NREL’s Research Support Facility: High Performance Building Through Integrated Design

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More than 800 people in DOE office space on NREL’s campus

- 220,000 ft²

- Design/build process with required energy use goals
  - 25 kBtu/ft²
  - 50% energy savings
  - LEED Platinum

- Replicable
  - Process
  - Technologies
  - Cost

- Site, source, carbon, cost ZEB:B
  - Includes plugs loads and datacenter

- Firm fixed price of $64M
  - $259/ft² construction cost (not including $27/ft² for PV)

- Open (first phase) June 10, 2010
Design Requirement: Energy Use Intensity (EUI)

- 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
Design Response to RFP Goals

- Optimal orientation and office space layout
- Fully daylit office wings with high-performance electric lighting
- Continuous insulation precast wall panels with thermal mass
- Operable windows for natural ventilation
- Hydronic radiant heating and cooling
- Outdoor air preheating
  - Transpired solar collector
  - Data center waste heat
  - Exhaust air energy recovery
  - Crawlspace thermal storage
- Aggressive plug load control strategies
- Data center outdoor air economizer with hot aisle containment
- Rooftop and parking lot-based PV
Design Response to RFP Goals

Research Support Facility

- 1.6 MW of photovoltaics on site
- Transpired solar collectors on southern facade of building
- Sculptural wood wall is built from beetle-kill pine
- Electrochromic west-facing windows (not shown) tint on command
- Open-ceiling offices introduce indirect northern light to building’s core
- Repurposed natural gas pipe used for structural columns

Credit: NREL
RSF Status

- RSF opened June 2010
- ~90% occupied
  - 14 of 14 wings occupied
  - 750 of 820 occupants
- Roof-mounted PV installed and operational
- Visitor parking lot and PV installation complete
- RSF2 construction underway
  - YE 2011 completion
- Parking garage in design development
  - YE 2011 completion
So How Is It Performing?

- For the last 10 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
  - Will continue to assess cooling this summer
    - Building cooling is close to the model
    - PUE increases during summer months due to chilled water cooling energy usage
January 28 was one of Colorado’s warm and sunny winter days.
October 2010 – July 2011 Lighting Power Density

Power Density (W/ft²) vs. Time of Day

- Model Average
- October 2010
- November 2010
- December 2010
- January 2011
- February 2011
- March 2011
- April 2011
- May 2011
- June 2011
- July 2011

Credit: Chad Lobato/NREL
October 2010 – July 2011 Mechanical System Power Density

Note: Control of the VFDs was optimized in late October 2010, resulting in energy savings.

Note: Control of the dampers was optimized in April 2011, resulting in energy savings.

Credit: Chad Lobato/NREL

Note: The mechanical load is comprised of only fans and pumps.

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2011 YTD Daily Cooling Energy

Average Daily Outdoor Temperature (°F)

Daily Cooling Energy (kWh)

- Model Daily Cooling
- RSF Daily Cooling
- Model Cooling Trendline
- RSF Cooling Trendline
Measured Versus Modeled Monthly End Use Energy Consumption

Note: July 2011 was the first net zero energy month

Credit: Chad Lobato/NREL
Conclusions

• Highest Building Performance Results from *Integrated Design Process*
  • Can Be Done With no Capital Cost Add
• Key is Performance Based Procurement (EUI-driven)
• Every Watt Counts
• Simulation Becomes Crucial
  • Tools can Inform Design, Codes & Standards, Commissioning
  • Better Tools Integration is Needed
• Measurement and Verification
  • Validation of Design, *and* Tools

• Thank You!