Session I: Energy Goals and Features of the RSF

Moderator: Bill Glover
Panelists:
  Tom Hootman
  John Andary
  Shanti Pless
ARCHITECTURAL PERSPECTIVE

Tom Hootman, AIA, LEED AP BD+C
RNL, Director of Sustainability
APPROACH

STRATEGIES

RESULTS
ENERGY + FORM
RSF vs. Evil Twin
FOOTPRINT

60’ Wide Wings

< 1/2

150’ Wide
Energy driven form
115,000 SF

Conventional form
65,000 SF
WINDOWS

<\frac{1}{2}

<30\%  
Window to Wall Ratio

>70\%  
Window to Wall Ratio
ROOF(PV)

70,000 SF

37,000 - Penthouse

X2

X2
Passive Design + Efficient Systems + Renewable Energy = ZERO
Orientation and 60’ Depth
PV Array
Solar Shading / Daylighting
>30% WWR
Radiant Cooling & Heating

Decoupled Ventilation with UFAD
Operable Windows
Thermal Mass
Transpired Solar Collector
Thermal Labyrinth
Pre-cast Concrete

Transpired Collector
NATURAL VENTILATION
PHOTOVOLTAIC ROOF
Green Facts

NREL Research Support Facility
Golden, Colorado

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EAp1 Fundamental Commissioning
EAp2 Minimum Energy Performance
EAp3 Fundamental Refrigerant Management
EAc1 Optimize Energy Performance
EAc2 On-Site Renewable Energy
EAc3 Enhanced Commissioning
EAc4 Enhanced Refrigerant Management
EAc5 Measurement & Verification
EAc6 Green Power

+1 Exemplary Performance Credit for EAc1
Baseline
132 kBtu/SF/year

Design
33 kBtu/SF/year

DESIGNED TO EARN THE ENERGY STAR

The estimated energy performance for this design meets US EPA criteria. The building will be eligible for ENERGY STAR after maintaining superior performance for one year.
NZEB MEASURES

Net Zero Site Energy Building

Net Zero Source Energy Building

Net Zero Energy Emissions Building

Net Zero Energy Cost Building
NREL’s Research Support Facility: An Operations Update

Shanti Pless
Senior Research Engineer
Commercial Buildings Research Group
July 2011
Innovation for Our Energy Future

Design Requirements

- 25 kBtu/ft²/yr for standard office space occupant density and data center loads
- Normalized up to 35.1 kBtu/ft²/yr for better space efficiency and to account for full data center load

Credit: Chad Lobato/NREL
Photovoltaic System

- Power Purchase Agreement (PPA) provides full rooftop array on RSF 1
- Zero energy = building, parking lot and future parking garage arrays

1,156 KW  408 KW
449 KW  524 KW
RSF Complex Update

- RSF opened June 2010
- ~80% occupied
  - 14 of 14 wings occupied
  - 650 of 820 occupants
- Roof-mounted PV installed and operational
- Visitor parking lot and PV installation complete
  - PV operational July 2011
- RSF2 construction underway
  - Fall 2011 completion
- Parking garage in design development
  - Winter 2011 completion
For the last 9 months, we have been comparing the measured end uses to the model end uses:

- **Winter Daytime lighting meeting the model predictions**
  - 25-30 kW of lighting (typical office building would use 170 kW)
  - 35-40 kW of lighting during the summer due to high sun angles
  - Addressing nighttime cleaning and staff lighting operation

- **Significantly below daytime plug load predictions**
  - Staff education programs have engaged occupants as active participants
  - Continuous occupant education needed to reduce nighttime plug loads

- **Fans and Pumps meeting the model predictions**
  - Nighttime loads half of model predictions

- **Datacenter cooling meeting the model predictions**
  - PUE of 1.1 - 1.15 during cooler months
  - Average PUE of 1.20 for June 2011

- **Rooftop PV meeting model predictions**
  - 32,800 kWh Dec production compared to 29,000 kWh modeled

- **Heating use close to model**
  - Internal gains of occupants and plugs less than modeled

- **Cooling use close to model**
  - Building cooling is close to the model
  - PUE increases due to data center hot air management
The PV system is sized for an annual EUI of 35.1 kBtu/ft².
Operational Lessons - Daylighting

- Lights fully dimmed (10%) or off when sunny
- Move cleaning to daylit hours?
- Even with direct glare designed out, fully daylit buildings still have “indirect” glare
  - Bright spots on ceiling and light fixtures
  - Bright background
  - Glare self-evaluation checklist to ensure “indirect” glare really the issue and not perceived privacy concerns
    - Adjust monitor brightness and tilt
    - Adjust workstation to change background
    - Diffusing films
    - Plants
    - “Privacy” screens final option
      - But this blocks others views
    - Move occupants that are “incompatible” with a specific workstation
- North wing reflections onto south wing
January 28 was one of Colorado’s warm and sunny winter days.
October 2010 – June 2011 Lighting Power Density

Credit: Chad Lobato/NREL
Operational Lessons - Datacenter

• Fully containing hot aisle difficult
  • Custom aisle floor and door seals
  • Ensure equipment designed for cold aisle containment
    • And installed to pull cold air
      – Not hot air…
• Have run ~1.1-1.15 PUE
  • A few hot spots were driving up PUE…
  • Summer time PUE of 1.20 because of increased cooling
Data Center PUE
October 2010 – June 2011 Daily Heating Energy

Credit: Chad Lobato/NREL
Need better window frames!

Window frames the weak point in the thermal envelope!
Even thermally broken frames
Small Improvements, Big Difference

- More efficient solar panels were purchased at a lower cost
- Less window area, while still fully daylighting office spaces
- Better thermal breaks in the window frames, leveraging the latest in commercial windows and aluminum frames, driving down energy consumption and increasing comfort
- Displacement ventilation in conference rooms, improving thermal comfort
- Natural passive cooling in stair wells vs. mechanical ventilation in the RSF
- Daylighting controls in daylit stairwells, allowing enhanced energy savings during the day
- Better workstation power strips
- Automatic plug load controls
RSF 1 and RSF 2 Energy Model Comparison

Annual EUI (kBtu/ft²)

ASHRAE 90.1-2004

- 220,000 sqft, 822 Occupants
- 137,000 sqft, 543 Occupants

ASHRAE 90.1-2007

- 220,000 sqft, 650 Occupants
- 137,000 sqft, 405 Occupants

Credit: Chad Lobato/NREL
Performance Statements

• The RSF complex (RSF1, 2, parking garage, and associated site lighting) was designed to produce more on-site renewable energy than it uses over the course of a typical weather year, when accounted for at the site.

• Overall, the first 9 months of end use performance monitoring and verification suggests that when the RSF complex is fully built out, we will meet the net zero energy goals.

• Continued performance monitoring and occupant education is required to ensure net zero energy goals will continue to be met.