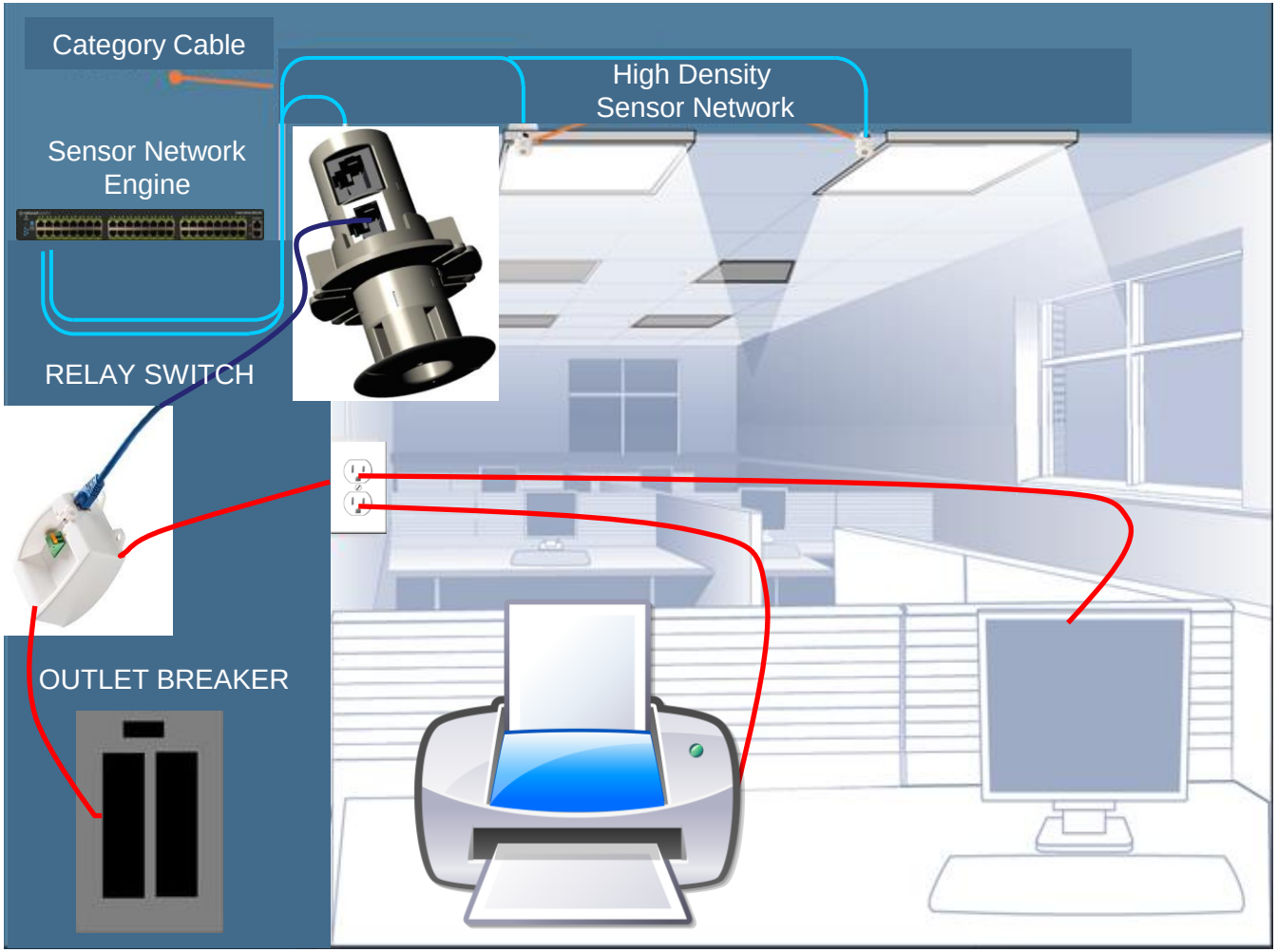
CommScope Office (Donuts in the Break Area)

- Executed experiment to validate occupancy analysis and visualization



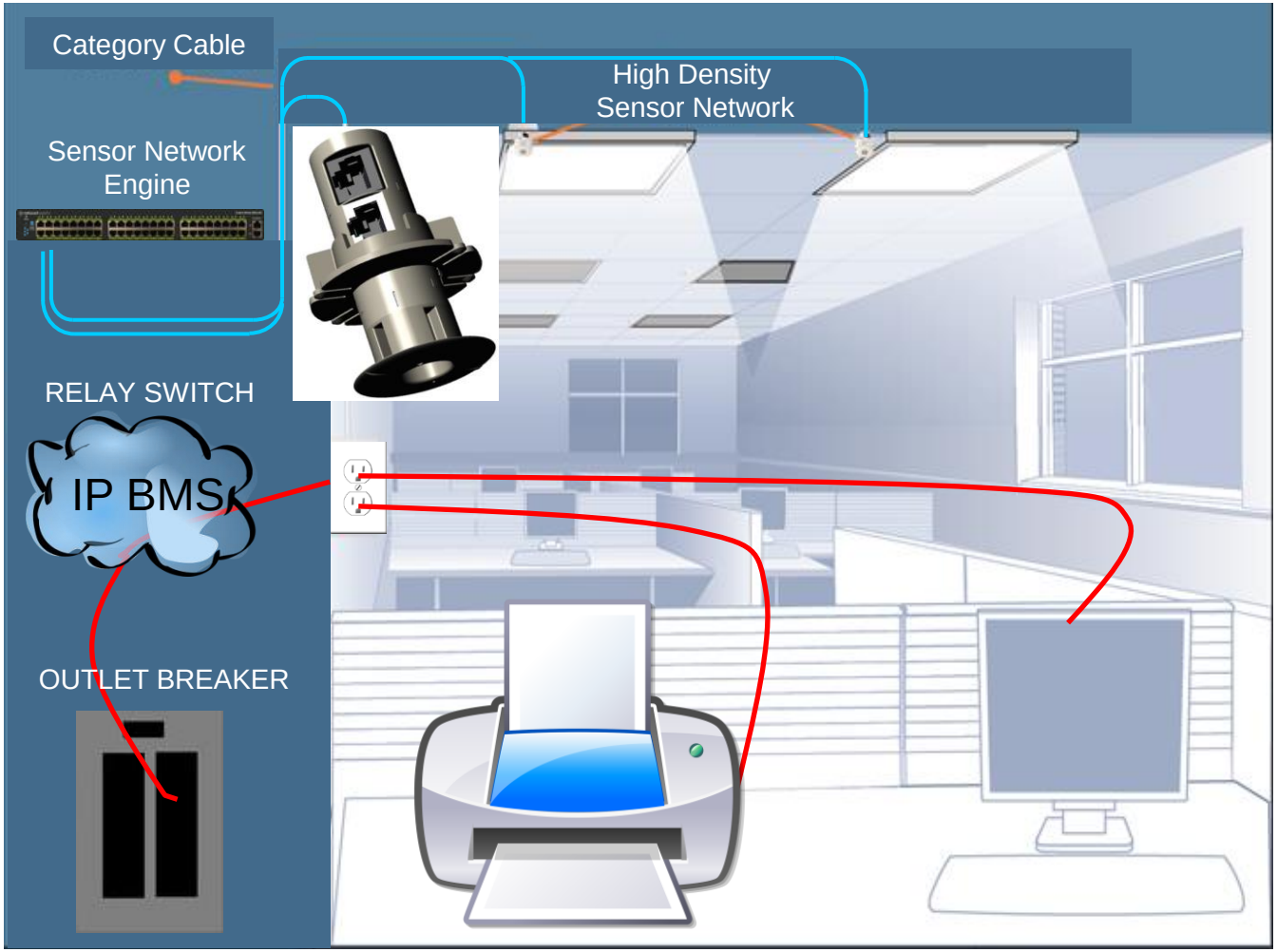
How to do Plug Load Control – Option 1 (hardwired)

- Traditional category cabling (RJ45)
- High-Density Sensor Network
  - Occupancy
- Hardwire AC Relay
  - Delivers Power when space is occupied
  - Provides Plug-load Control when space is not



How to do Plug Load Control – Option 2 (IP based BMS)

- Traditional category cabling (RJ45)
- High-Density Sensor Network
  - Occupancy
- IP Based BMS System Integration
  - Greater control of more devices
  - Direct Measurement and correlation with other systems



Thank You

Plug Loads, Space Design & Community Engagement

THE ALLIANCE CENTER

Jason Page
Alliance Center Director
May 2015

The Alliance Center

- Colorado's Hub of Sustainability
  - 40+ organizations working on differing aspects of sustainability
- ~40,000 sq ft
- Energy Star Leader, LEED EBOM Gold
- Better Buildings Challenge Showcase Project

In Need of a Change

It’s about the People!

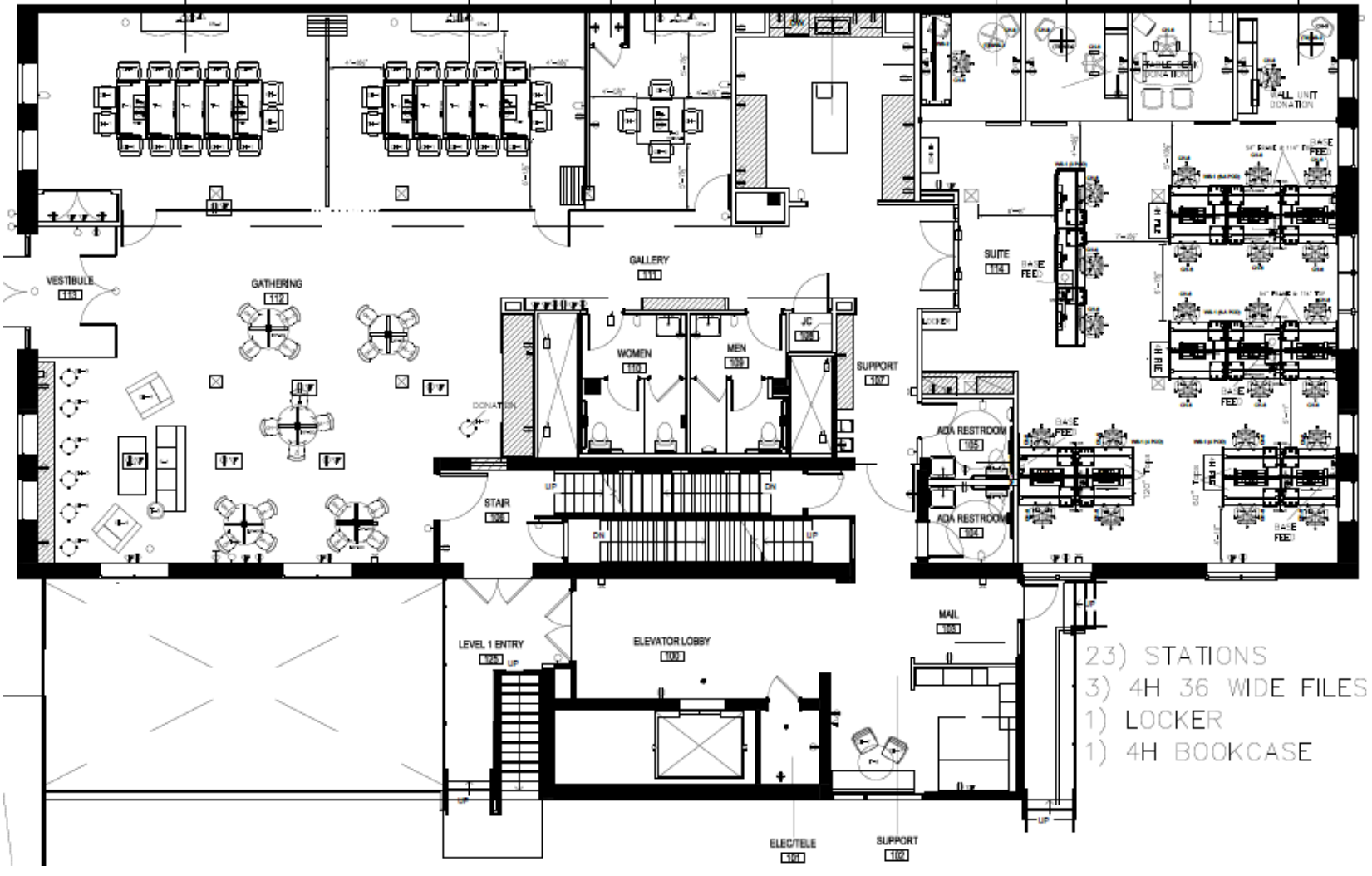
Why come to the office?

- 8 cents!
- Connection
- Different spaces for different work
- Technology & flexibility

➢ Point of building is to be used.
Per capita metrics, not per kwh

Space Utilization–How use facility?

- Address business needs, not space needs
  - ➢ Not per square foot
- Variety of spaces & technologies
- Density is critical!
  - ➢Right arrangements
  - ➢Flexibility – license, not lease


VESTIBULE
118
GATHERING
112
GALLERY
111
WOMEN
110
MEN
109
JC
108
SUPPORT
107
DONATION
STAIR
106
UP
DN
SUITE
114
BASE FEE
ADA RESTROOM
105
ADA RESTROOM
104
FULL UNIT DONATION
LEVEL 1 ENTRY
103
ELEVATOR LOBBY
102
MAIL
101
ELEC/TELE
101
SUPPORT
100
23) STATIONS
3) 4H 36 WIDE FILES
1) LOCKER
1) 4H BOOKCASE


Stir it up.

Smart Building Critical

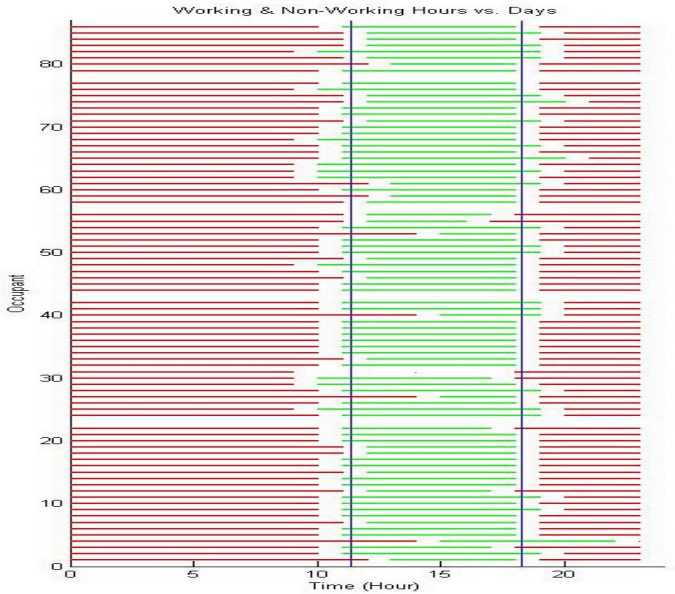
Integrated Systems

- Responsive, Integrated BMS
  - Room Scheduling/Mgmt
  - Mechanical / Lighting
  - Plug loads

➢Model requires usage data

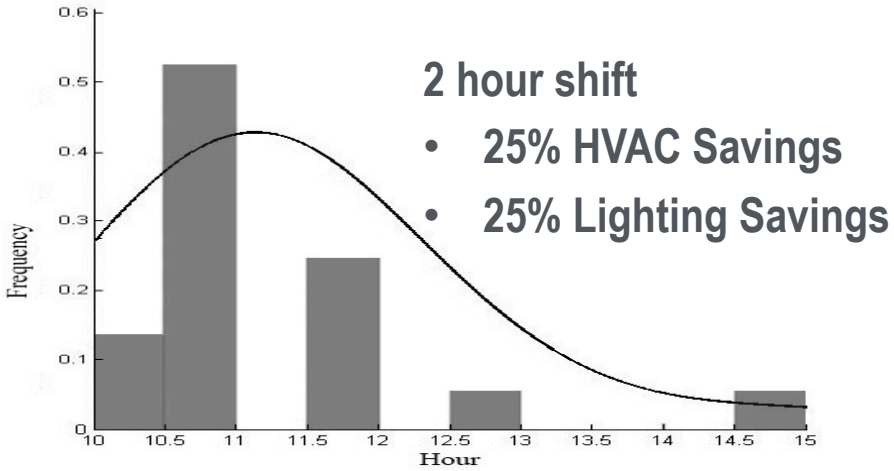
Feedback – Space, Time, Human

Energy-use Schedule Identification to Optimize Building Systems



Work hour / Non-Work Hour Ranges

HVAC / Lighting Schedules



2 hour shift

- 25% HVAC Savings
- 25% Lighting Savings

Start Work Hour Probability Distribution

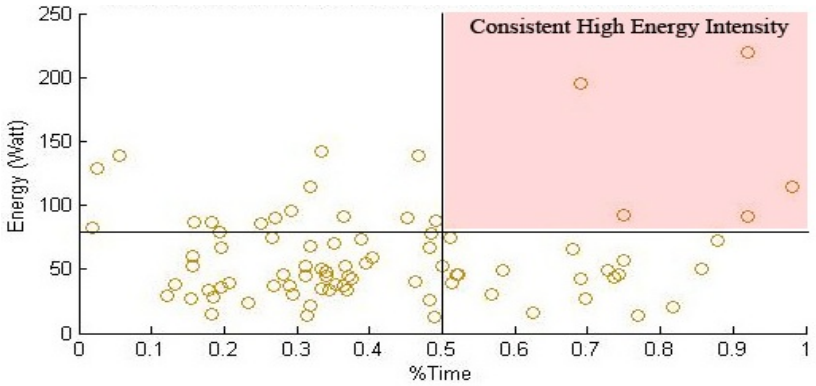
The office is filling up 2-hours later than expected!

Targeted Initiatives

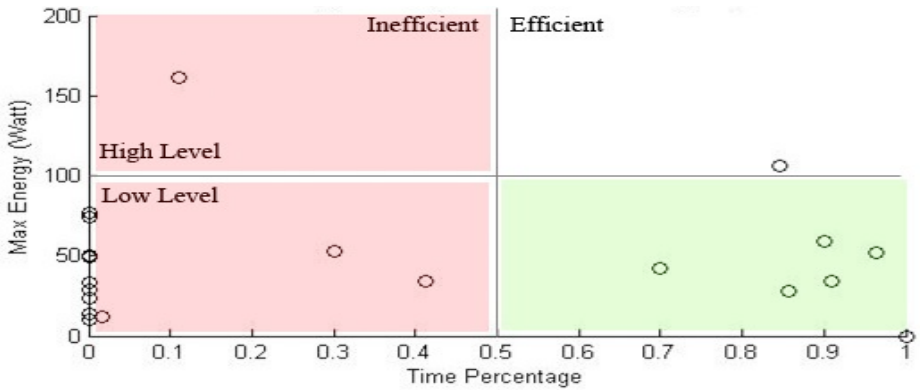
Targeted Interventions

Energy Intensive Equipment | **Inefficient Behavior**

20% Plug-load Savings



Max Work Hour Energy vs. Time in Max Energy Cluster

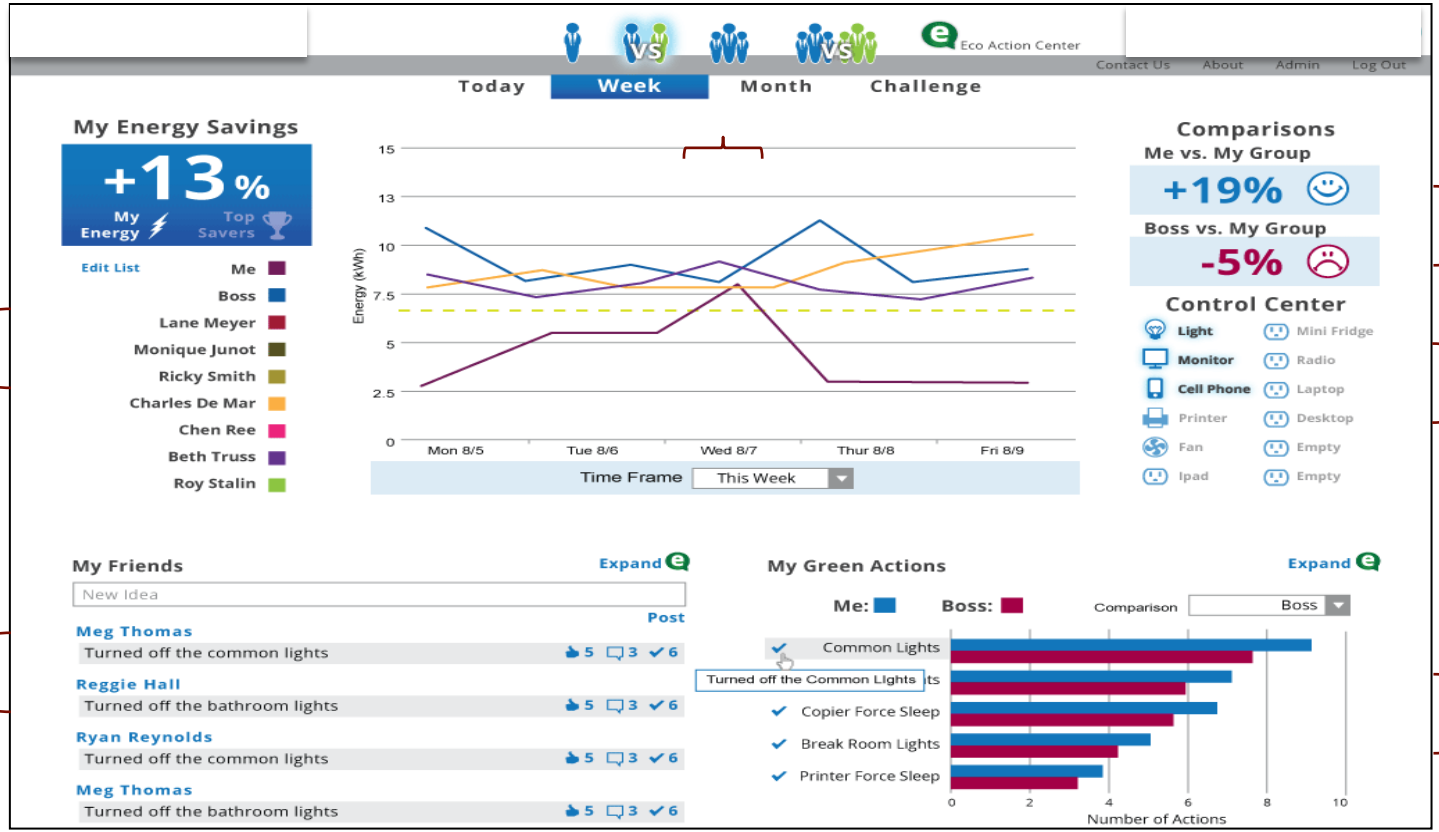


Non-Workday Efficiency vs. Max Energy Level

Engagement

Need Tenant Buy In

- Blur owner/facilities and tenant as much as possible
  - Advisory Council
  - Data transparency = systems, sub metering and dashboards
- Competitions and gamification
  - No big change if just seen by individual, but being to compare against others drives change



Direct Employee Electricity Comparison

Action Reporting and Discussion

Individual to Group Comparison

Appliance Remote Control

Employee Action Comparisons

Future Predictions

Future

- Smart building as base
- As efficiency increases, occupants needed even more to achieve gains
- More than space - buildings compete on technology and intangibles
- More models like ours
  - Appraised 25% higher than conventional office

Thank you!

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