J. Craig Venter Institute | La Jolla, CA Photo: Stephen Walker Photography

Getting to Zero Energy Outcomes

November 4, 2015

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Upcoming Getting to Zero Webinars

All sessions 10-11:30 am Pacific/1-2:30 pm Eastern

January 13, 2016 *Both Sides of the Meter*

February 17, 2016 *From Policy to Practice*

March 16, 2016 *Strategies for Getting to Zero*

April 20, 2016 *Beyond a Building*

May 18, 2016 *ZNE Policies within and Across Borders*

More information at newbuildings.org/demand-webinars

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ZNE in the Occupancy Phase

Glazing performance – building orientation – cooling efficiency – infiltration – operating hours – climate – weather – occupant density – heating efficiency – duct design – fan size – window area – HVAC control sophistication – building mass – interior shading – occupant habits – data centers – kitchen equipment – lighting power density – filter condition – wall color – lighting controls - furniture configuration – exterior vegetation - operable window use – insolation- glazing orientation – wall insulation – ventilation rate - exposed interior surface characteristics - domestic hot water use – number of computers – copiers and printers – elevators – exterior lighting - occupant gender ratio – elevation – photovoltaics - development density – register location – cooling distribution system – roof insulation – building manager training – cool roof – building surface to volume ratio – building use type – janitorial services – metering strategies – commissioning – structural system – acoustic treatment – slab edge detailing – night setback temperature – ground water temperature – humidity – occupant dress code – lamp replacement strategy – roof slope – daylight controls – sensor calibration – corporate culture – lease terms – utility meter characteristics – parking garage ventilation – HVAC system capacity – number of separate tenants – retail space – age of equipment – ceiling height – heating fuel – transformer capacity – window mullion pattern – terms of maintenance contract – wall thickness – building height – lighting fixture layout – overhangs – thermostat location – exit lighting – private offices – refrigerators – solar hot water – utility meter – load diversity

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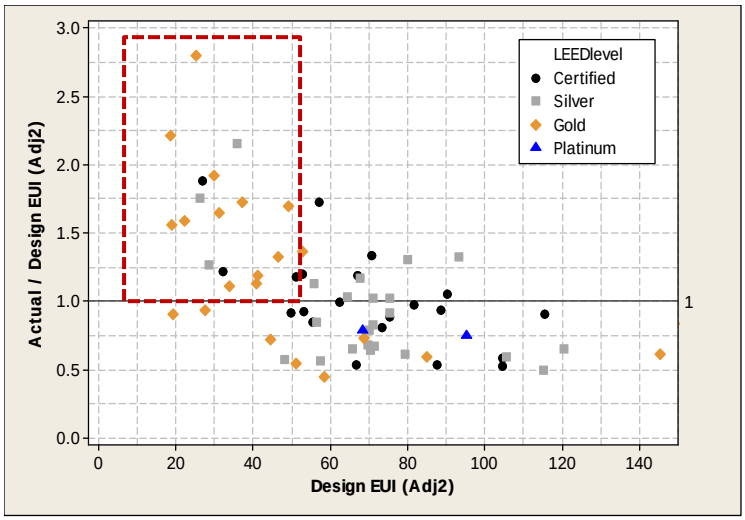
Performance Expectations vs. Outcome



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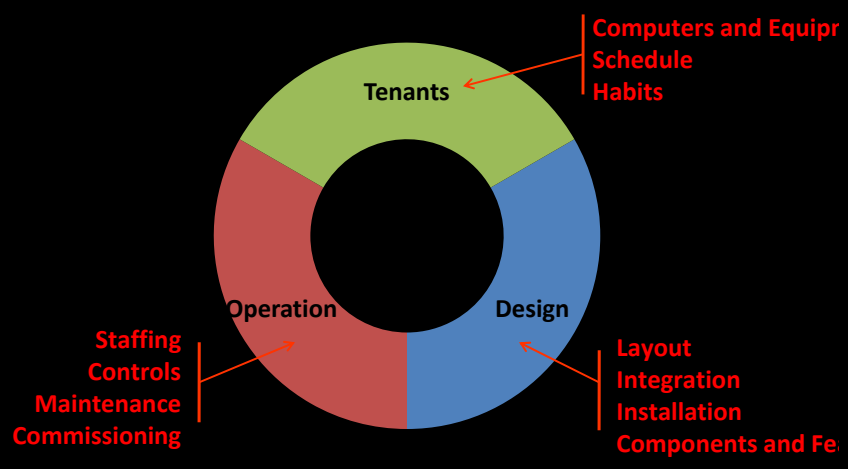
Different Players Affect Building Performance



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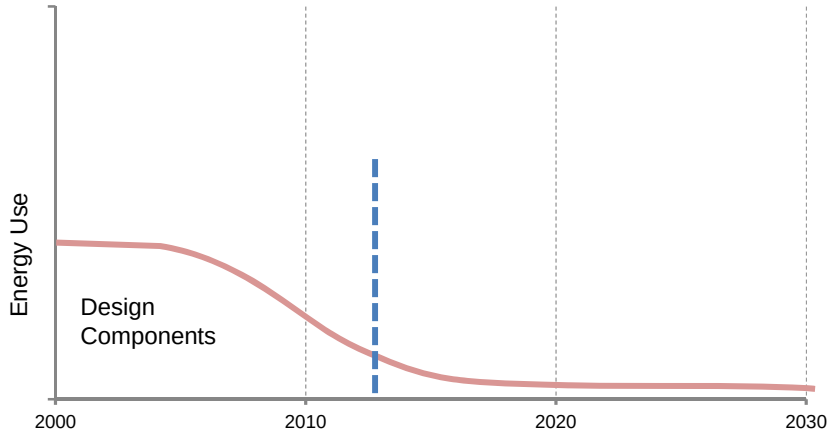
Components of energy outcomes



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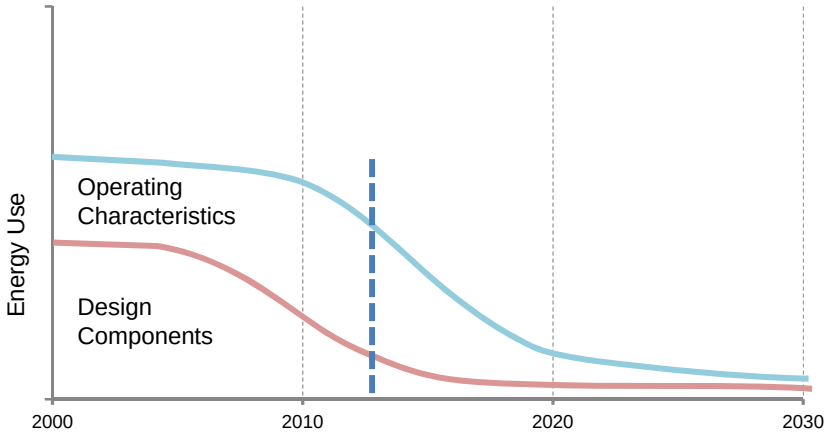
Building Operation

Components of energy outcomes



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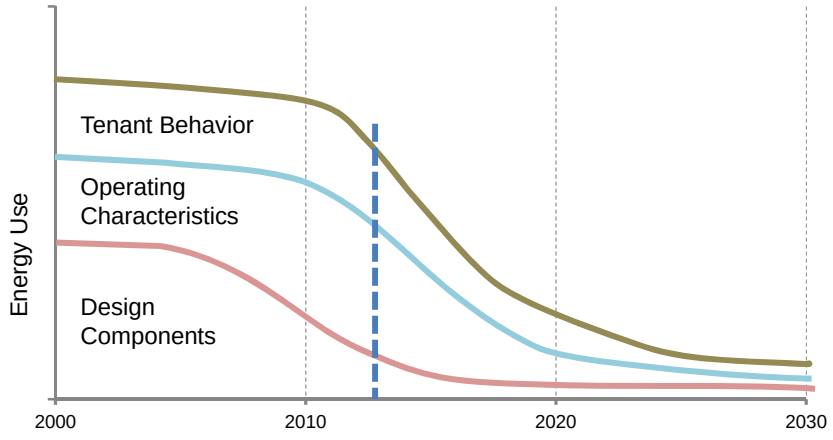
Occupancy


Hood River Middle School, OR . Courtesy: Michael Mathers

Components of energy outcomes



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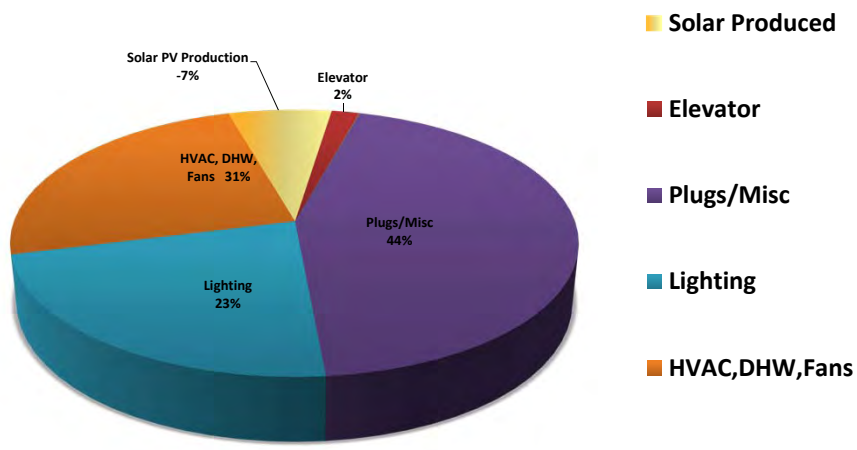
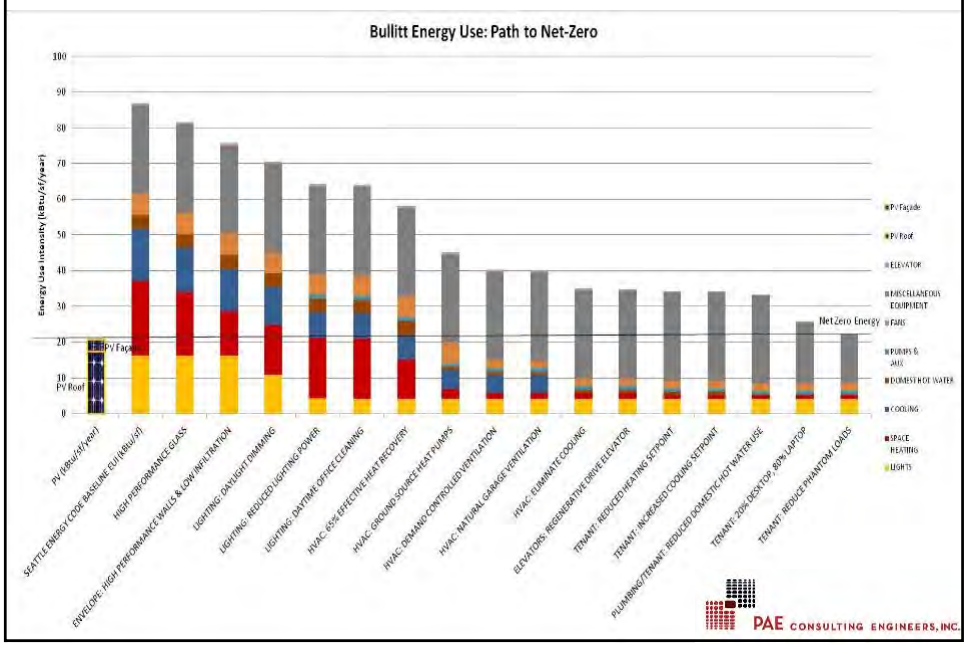
End Use in HP Buildings

RFM: Energy End Use based on 2 years

EUI = 20 kBtu/sf/yr



Net Zero Site Limits



Operator & Occupant Engagement

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Performance Analysis Tools

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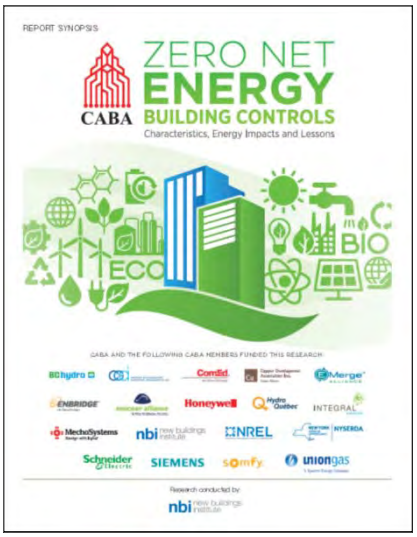
Outcome Project Examples

- Edith Green Wendell Wyatt Federal Building; Portland -SERA
- George Deukmejian Courthouse, Long Beach –AECOM/Clark
- Federal Center South; Seattle -ZGF



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It's High-Performance NOT High-Desires

National Institute of BUILDING SCIENCES
An Authoritative Source of Innovative Solutions for the Built Environment

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@rmcolker

Public Law 93-383, Sect. 809

Congress directed the Institute to "exercise its functions and responsibilities in four general areas……."

- **Develop and maintain** performance criteria for maintenance of life, safety, health, and public welfare for the built environment
- **Evaluate and prequalify** building technology and products
- **Conduct** related and needed investigations
- **Assemble, store, and disseminate** technical data and related information

National Institute of BUILDING SCIENCES

The Institute at Work

Industry Advocacy & Outreach

- Consultative Council
- Council on Finance, Insurance and Real Estate (CFIRE)
- Off-Site Construction Council (OSCC)
- Science, Technology, Engineering and Mathematics (STEM)
- Commercial Workforce Credentialing Council (CWCC)
- National Council of Governments on Building Codes and Standards (NCGBCS)

Facility Performance & Sustainability

- Building Enclosure Technology and Environment Council (BETEC)
- Sustainable Buildings Industry Council (SBIC)
- High Performance Building Council (HPBC)
- National Mechanical Insulation Committee
- Facility Maintenance and Operation Committee (FMOC)

Information Resources & Technology

- Whole Building Design Guide
- National Clearinghouse for Educational Facilities
- Building Research Information Knowledgebase (BRIK)
- buildingSMART alliance
- National BIM Standard-U.S.

Security & Disaster Preparedness

- Building Seismic Safety Council (BSSC)
- Multihazard Mitigation Council (MMC)
- Integrated Resilient Design Program
- Multihazard Risk Assessment/HAZUS

High-Performance Buildings

High-Performance building means a building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy [and water] conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.

-Energy Independence and Security Act of 2007 §401 (PL 110-140)

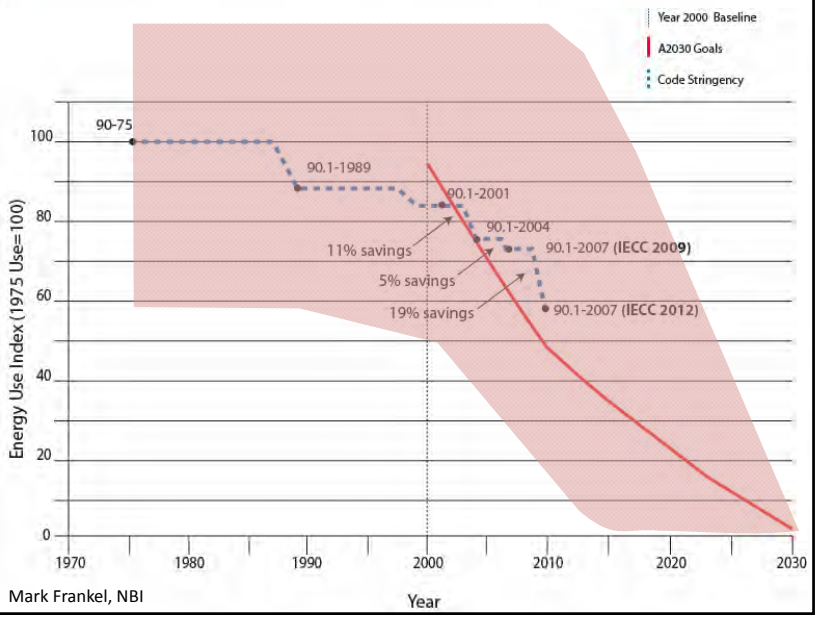
Identifying a Path Forward

- Wide-ranging examination of key issues with recommendations
- http://newbuildings.org/performance-outcomes-event-report
- Follow-on discussions in early 2016

Common Definition for ZEB

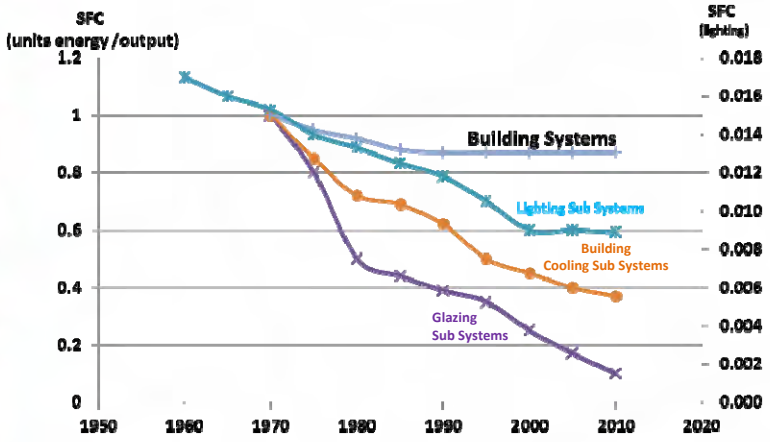
- Zero Energy Building (ZEB):
  - An energy-efficient **building** where, on a **source energy** basis, the actual **annual delivered energy** is less than or equal to the on-site renewable **exported energy**.
- The designation *Zero Energy Building (ZEB)* should be used only for *buildings* that have demonstrated through actual annual measurements that the *delivered energy* is less than or equal to the *on-site renewable exported energy*.
- http://energy.gov/eere/buildings/downloads/common-definition-zero-energy-buildings

Role of Energy Codes



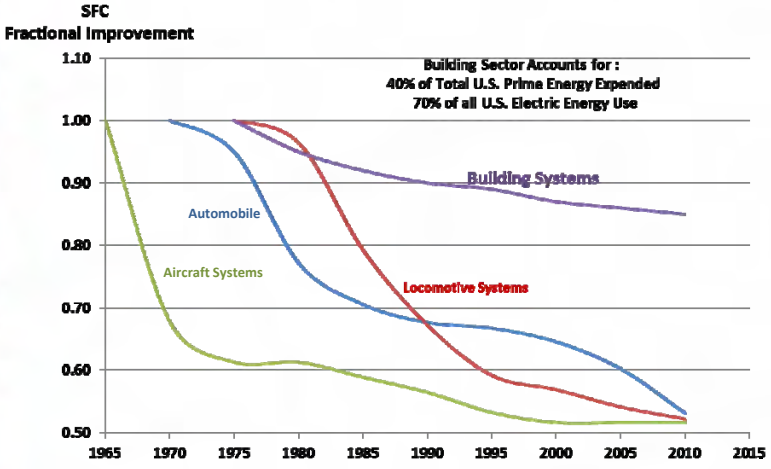
Mark Frankel, NBI

Individual sub-systems have become more efficient, but overall efficiency has been flat



Energy Efficient Buildings Hub/Consortium for Building Energy Innovation

Efficiency Improvements: Building Sector vs. Other Sectors



Energy Efficient Buildings Hub/Consortium for Building Energy Innovation

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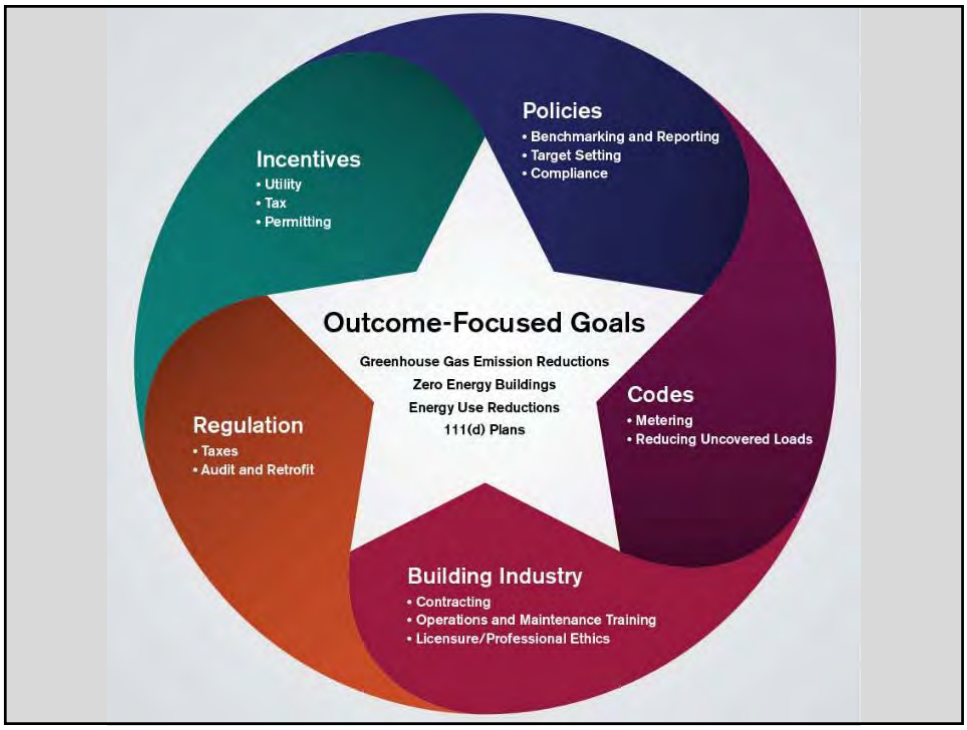
Driving to Outcomes

- We've done the easy stuff
  - Optimized current equipment/methodologies
  - Honed individual disciplines
- Drive for high-performance
  - Integrate and optimize to achieve multiple requirements
- Owners, Occupants, Policymakers demanding results
- Fundamental shift to life-cycle performance
  - Driving new tools, contracts, delivery methods
- Comprehensive strategy, collaborative approach
  - Integrated Design, BIM, Delivery Methods, Contracts, Commissioning



Tackling the Energy Code Challenges

- Bring wider focus to design→construction→operations
- Tie to actual, measured results
- Limit burdens on code departments
- Incent smooth handover
- Move beyond prescriptive and component-by-component approach
- All energy uses covered
- Compliance through most cost-effective means

Outcome-based Pathway in the International Green Construction Code

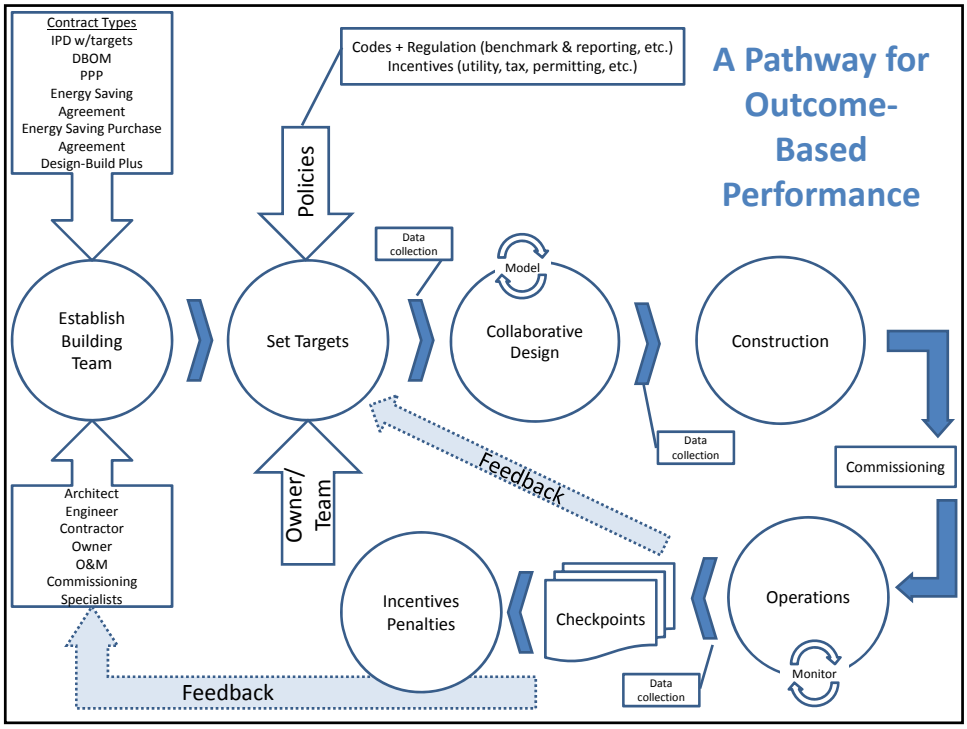
- Sets targets
  - Table based on CBECS
  - Ratio of actual performance to table reference
- Compliance
  - Issue Temporary Certificate of Occupancy or Post Occupancy Verification Permit
  - Owner bears burden of reporting to resolve TCO/POVP
    - 12 months compliant data within 3 years
    - Certified by registered design professional
    - Could hinder financing, insurance, leasing, sale, permitting, etc.
  - Penalties/resolution up to AHJ
  - Requires links with other policies/departments

Seattle Target Performance Path

- Outcome-based pathway
- Establishes energy use targets
- Requires demonstration of operational energy use
- Financial security to be used as penalty ($4sqft)
  - Proportion eligible for mitigation

Setting the Stage

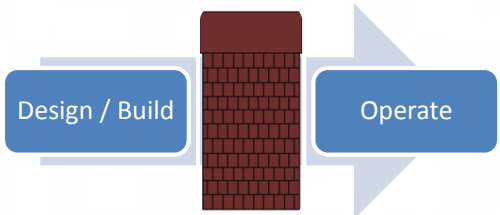
- Link with comprehensive policy approaches to performance goals
- Coupled with benchmarking & reporting can begin to develop localized targets
- Supports movement beyond one time demonstration to ongoing compliance
- Allows future focus on regulating performance of existing buildings
- Create feedback loops within & between AEC, O+M, government
- Drive improvements in performance data, modeling, turnover, integrated design and operations

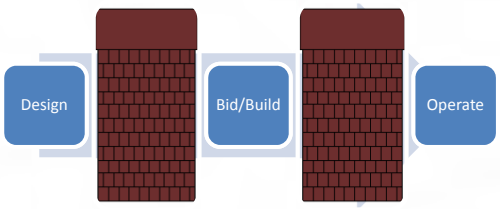


It's Not Just Codes. . .

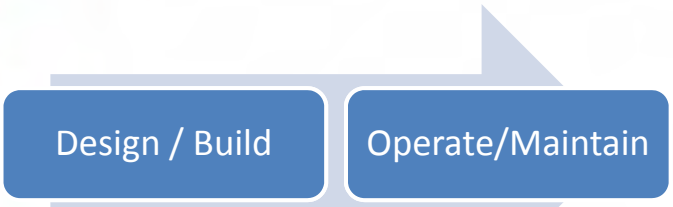
- Emergence of Performance Contracting
  - GSA
  - Washington
  - California
- Advancing past Design-Bid-Build
- New AIA Guide on PPP
  - http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab104939.pdf
- Commission on Environmental Cooperation Integrated Design & Delivery Guide

Procurement methods





Re-examine Procurement Methods



CONTRA COSTA TIMES
ContraCostaTimes.com

Team chosen to build, operate Long Beach Courthouse

By Karen Robes Meeks, Staff Writer

Posted: 06/28/2010 11:01:53 AM PDT

Updated: 06/28/2010 07:04:30 PM PDT

This is a rendering of what architect AECOM has envisioned for Long Beach Courthouse

PRESS-TELEGRAM

MUNICIPAL GOVERNMENTS

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Long Beach Civic Center financing plan proposal explained

By Erie Bradley, *Press-Telegram*

POSTED: 07/01/08, 7:43 PM PDT UPDATED: 3 WEEKS, 6 DAYS AGO 0 COMMENTS

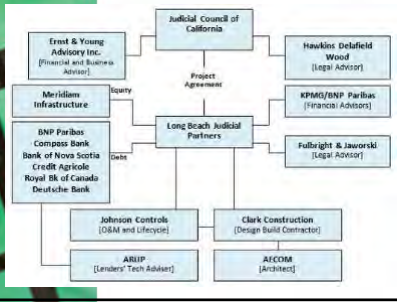
LONG BEACH >> City officials laid out a financial plan Tuesday to rebuild the Civic Center by combining funds spent on the current facility with money from selling land at the 16-acre complex to the developer.

The sale of six acres not used for new government buildings or facilities would net about $29 million, officials said, and is integral to realizing the city's vision of a revitalized downtown with new residences, restaurants, retail shops and a hotel connected to the Civic Center megablock.

In October, two competing proposals were revealed to replace the 37-year-old Civic Center, which includes City Hall, the Main Library and Lincoln Park.

The designs by Long Beach CivicCore Alliance and Plenary-Edgemoor Civic Partners — estimated at $344.3 million and $337.7 million, respectively — both placed city and port administrative buildings at Ocean Boulevard and Magnolia Avenue and moved the Main Library to the northern edge of Lincoln Park on Pacific Avenue.

Governor Deukmejian Courthouse, Long Beach



- Public-Private Partnership/DBFOM
- The performance-based contract allowed the courthouse to be constructed without any public funding and provides for the ongoing maintenance and performance of the facility. Under the terms of the agreement, the Judicial Council can deduct a specific amount from the availability payment if components of the building do not work. For example, there is a $5,000 deduct for every two hours that certain elevators are inoperable.

GSA Federal Center South

*7. CLIN 0005 – M&V and Warranty Period Verification. The Government will **retain a pre-determined amount of dollars** from the overall contract award during performance evaluation. Release of **payment** for this withheld amount **will be contingent upon final confirmation that the energy performance standards for the facility (i.e. actual BTU/GSF saved) have been achieved** as verified by the M&V and Warranty Period testing to be conducted within 365 days from final completion. The basis for the pre-determined amount shall be equal to **.5%** of the proposed construction price.*

Olympia, Washington Government Project

1063 Block Replacement Project

Click on the images above for a larger version.

The 2013 Legislature authorized, with some conditions, Enterprise Services to replace the 1063 Capitol Way S. block with:

- a 200,000-225,000 square foot;
- high-performance multi-tenant office building;
- using the design-build procurement process (RCW 39.10);
- with a five-year performance guarantee on energy, operations and maintenance;
- tenant lease cost of no more than $26 per gross square feet.

Project Updates/Announcements

- Sellen Construction Co. of Seattle and ZGF Architects of Portland have been selected as the apparent successful design team. Read the press release.

Subscribe for Updates

Just having the map doesn't mean you get the treasure. . .

- Need leaders to step up and lead the way
- Share your experiences/Educate peers
- Demand results/Deliver results
- Participate in development of tools, policies

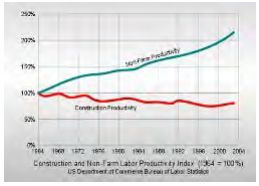
Overall Needs for Effective Outcomes

- Education across industry
  - AEC
  - Code Officials
  - Government
- Guidance documents
  - Modeling
  - Benchmarking
  - Policy Frameworks
- Insurance Markets
- Contracting Tools

Overall Needs for Effective Outcomes

- Procurement guides
- Data protocols
- Links with 111(d) programs as measurable, verified reductions in energy/GHGs
- Shifts in processes, design fees, risk profiles, project scope, attitudes
- Case studies

Shifting Perceptions on the Cost of High Performance



High Performance Buildings
- Operationally Cost effective
- Sustainable / Green / Energy Efficient
- Resilient / DR-COOP
- Supports Productivity / Mission
- Functional / Operational
- Preserve historical value
- Safe to work in
- Secure from threats
- Accessible
- Aesthetically pleasing

+

Improved Facility Delivery
- Reduce product waste
- Prefabrication
- Improve supply chain
- Process optimization
- Systems analysis
- Performance analysis
- Commissioning
- Improve product selection
- Common information base
- Coordinate decision making
- Integrate scheduling
- Optimize design
- Design to sustain

=

Results
Achieve net zero energy
Reduce water consumption
Protect environment
Reduced carbon footprint
Meet LEED goals
Meet Energy Star Goals
Asset optimization

Initial Investment Costs + Lifetime Cost Reductions = Zero or Net Positive

Utilizing BIM to Optimize Operations

- UK Government leading the way
  - Soft Landings

As stated in the Government Construction Strategy, May 2011, Soft Landing objective:

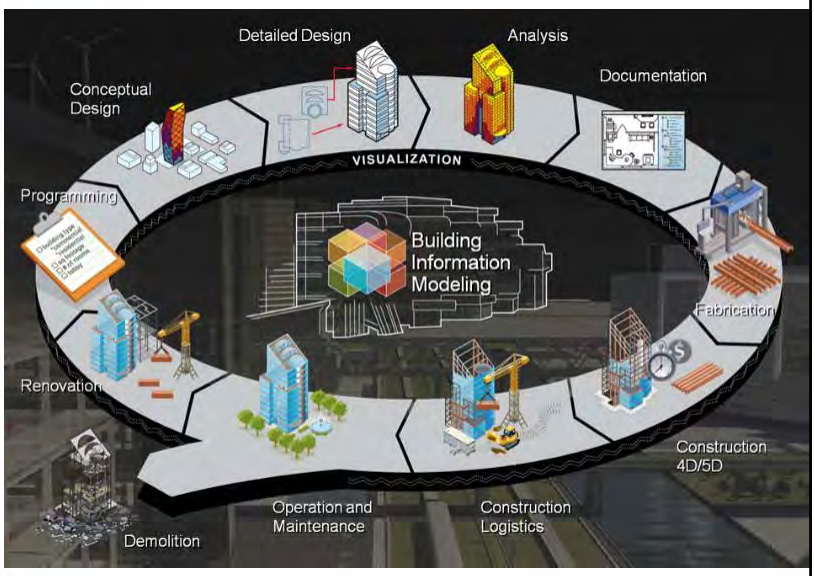
Aligning the interests of those who design and construct an asset with those who subsequently use it

Specific Action : Trial introduction of a period (say 3 to 5 years) of post completion proving of the asset by constructors. Note connection with BIM and its potential to connect design and construction information to asset management.

Outcome sought : Project designed and delivered to required operational standards; and to allow asset to operate to the required standard for the whole of its life.

  - Focus on the "Golden Thread"
    - Why we build the building in the first place
- BIM is not just a design tool, but a life-cycle management tool

The Facility Lifecycle



Courtesy of Autodesk

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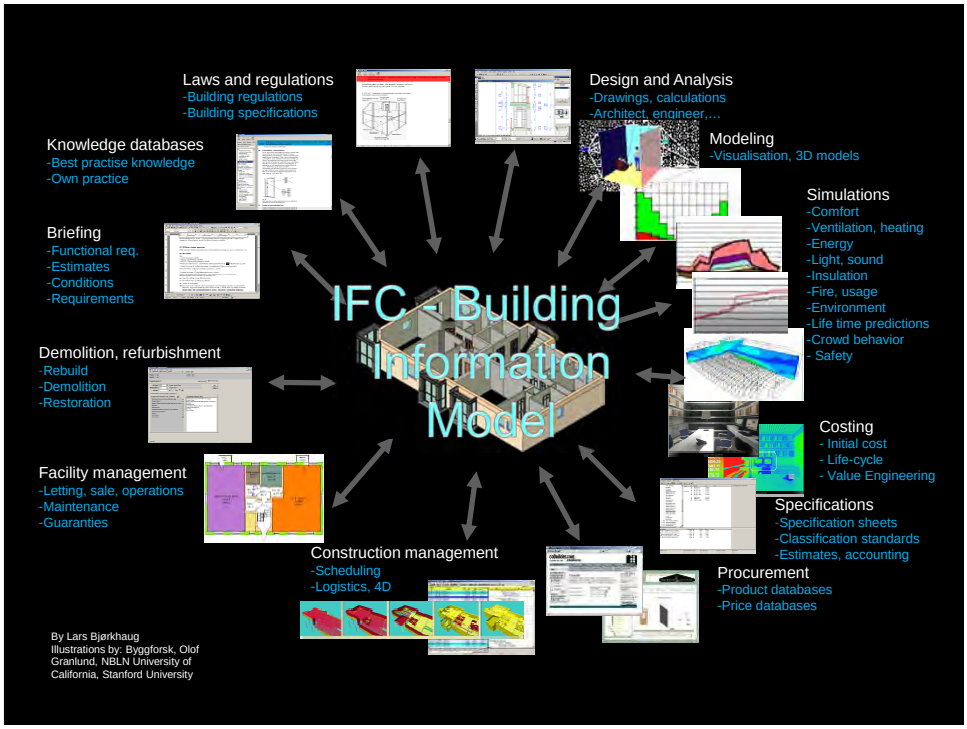
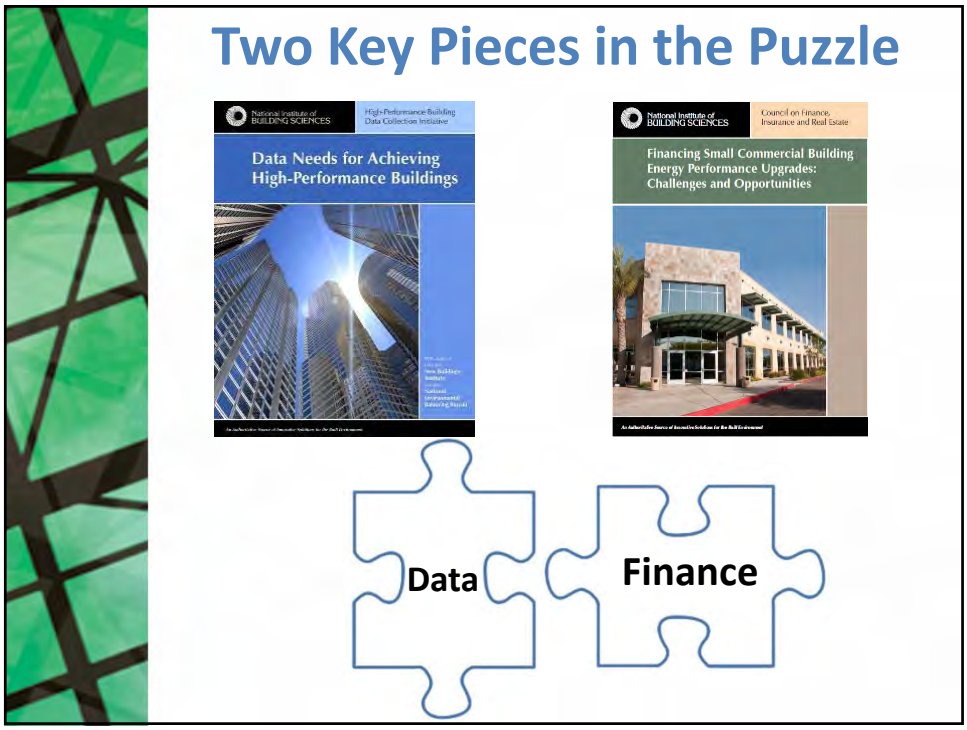
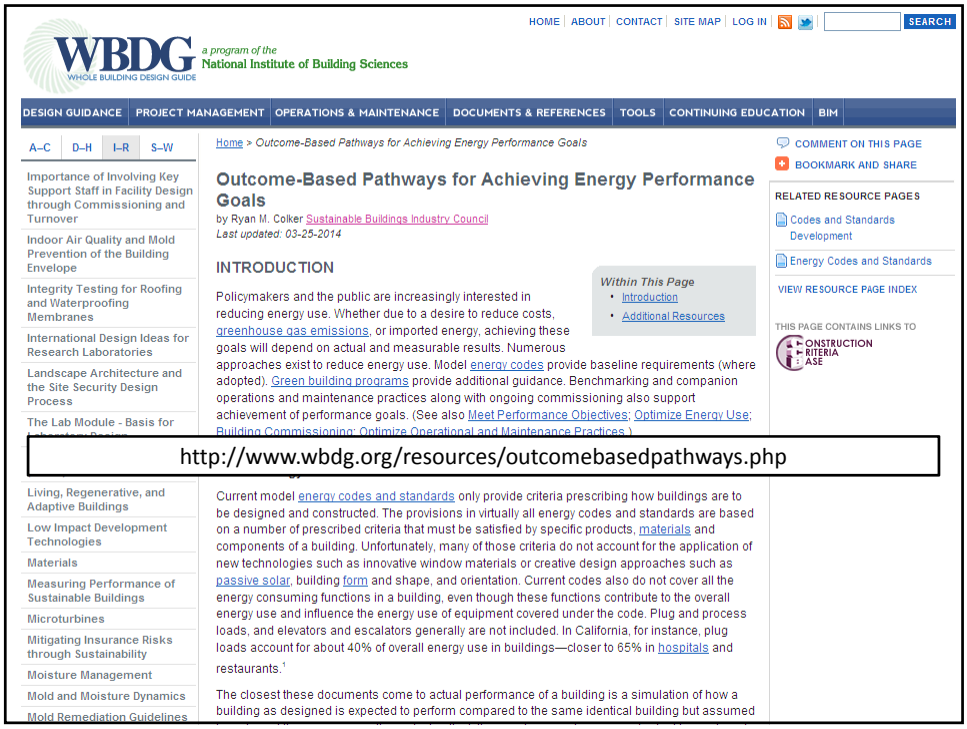
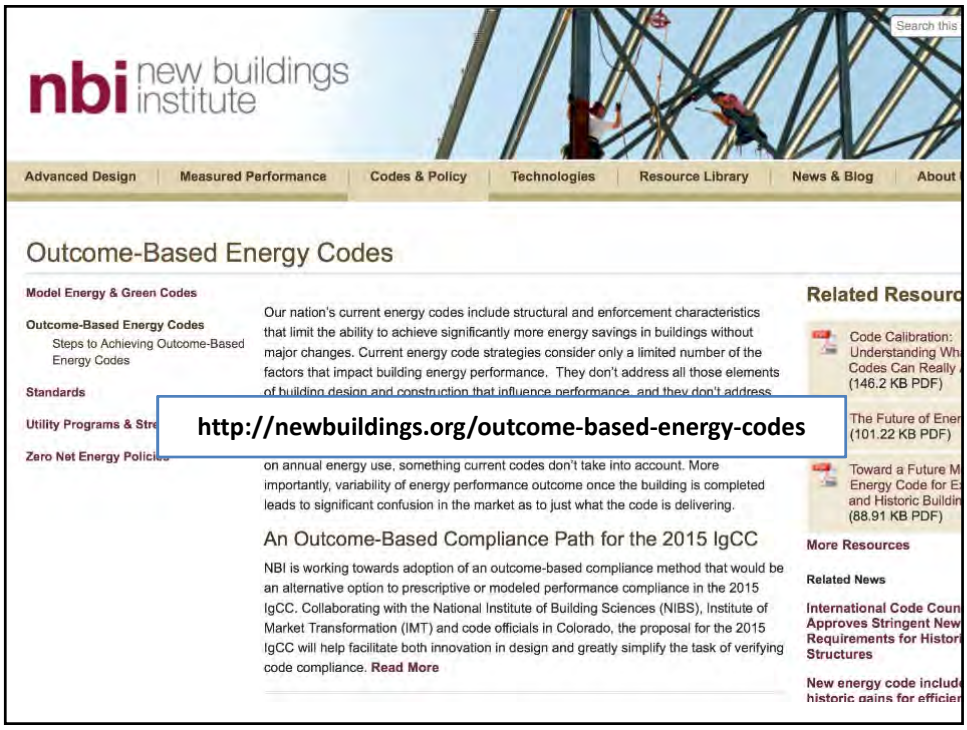

Laws and regulations
-Building regulations
-Building specifications
Design and Analysis
-Drawings, calculations
-Architect, engineer,...
Knowledge databases
-Best practise knowledge
-Own practice
Modeling
-Visualisation, 3D models
Simulations
-Comfort
-Ventilation, heating
-Energy
-Light, sound
-Insulation
-Fire, usage
-Environment
-Life time predictions
-Crowd behavior
- Safety
Briefing
-Functional req.
-Estimates
-Conditions
-Requirements
IFC - Building Information Model
Demolition, refurbishment
-Rebuild
-Demolition
-Restoration
Costing
- Initial cost
- Life-cycle
- Value Engineering
Facility management
-Letting, sale, operations
-Maintenance
-Guaranties
Specifications
-Specification sheets
-Classification standards
-Estimates, accounting
Construction management
-Scheduling
-Logistics, 4D
Procurement
-Product databases
-Price databases
By Lars Bjørkhaug
Illustrations by: Byggforsk, Olof Granlund, NBLN University of California, Stanford University


Two Key Pieces in the Puzzle
National Institute of BUILDING SCIENCES
High-Performance Building Data Collection Initiative
Data Needs for Achieving High-Performance Buildings
National Institute of BUILDING SCIENCES
Council on Finance, Insurance and Real Estate
Financing Small Commercial Building Energy Performance Upgrades: Challenges and Opportunities
Data
Finance

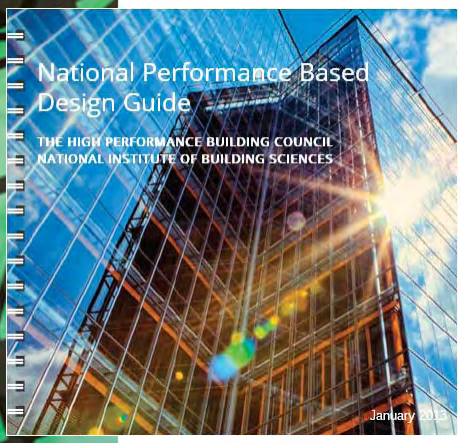


http://www.wbdg.org/resources/outcomebasedpathways.php



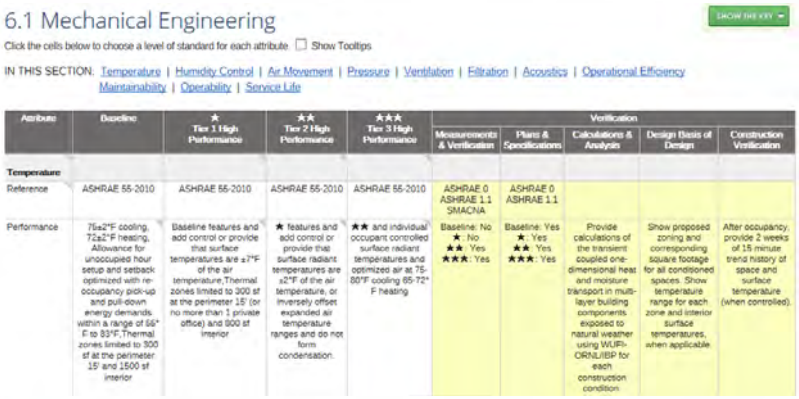
http://newbuildings.org/outcome-based-energy-codes

National Performance Based Design Guide



Go to http://npbdg.wbdg.org for latest version

National Performance Based Design Guide



6.1 Mechanical Engineering

SHOW THE KEY

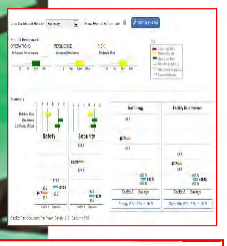
Click the cells below to choose a level of standard for each attribute ☐ Show Tooltips

IN THIS SECTION: Temperature | Humidity Control | Air Movement | Pressure | Ventilation | Filtration | Acoustics | Operational Efficiency | Maintainability | Operability | Service Life

Attribute	Baseline	★ Tier 1 High Performance	★★ Tier 2 High Performance	★★★ Tier 3 High Performance	Verification: Measurements & Verification	Verification: Plans & Specifications	Verification: Calculations & Analysis	Verification: Design Basis of Design	Verification: Construction Verification
Temperature									
Reference	ASHRAE 55-2010	ASHRAE 55-2010	ASHRAE 55-2010	ASHRAE 55-2010	ASHRAE 0 ASHRAE 1.1 SMACNA	ASHRAE 0 ASHRAE 1.1			
Performance	76±2°F cooling, 72±2°F heating. Allowance for unoccupied hour setup and setback optimized with re-occupancy pick-up and pull-down energy demands. within a range of 66° F to 83°F. Thermal zones limited to 300 sf at the perimeter 15' and 1500 sf interior	Baseline features and add control or provide that surface temperatures are ±7°F of the air temperature. Thermal zones limited to 300 sf at the perimeter 15' (or no more than 1 private office) and 900 sf interior	★ features and add control or provide that surface radiant temperatures are ±2°F of the air temperature, or inversely offset expanded air temperature ranges and do not form condensation.	★★ and individual occupant controlled surface radiant temperatures and optimized air at 75-80°F cooling 65-72° F heating	Baseline: No ★: No ★★: Yes ★★★: Yes	Baseline: Yes ★: Yes ★★: Yes ★★★: Yes	Provide calculations of the transient coupled one-dimensional heat and moisture transport in multi-layer building components exposed to natural weather using WUFI-ORNL/IBP for each construction condition	Show proposed zoning and corresponding square footage for all conditioned spaces. Show temperature range for each zone and interior surface temperatures, when applicable.	After occupancy, provide 2 weeks of 15 minute trend history of space and surface temperature (when controlled).

Go to http://npbdg.wbdg.org for latest version

Owner's Performance Requirements Tool



- **Assists the design community** to plan new building designs and retrofit projects by analyzing different performance scenarios and producing cost effective strategies as outputs
- **Allows decision makers to make judgments** in terms of how much exposure and cost is acceptable for:
  - Resilience performance
  - Overall Risk levels
  - Seismic risk
  - Flood risk
  - Tornado risk
  - Blast range threat
  - Ballistic threat
  - CBR exposure
  - Exterior glazing
  - Air tightness/leakage
  - Unit energy cost
  - Natural ventilation
  - Solar energy
  - Noise control

Available at www.oprtool.org

OPR Enables Owner ROI Analysis

Planning Process

New Construction OPR

Retrofit OPR

Fire, Safety
Security
Energy
Environment

HP Considerations
HP Materials
Multi-Hazards

Owner Prioritized HP A&D → Owner Prioritized Engineering

Performance Improvements	Selected Results	
• Illustrates how the OPR tool can show the ROI when increasing performance. • Based on a realistic example of an office building. Performance was increased for all safety and security attributes – CBR not included		
Highest Improved Performance Scenario – Negligible damage, minor repairs required to the envelope, no disruption in operations	70% Increase in CapEx	1200% Decrease in Exposure
Moderate Improved Performance Scenario - Repairable damage to envelope, some disruption in operations	57% Increase In CapEx	230% Decrease in Exposure
Lowest Improved Performance Scenario (Life Safety) – Building destroyed but does not collapse	20% Increase In CapEx	0 % Decrease in Exposure

Cost vs. Resilience (Return on Investment)

OPR also evaluates ROI from operational improvements (energy savings, and durability)

Occupant Inputs = Zero Energy Output

Paul A. Torcellini, Ph.D., P.E.
Principal Engineer, NREL

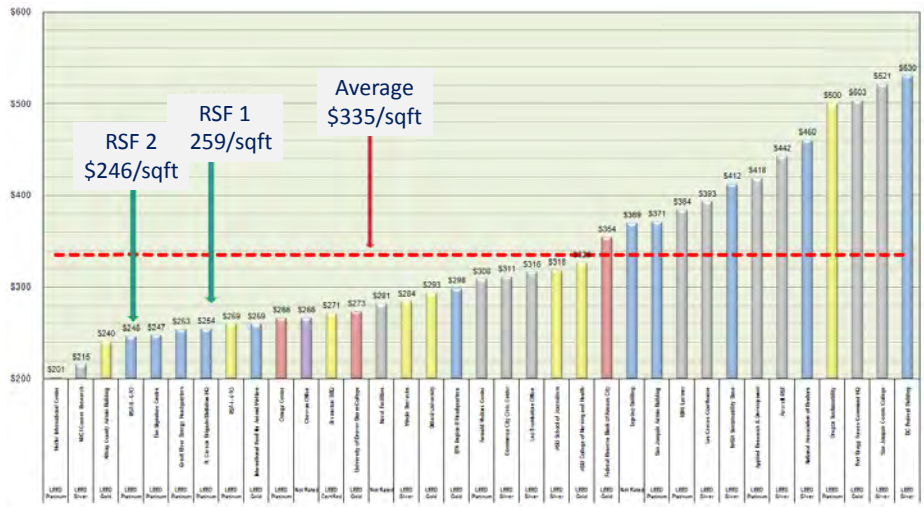
November 4, 2015

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

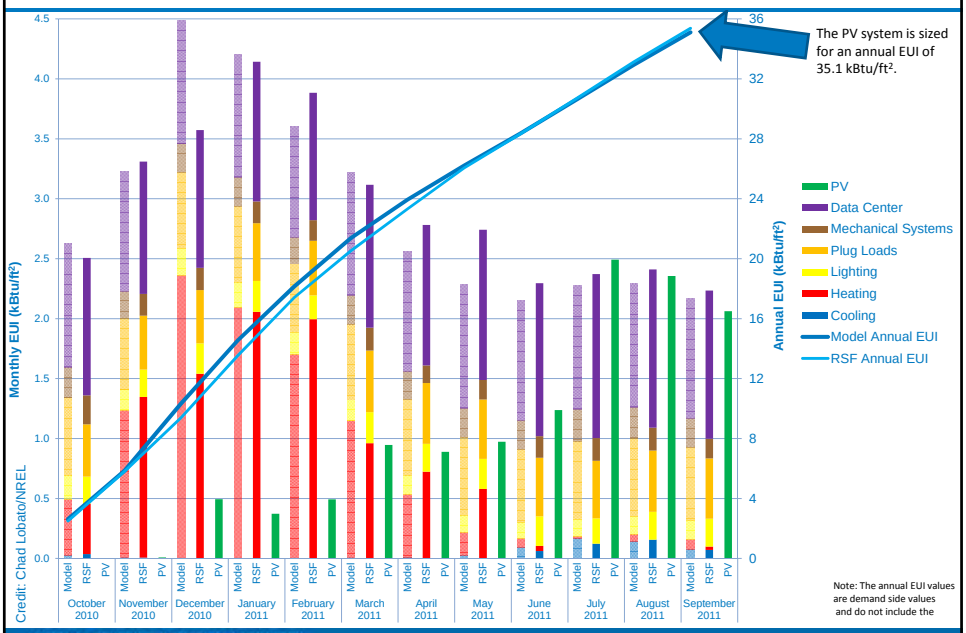
- RSF uses 50% less energy than if it were built to current commercial codes at no extra capital cost
- RSF increases space at NREL by 60% but only increases energy use by 6%

NREL/17833

RSF Built for "No Additional Cost"



Measured Versus Modeled Monthly and Cumulative EUI

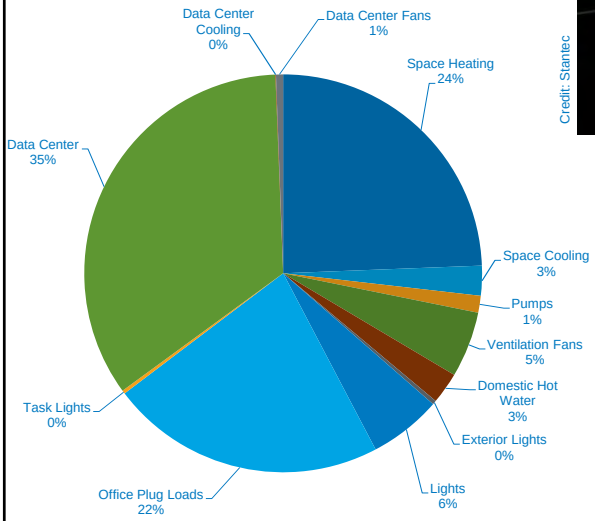


Buildings Are For Occupants!

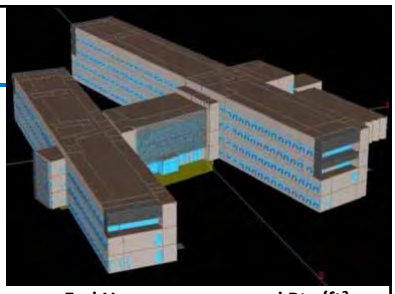
- Occupants and Operators ultimately control *all* the energy loads
- Frustration when Occupants are expected to "perform" but have no levers to control
- Plug loads
- Design elements for the Occupants
- Occupant training

RSF Energy Modeling

NREL RSF Energy Use Breakdown



Credit: Chad Lobato/NREL



Credit: Stantec

End Use	kBtu/ft²
Space Heating	8.58
Space Cooling	0.85
Pumps	0.48
Ventilation Fans	1.88
Domestic Hot Water	0.90
Exterior Lights	0.12
Lights	2.07
Office Plug Loads	7.87
Task Lights	0.10
Data Center	12.11
Data Center Cooling	0.02
Data Center Fans	0.20

Day vs. Night Plug and Process Loads

Only occupied about ⅓ of the time
- -Nights Unoccupied
- -Weekends Unoccupied
- -Holidays Unoccupied

Occupied Hours Power Density (W/ft²)	Unoccupied Hours Power Density (W/ft²)														
	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50
0.10	3.0	5.2	7.4	9.7	11.9	14.1	16.3	18.6	20.8	23.0	25.2	27.4	29.7	31.9	34.1
0.20	3.8	6.0	8.2	10.4	12.7	14.9	17.1	19.3	21.5	23.8	26.0	28.2	30.4	32.7	34.9
0.30	4.5	6.8	9.0	11.2	13.4	15.6	17.9	20.1	22.3	24.5	26.8	29.0	31.2	33.4	35.6
0.40	5.3	7.5	9.7	12.0	14.2	16.4	18.6	20.9	23.1	25.3	27.5	29.7	32.0	34.2	36.4
0.50	6.1	8.3	10.5	12.7	15.0	17.2	19.4	21.6	23.8	26.1	28.3	30.5	32.7	35.0	37.2
0.60	6.8	9.1	11.3	13.5	15.7	17.9	20.2	22.4	24.6	26.8	29.1	31.3	33.5	35.7	38.0
0.70	7.6	9.8	12.0	14.3	16.5	18.7	20.9	23.2	25.4	27.6	29.8	32.1	34.3	36.5	38.7
0.80	8.4	10.6	12.8	15.0	17.3	19.5	21.7	23.9	26.2	28.4	30.6	32.8	35.0	37.3	39.5
0.90	9.1	11.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.7	26.9	29.1	31.4	33.6	35.8	38.0	40.3
1.00	9.9	12.1	14.4	16.6	18.8	21.0	23.2	25.5	27.7	29.9	32.1	34.4	36.6	38.8	41.0
1.10	10.7	12.9	15.1	17.3	19.6	21.8	24.0	26.2	28.5	30.7	32.9	35.1	37.3	39.6	41.8
1.20	11.4	13.7	15.9	18.1	20.3	22.6	24.8	27.0	29.2	31.4	33.7	35.9	38.1	40.3	42.6
1.30	12.2	14.4	16.7	18.9	21.1	23.3	25.5	27.8	30.0	32.2	34.4	36.7	38.9	41.1	43.3
1.40	13.0	15.2	17.4	19.6	21.9	24.1	26.3	28.5	30.8	33.0	35.2	37.4	39.7	41.9	44.1
1.50	13.7	16.0	18.2	20.4	22.6	24.9	27.1	29.3	31.5	33.8	36.0	38.2	40.4	42.6	44.9

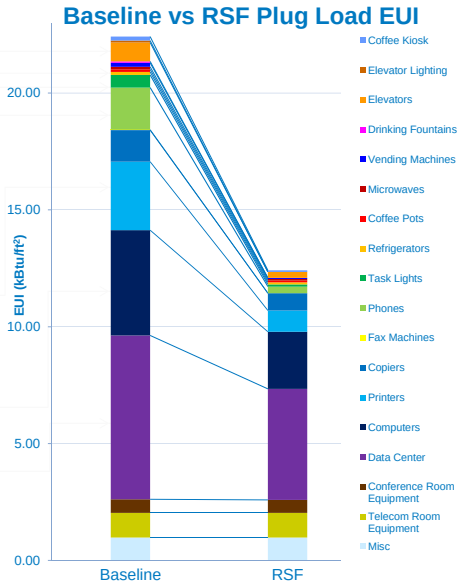
Plug Loads

- **4 Quads—20% of commercial building energy use**
- **Office equipment is 7% of total electrical use**
- **Very diverse and diffuse making them hard to manage and control**
- **Evaluated current plug loads**
- **Developed a process to reduce**
  - o Unused equipment
  - o Space conditioning
  - o Lighting needs

RSF Plug Load Reduction Strategies

- **Elevators**
  - Use energy efficient traction elevators
  - Change elevator lighting to energy efficient fluorescent lighting
  - Turn off elevator lighting when the elevator is unoccupied
- **Break Rooms**
  - Increase the number of people that use each break room from approximately 40 to 60
  - Eliminate the cooler on the drinking fountain
- **Task Lights**
  - Move from 35W fluorescent task lights to 6W LED task lights
- **Phones**
  - Go from 1000 standard phones to 1000 VOIP phone that consumes 2W each
- **Copiers, Printers, Fax Machines**
  - Decrease the number people that use individual copiers, printers and fax machines
  - Increase the number of people that use common, or group, copiers, printers and fax machines from 15 to 20
  - Increase the use of all-in-one machines
- **Computers**
  - Go from approximately 260 laptops, 33% of staff, to 720, 90% of staff, ensure standby mode works for all workstations
- **Data Center**
  - Blade Servers with Virtualization
  - High efficiency UPS
  - 65W/employee current to 48W/employee in RSF

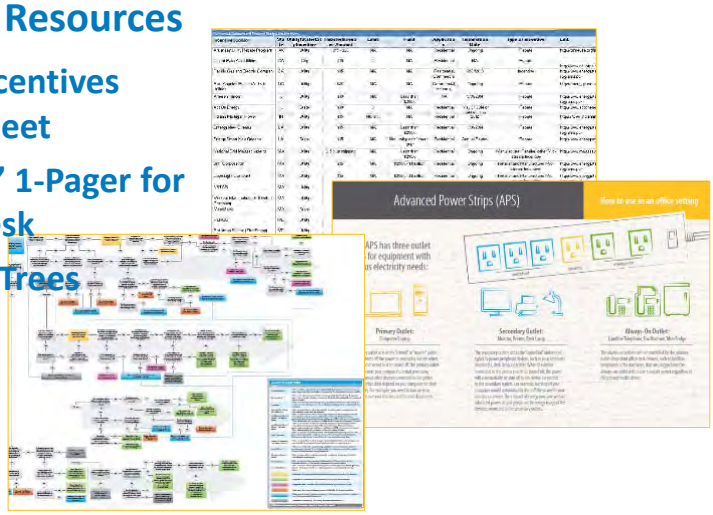
- **The result of these strategies is a 47% reduction in plug loads**



Graphics and Technical Resources

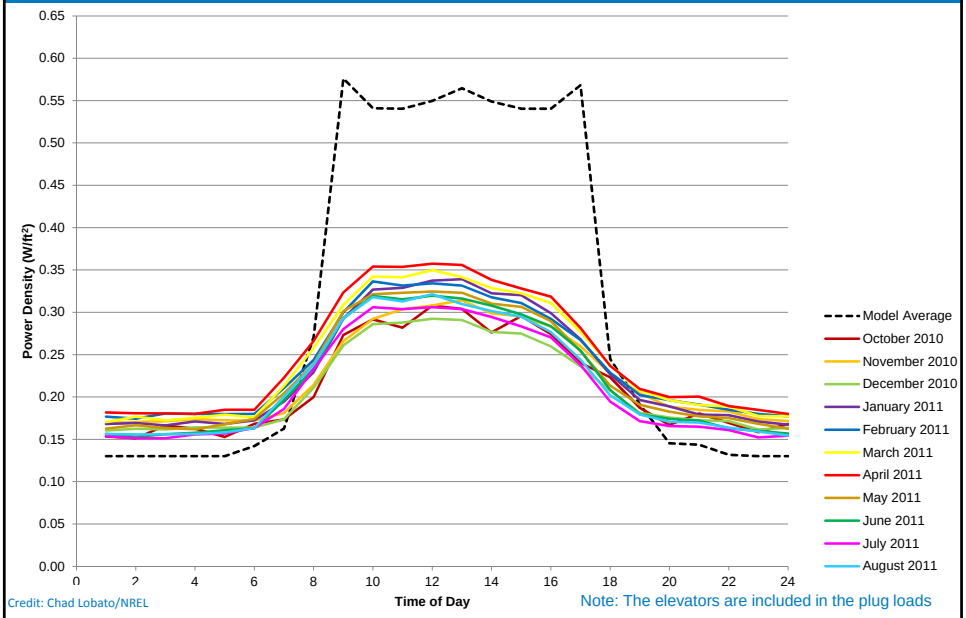
Technical Resources

- **Utility Incentives Spreadsheet**
- **"How To" 1-Pager for Office Desk**
- **Decision Trees**



70

October 2010 – August 2011 Plug Load Power Density

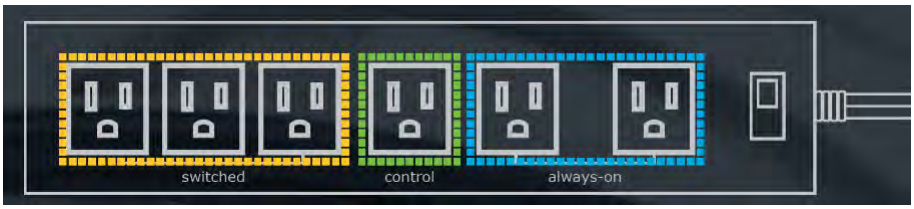


Credit: Chad Lobato/NREL

Note: The elevators are included in the plug loads

Tools Deployed

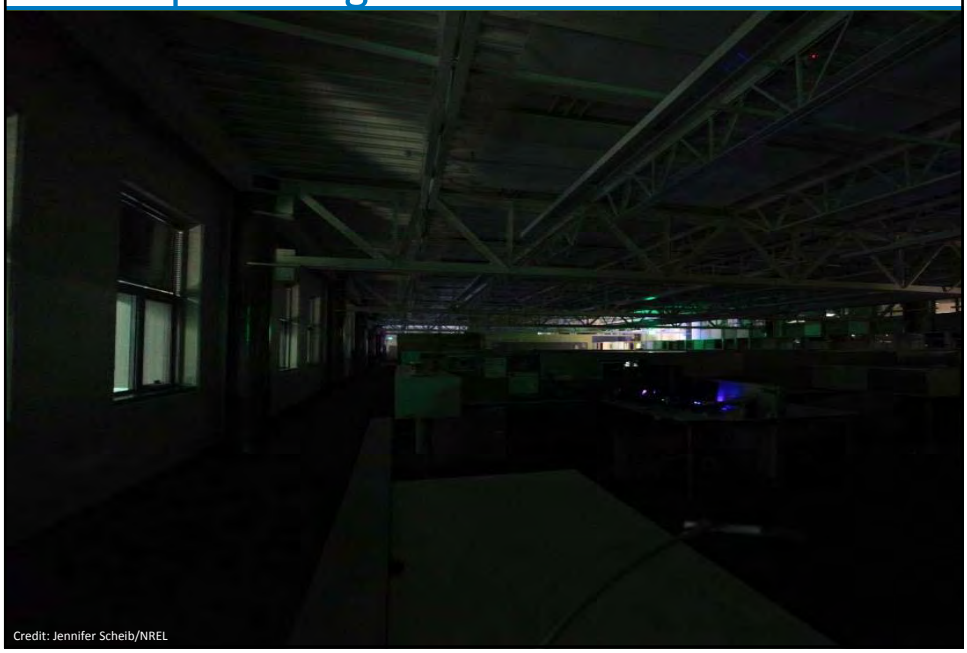
- **Effective break rooms**
  - Water
  - Refrigeration
  - Thermal comfort
- **Advanced Power Strips**



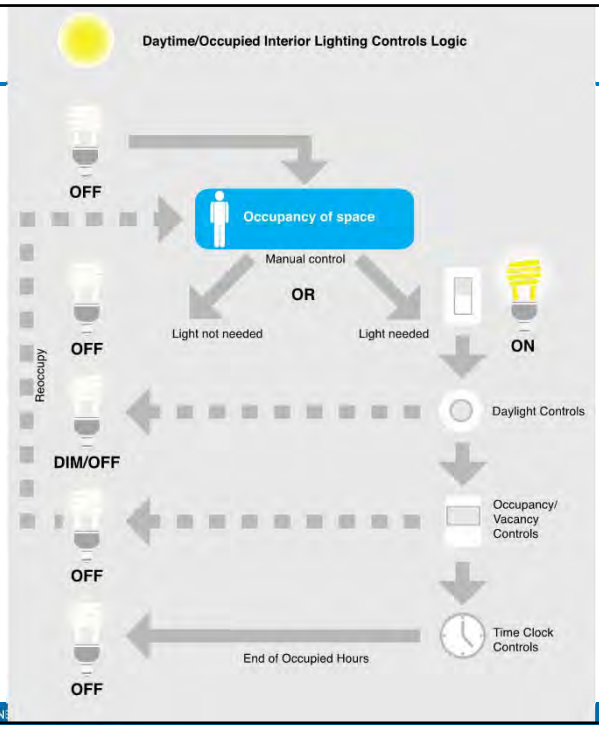
Lighting Control

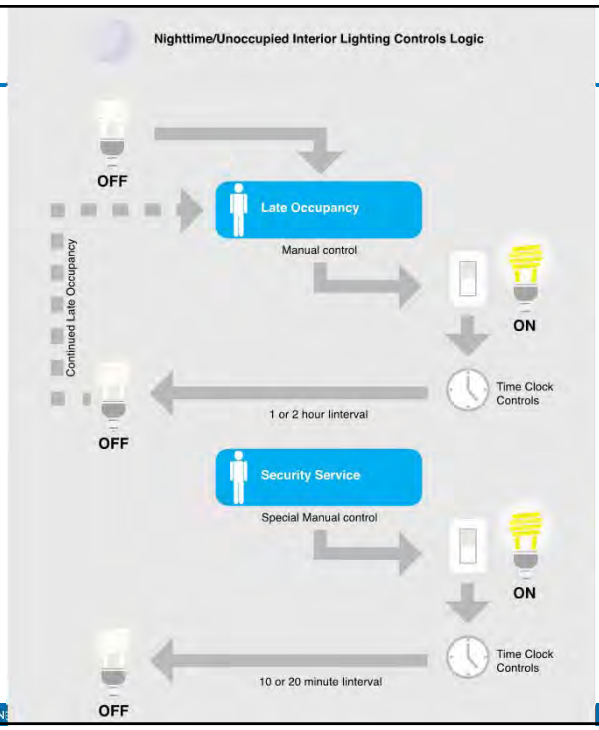
- Must look like an on/off switch
- Give the users control
- Vacancy control strategy

Is this photo significant?



Credit: Jennifer Scheib/NREL


Daytime/Occupied Interior Lighting Controls Logic
OFF
Occupancy of space
Manual control
OR
Light not needed
Light needed
OFF
ON
Reoccupy
Daylight Controls
DIM/OFF
Occupancy/
Vacancy
Controls
OFF
Time Clock
Controls
End of Occupied Hours
OFF
NATIONAL RENEWABLE EN
75


Nighttime/Unoccupied Interior Lighting Controls Logic
OFF
Late Occupancy
Manual control
Continued Late Occupancy
ON
Time Clock
Controls
1 or 2 hour linterval
OFF
Security Service
Special Manual control
ON
Time Clock
Controls
10 or 20 minute linterval
OFF
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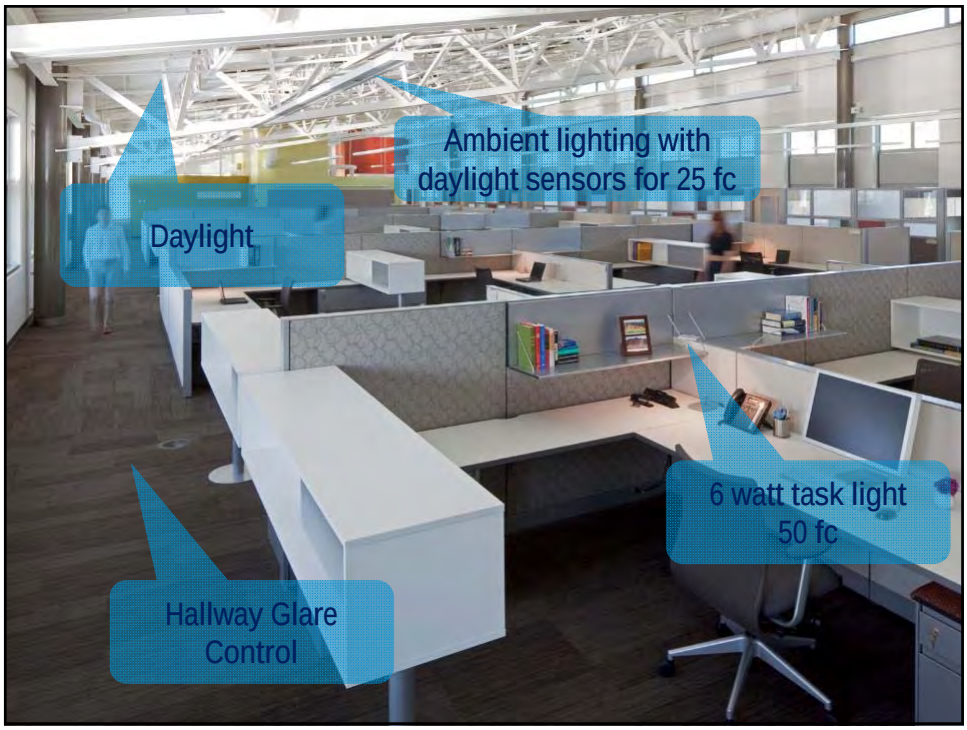
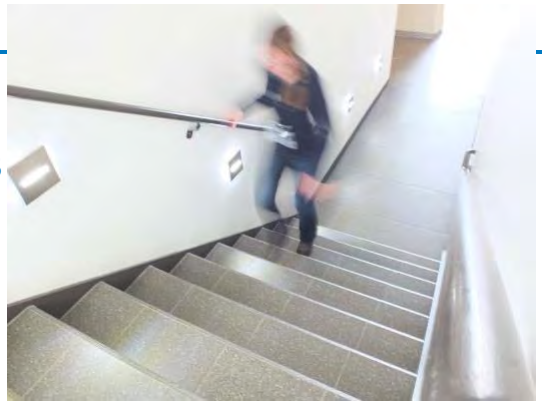
76


Radiant Ceilings
Underfloor Ventilation
Thermal Mass Walls
Operable Windows


Ambient lighting with daylight sensors for 25 fc
Daylight
6 watt task light 50 fc
Hallway Glare Control

Space Layout

- Inviting stairwells
- Hallways with bright ends
- Elevators only in the center spline



USER MANUAL

Figure 8. iGo Power Smart

Computer Standby:

Your computer automatically enters standby m
away from your workstation for more than 15 m
placing your computer into standby mode. Perf
standby.

- ☐ If you have a PC, press Ctrl+Alt+Delete si button and select *Stand by* from the dr
- ☐ If you have a Mac, you can either choose select "Sleep" from the popup.

Move your mouse or press the power button to
password to begin working. If your computer is
please contact Client Services at ext. 4171 for a

More Energy Saving Opportunities:

The following are some additional ways you car

- ☐ Use the stairs whenever possible to redu
- ☐ Check that shared printers, plotters, and inactivity and if you notice that they rei morning and no one has printed, but th
- ☐ Please do not use a personal heater or fa can also pose a safety hazard. If your w the Work Control Center at ext. 3232 o sweater at your desk for those chilly da summer days.

NREL Research Support Facility (RSF) Energy Efficiency Manual

The Research Support Facility (RSF) building was designed with energy efficiency and sustainability in mind. Many of the innovative technologies included in the RSF utilize passive and active processes to provide energy for the operation of the building, such as electricity, heating and cooling. The goal of this unique office building is to reach net zero energy usage by partnering these technologies with staff practice – you are an active part in this living laboratory that shows the world that a large office building can achieve high energy efficiency. This document details the ways that you will interact with the RSF to help NREL achieve our goal through efficient use of lighting, cooling and ventilation, and electric device usage.

Lighting

Offices and Workstations:

The RSF uses natural daylighting from the north and south windows as its primary lighting strategy. On overcast days and early or late in the day in the winter when daylight is limited, electrical lighting is used in conjunction with daylighting, as needed. Refer to Figure 1 for an illustration of how daylighting works in the RSF.

Figure 1. RSF daylighting concept

Each work zone is equipped with light switches that help you interact with the RSF's energy saving features. Status lights show you the lighting mode, as follows.

Indicator light convention for RSF I:

- ☐ Red light: The lights are on.
- ☐ Green light: The lights are currently off and can be turned on, if needed.

Indicator light convention for RSF II:

- ☐ Upper green light illuminated: The lights are on.
- ☐ Lower green light illuminated: The lights are off.


STAFF WEBSITE
Research Support Facility
How You Can Help the RSF Use Less Energy
Lights
Light Switches
RSF I Indicator Lights (B and C wings)
RSF II Indicator Lights (A wing)
Windows
Use Recommended Equipment
Standby Your Computer When Away
NATIONAL RENEWABLE ENERGY LABORATORY
81


Research Support Facility
Energy Tracker
Lighting
6.8kW
Plug Loads
50kW
Data Center
150.9kW
Whole Building
-1433.9 kW
Photovoltaics
1805.5kW
Mechanical
5.7kW
Cooling
0kW
Heating
158.2kW
Home
Whole Building
Photovoltaics
Plug Loads
Mechanical
Lighting
Data Center
Heating
Cooling
Comfort
NATIONAL RENEWABLE ENERGY LABORATORY
82

Summary

- Keep the building simple
- Let the occupants help with the controls—engage them
- Default is maximum energy savings
- Make the user interface SIMPLE
- Design the building to be robust and to work with the occupants, not ignore the occupants
- Occupants can be come your biggest ally.

NREL

www.nrel.gov/rsf
Buildingdata.energy.gov/cbrd
Paul Torcellini
Paul.Torcellini@nrel.gov



Results from a Living Building

The Bullitt Center Turns Two

Presented By: Ruwan Jayaweera, PE, LEED AP, Senior Associate

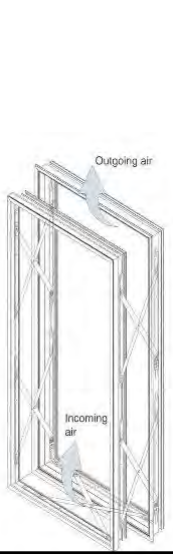
So, Did We Hit the Mark?

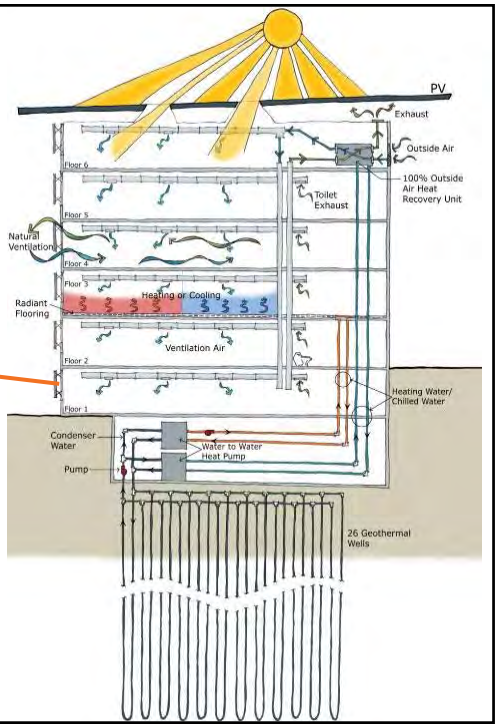
LIVING BUILDING CHALLENGE™ 2.0

✓ **Certified March 2015**

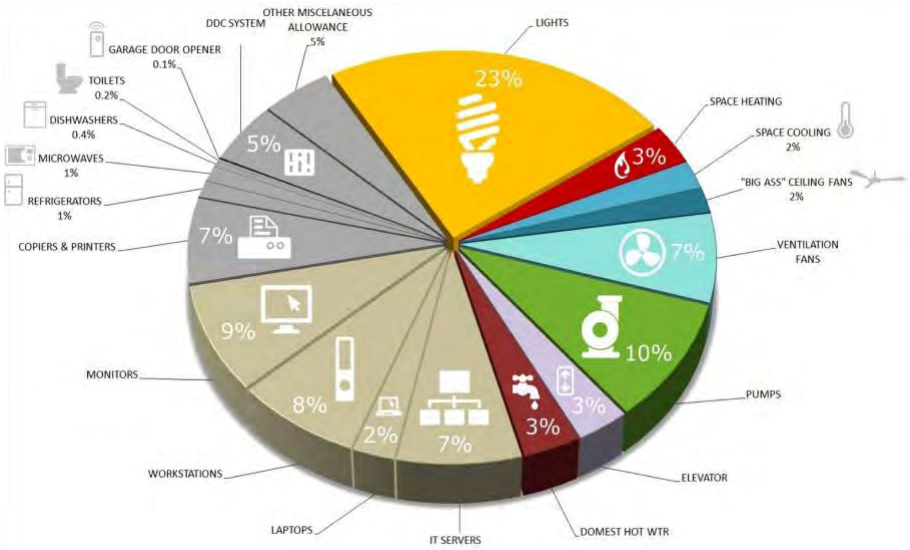
Bullitt Center

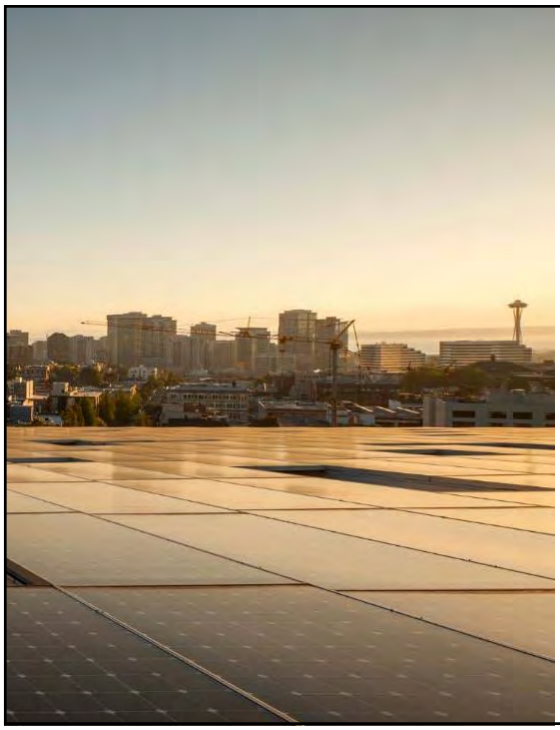
HVAC System Overview





Proposed Building Energy Use





Actual Performance

Bullitt Center Performance

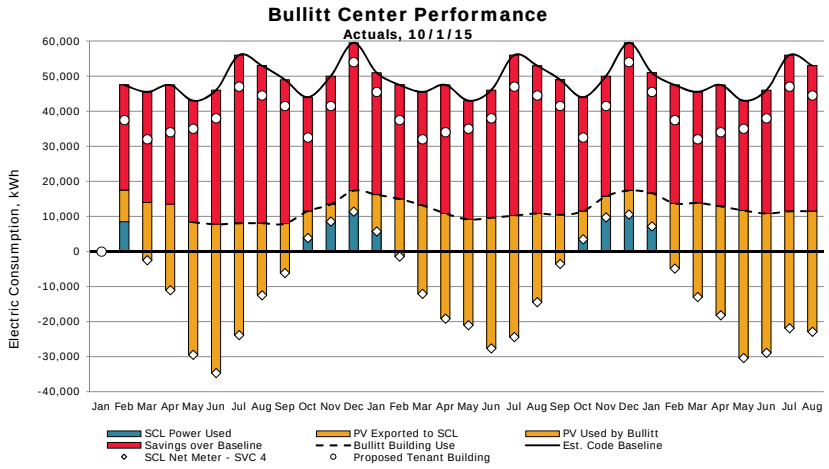
Net **positive** building

EUI under **10** in 2014 | Predicted EUI of 16

85% occupied

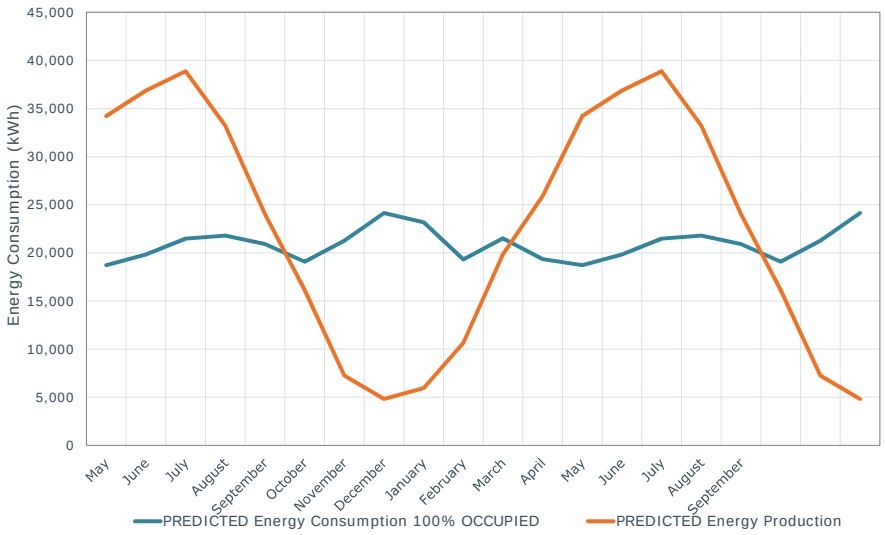
Predicted vs. Actual

Bullitt Center Performance



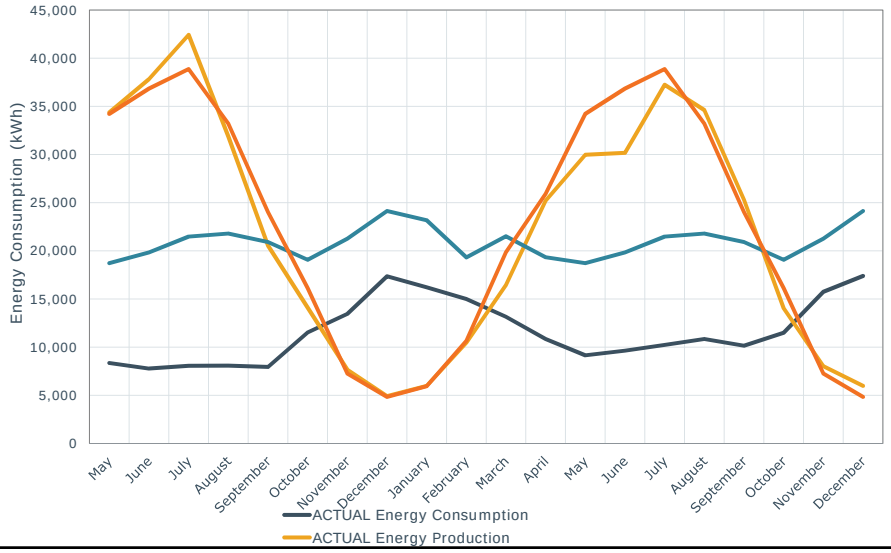
Bullitt Center Energy

Predicted Energy Production & Consumption



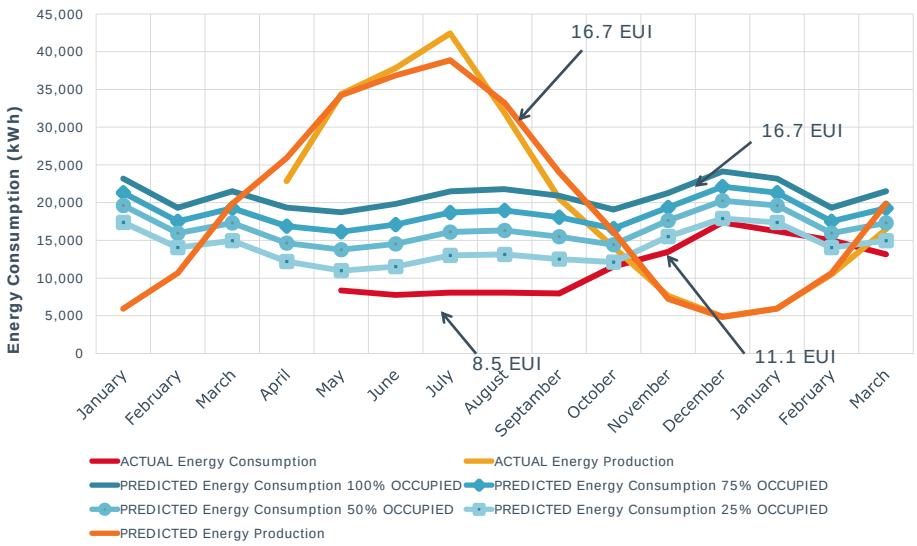
Bullitt Center Energy

Predicted Energy Production & Consumption



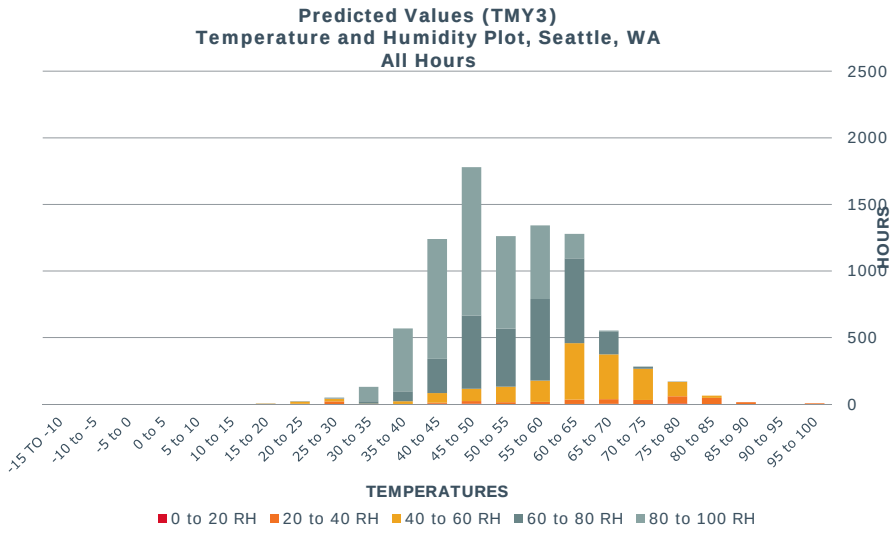
Bullitt Center Energy

Predicted vs. Actual Energy Production & Consumption



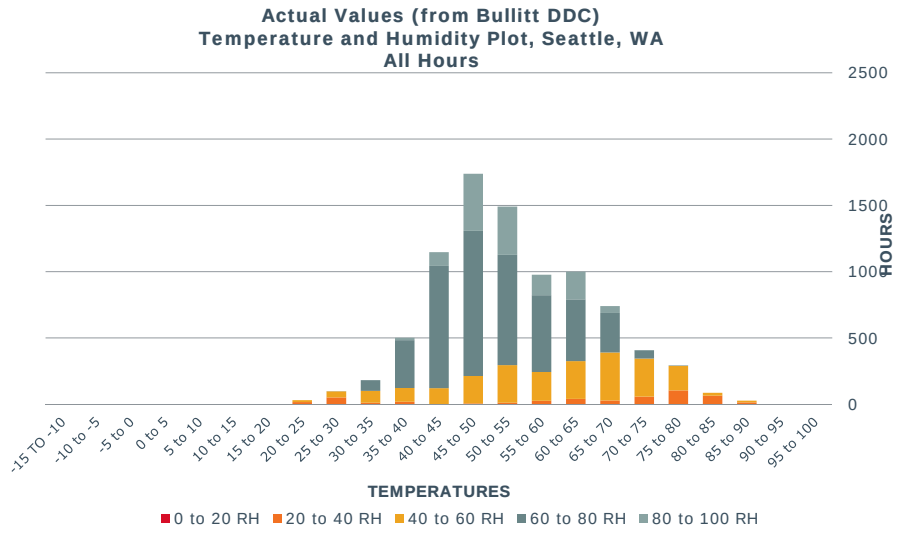
Performance

Predicted Weather



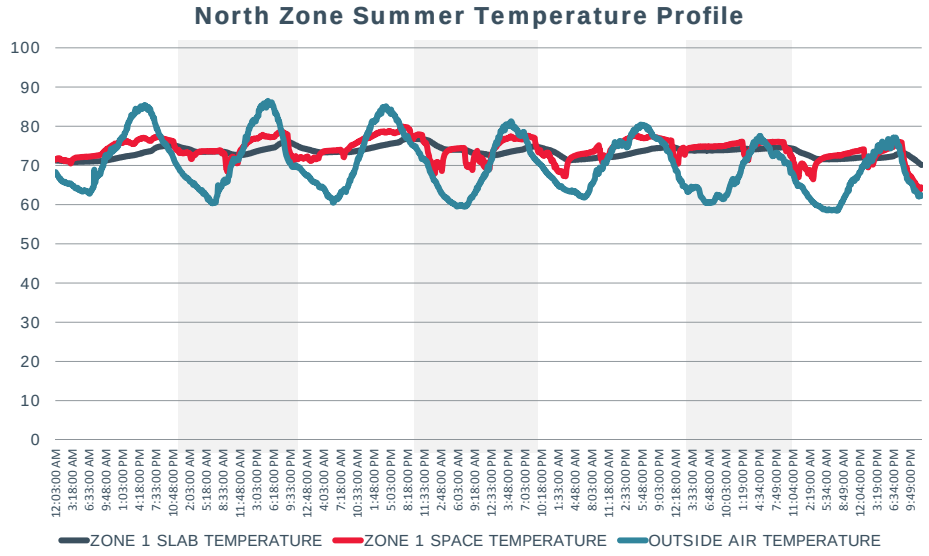
Performance

Actual Weather



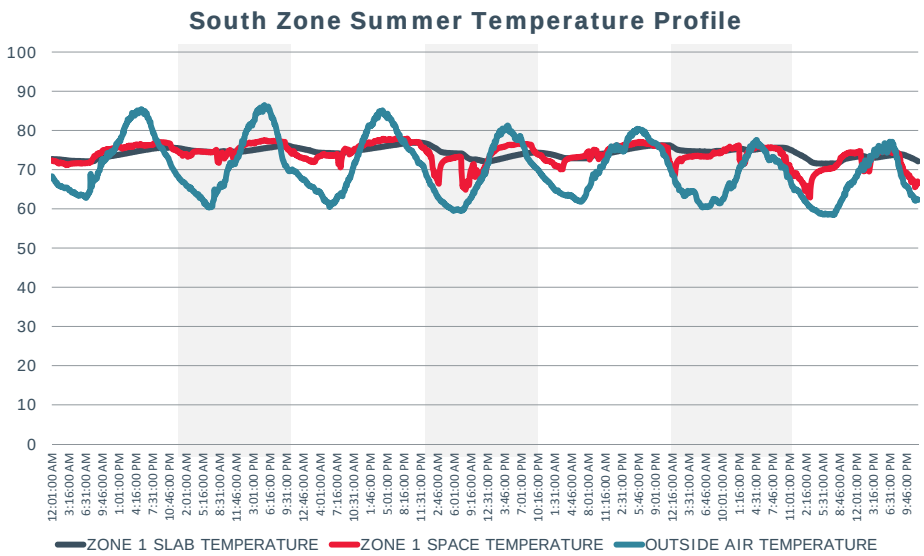
Performance

Thermal Comfort



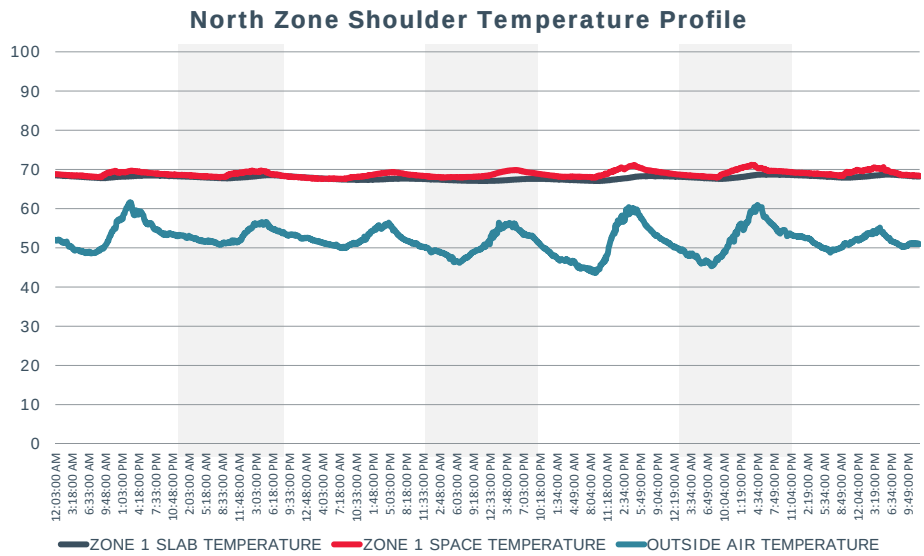
Performance

Thermal Comfort



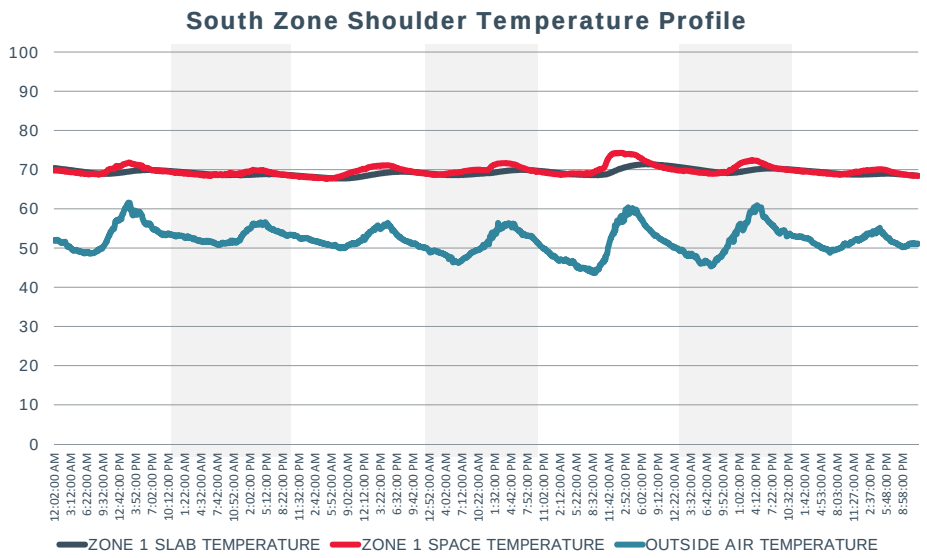
Performance

Thermal Comfort



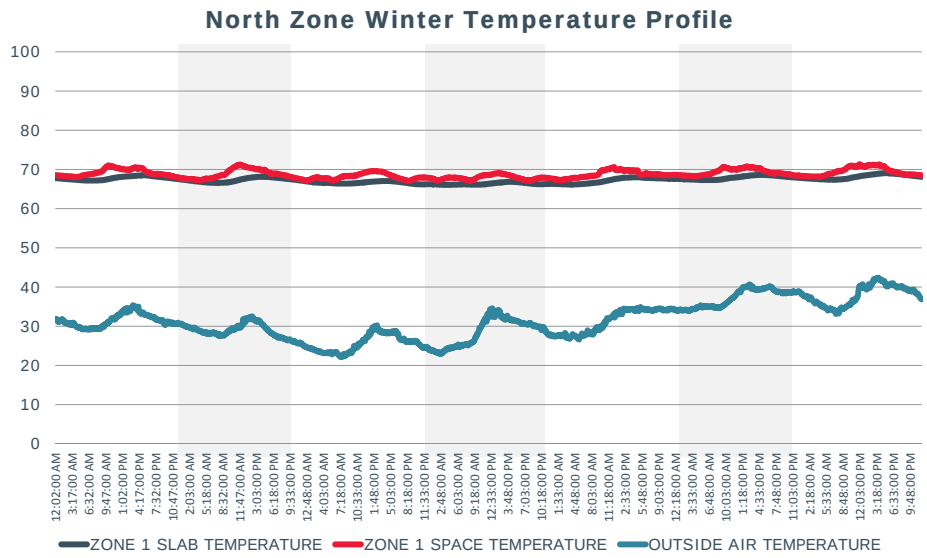
Performance

Thermal Comfort



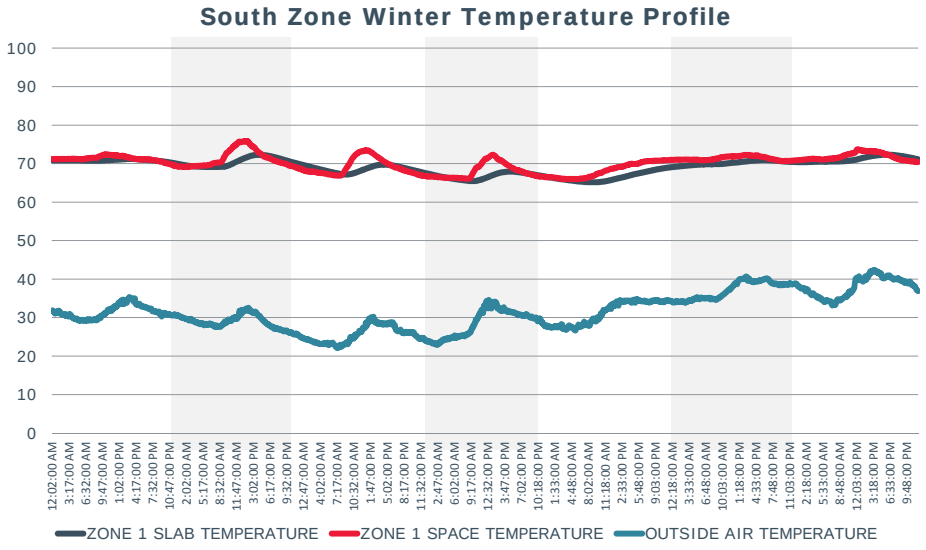
Performance

Thermal Comfort



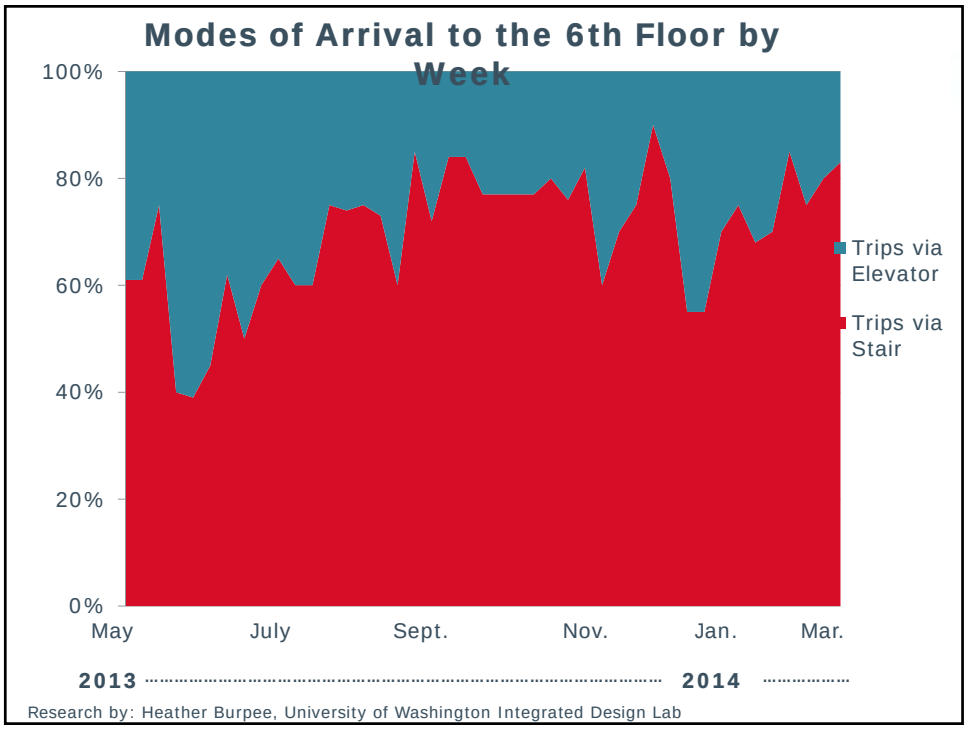
Performance

Thermal Comfort



Living in a Living Building

Building Culture

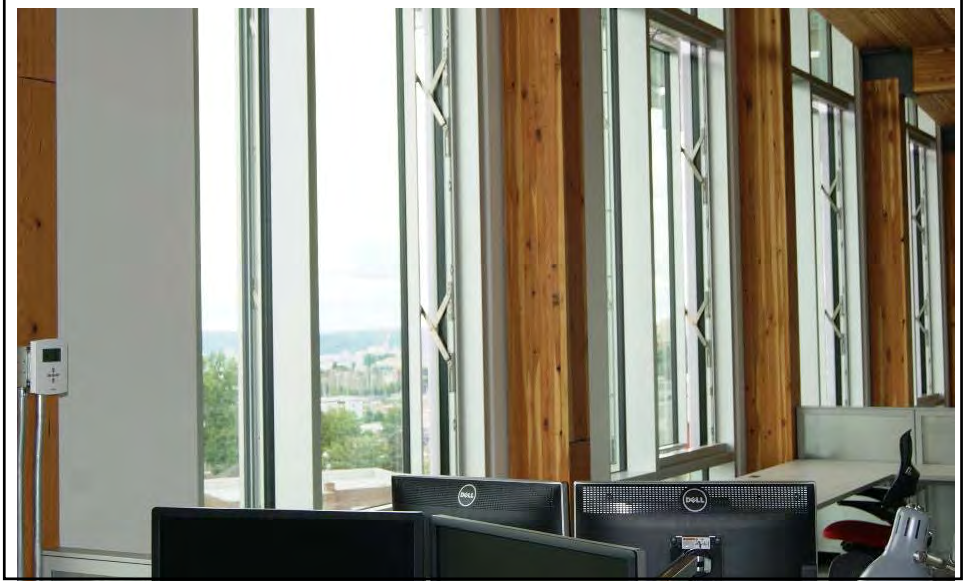

Modes of Arrival to the 6th Floor by Week
100%
80%
60%
40%
20%
0%
May
July
Sept.
Nov.
Jan.
Mar.
2013
2014
Trips via Elevator
Trips via Stair
Research by: Heather Burpee, University of Washington Integrated Design Lab


Living in a Living Building
Thermal Comfort


Living in a Living Building
Daylighting

Living in a Living Building

Indoor Air Quality



Living in a Living Building

The Restroom Experience


Grrrrrrrrr...


Living in a Living Building
SANITARY WASTE

Composting Toilet System

First Compost Removal

Composting Toilet System

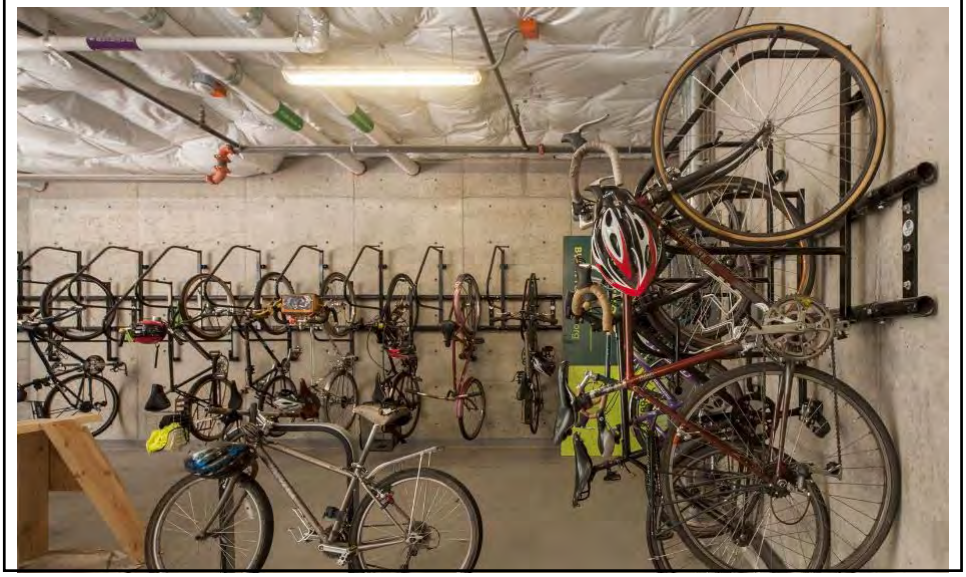
First Compost Removal

No odors, just dry compost

Lessons Learned

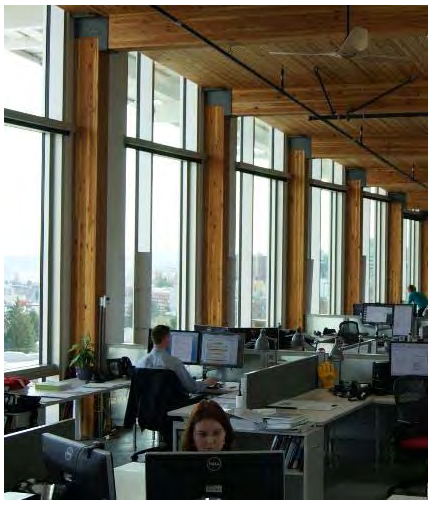
Living in a Living Building

Tenant Buy-In

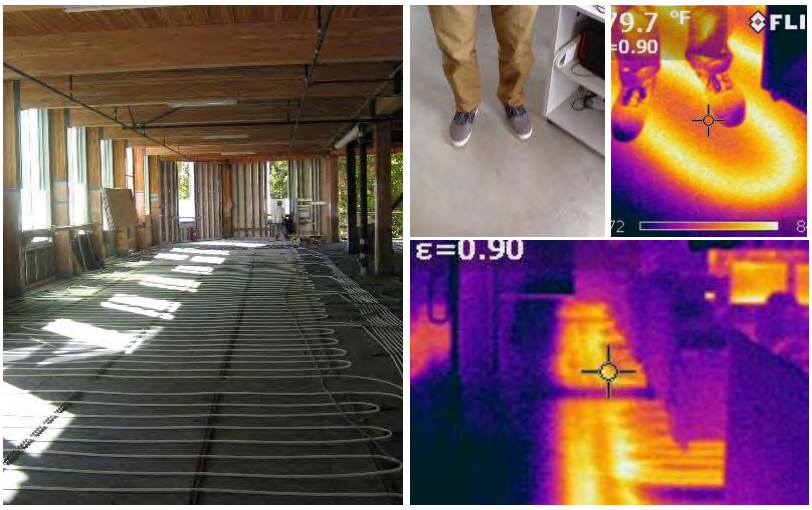


Living In A Living Building

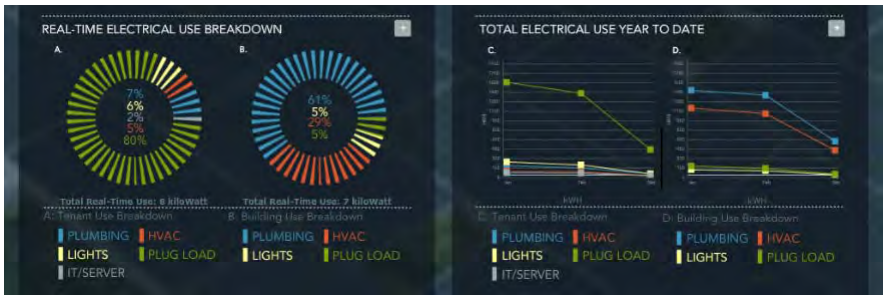
Solutions



Post Occupancy Adjustments



Building Operation

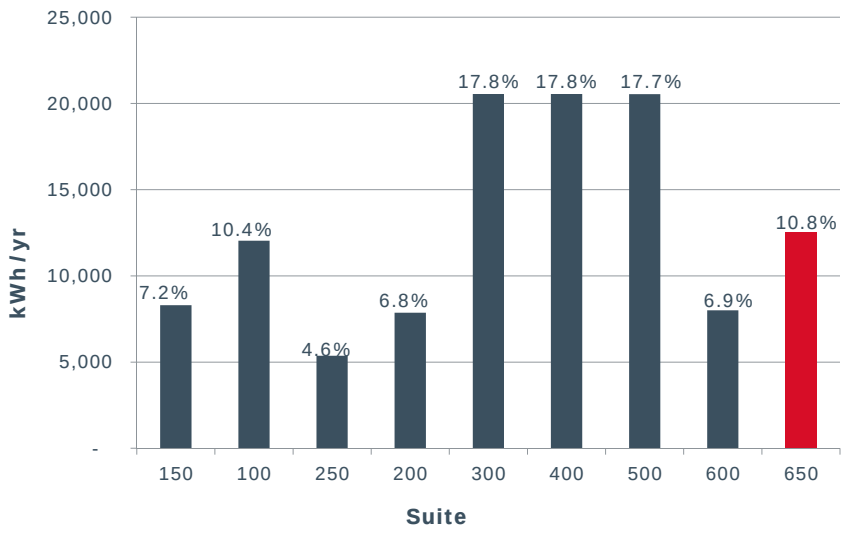


Ensuring energy performance

Metering challenges

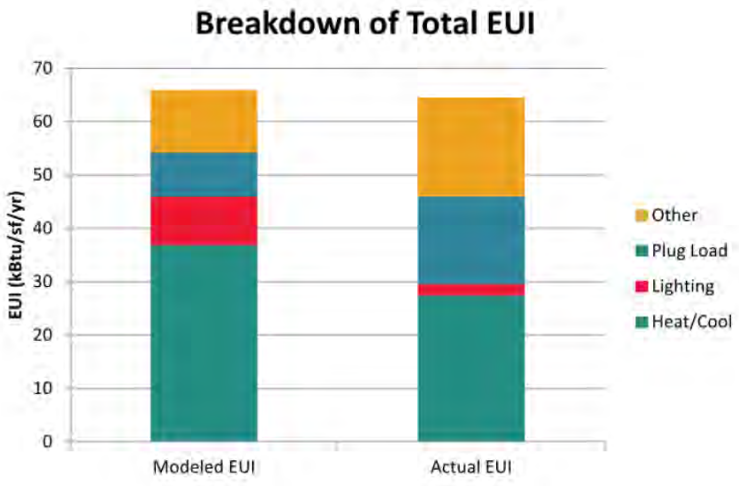
3rd party option

Tenant Budgets



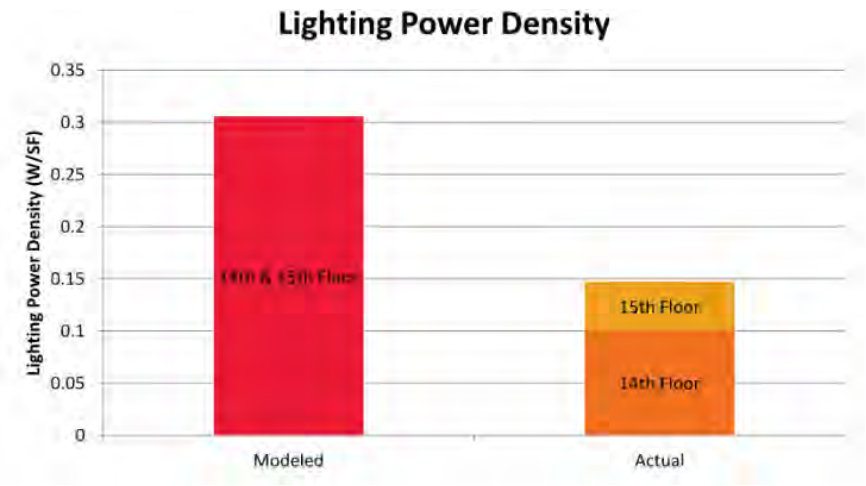
What Metering Tells Us

M&V at PAE's Portland Office



What Metering Tells Us

M&V at PAE's Portland Office



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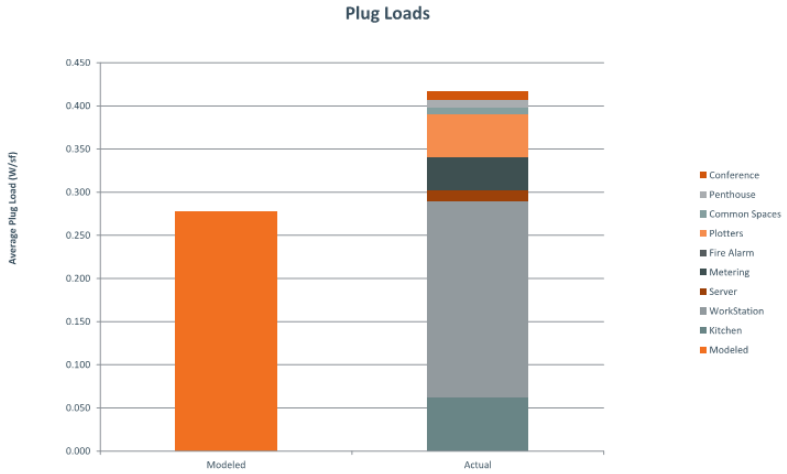

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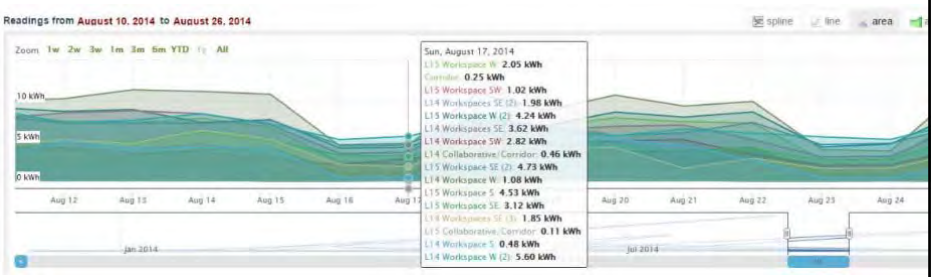
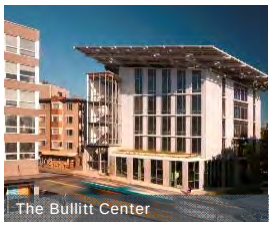
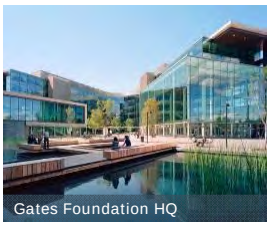
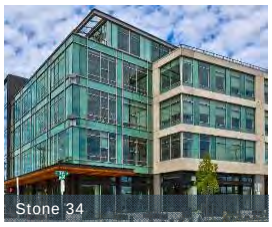


Financial Considerations

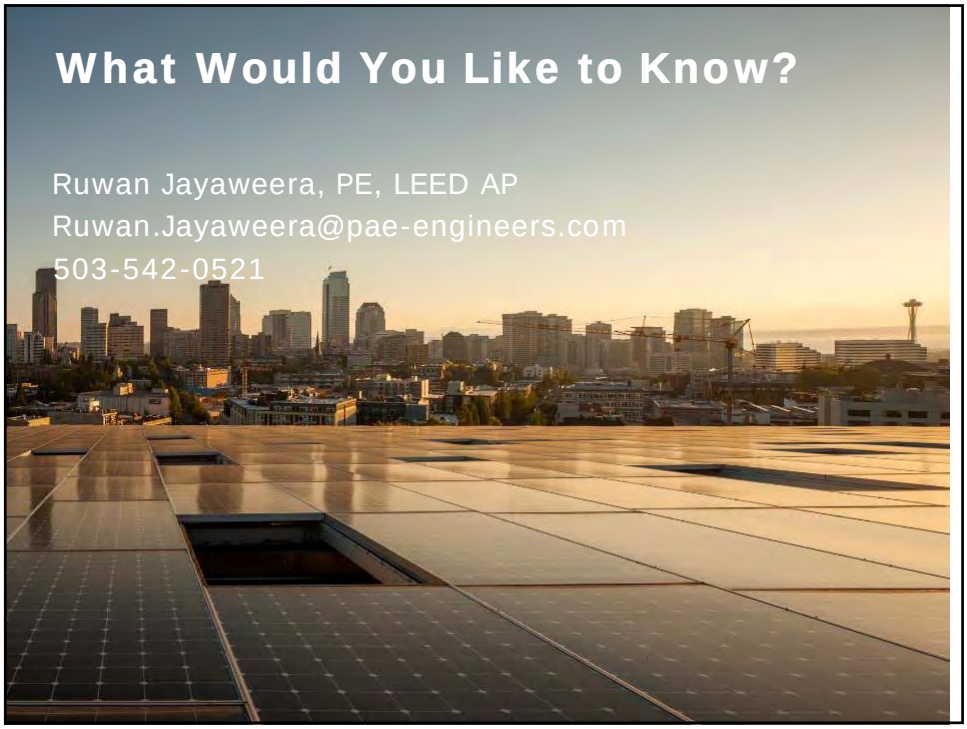
Comparisons


The Bullitt Center


Gates Foundation HQ


Stone 34

52,000 sf	900,000 sf	120,000 sf
$32.5 M	$500 M	$70.1 M
$625/sf	$556/sf	$584/sf
Seattle, WA	Seattle, WA	Seattle, WA
Living Building, Net Zero	**LEED Platinum**	**LEED Platinum**



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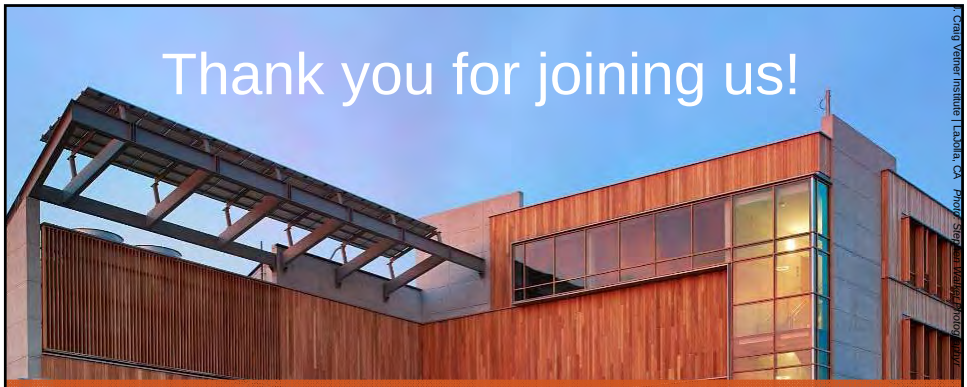

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