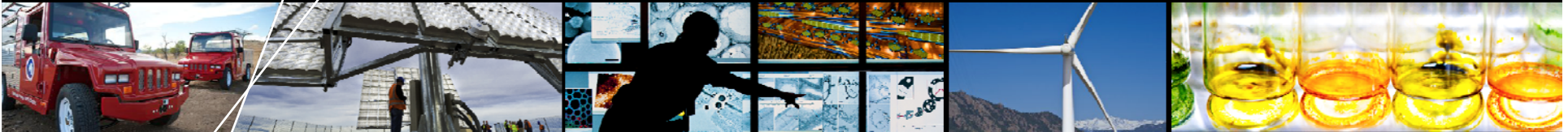




U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy



Integrating Energy Modeling into the Design Process



NASA Net Zero Workshop

Rois Langner

Rob Guglielmetti

June 6, 2012

Energy Use Requirements in New Construction at NREL

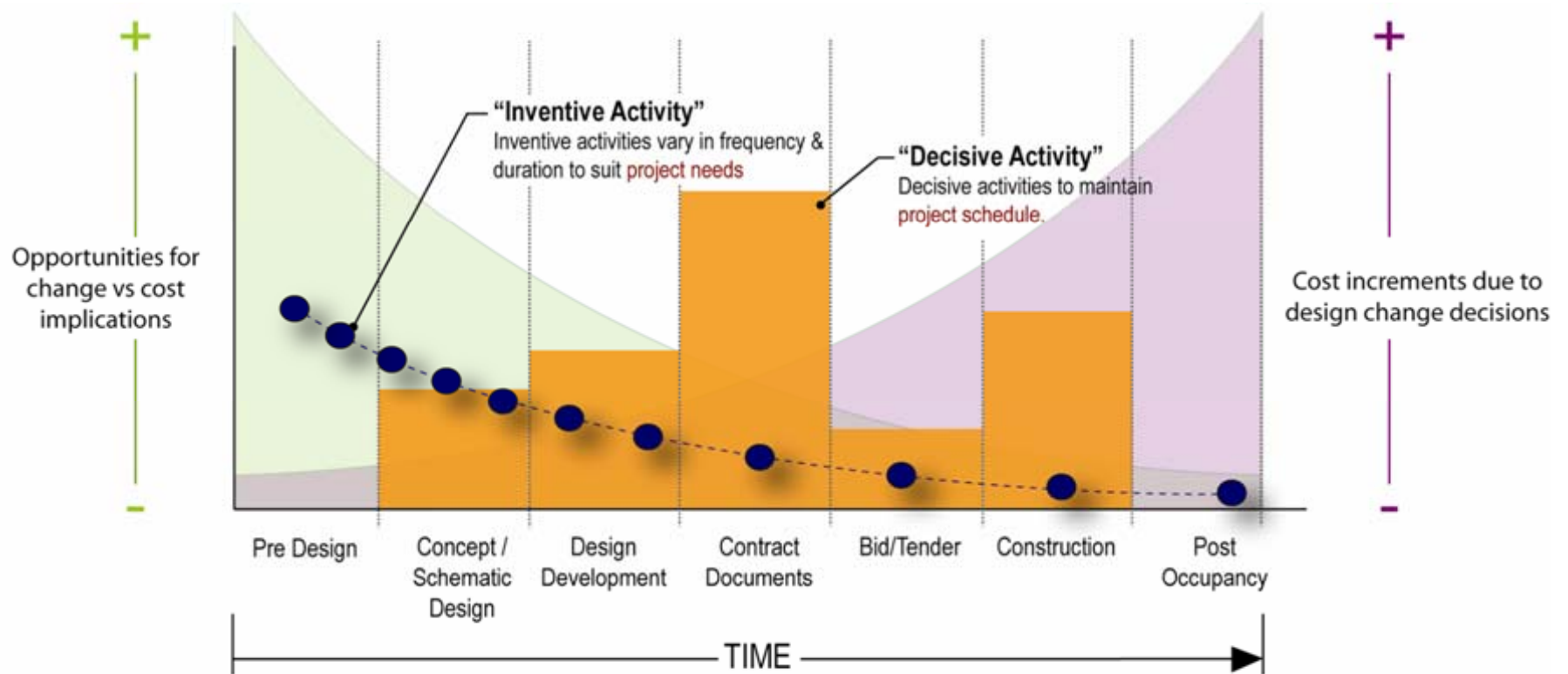
■ Performance Based Design Build Acquisition Processes

- Energy Use Requirements included in RFP
- Force early design and integrated solutions on fixed budget
- Incentives for real performance

■ Unique energy requirements by building/space type

- Office Buildings with Datacenter
 - ✓ 35.1 kBtu/ft²
- Parking Garage
 - ✓ 0.5 kBtu/ft²
- Cafeteria
 - ✓ Best in class kitchen efficiency
- Super Computer
 - ✓ 1.06 PUE
- Smart Grid Research Laboratories
 - ✓ 30% Savings, no chilled water use

Integrating Modeling into the Design Process



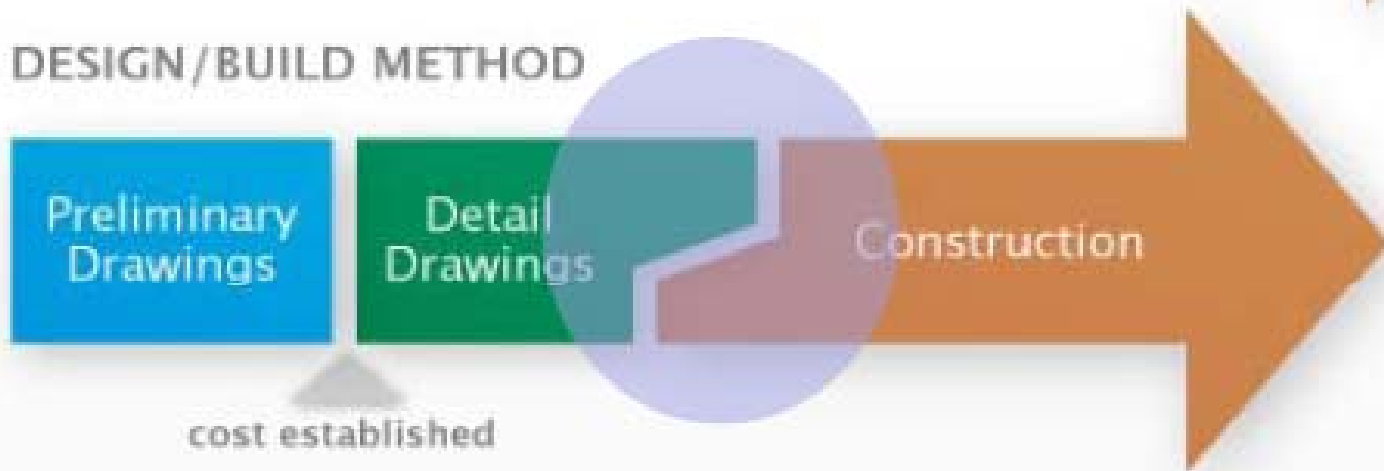
Credit: David Okada/Stantec

Acquisition Method

TRADITIONAL METHOD



DESIGN/BUILD METHOD



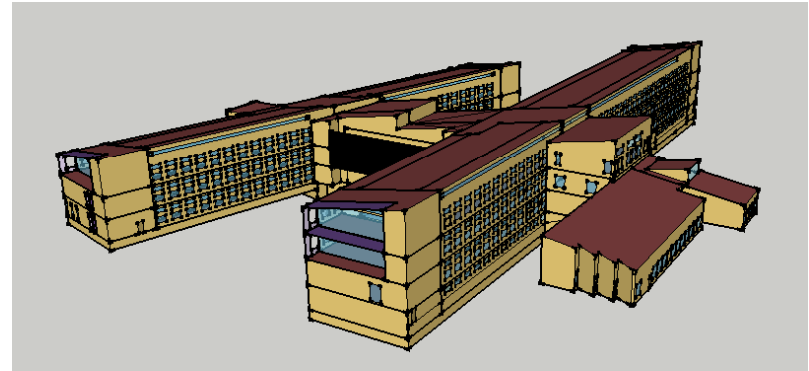
Design Strategies for Net Zero



- **Envelope and orientation to reduce loads**
 - Well insulated roofs, walls, floors, windows (with shading)
- **Envelope and orientation to meet loads**
 - Daylighting
 - Passive solar heating, Trombe walls
 - Natural ventilation
- **Lighting design to match daylighting**
- **Plug loads**
 - Design vs. owner loads
- **Climate specific HVAC designed for the remaining loads**
- **Commissioning (making sure the building works)**
- **Metering and evaluation**
- **Make it simple**
- **Site specific renewable generation within footprint, site, off-site**
- **Small amounts of RECs**

Modeling for Absolute Energy Use Requirements

- **All energy use in building**
 - Demand side only
 - All HVAC and Lighting
 - including exterior and site uses
 - Data center
 - Plug loads
 - *And everything else!*
- **Include “everything” in model**
 - Better chance predictions match reality
 - Consider all efficiency strategies
- **Design time focused on actual design rather than fictitious baseline needed to calculate energy savings**
- **We can measure performance during operation**
 - And incentivize D/B team if predicted goals are met in operation
- **Requires significant additional design/modeling time understanding common assumptions!**



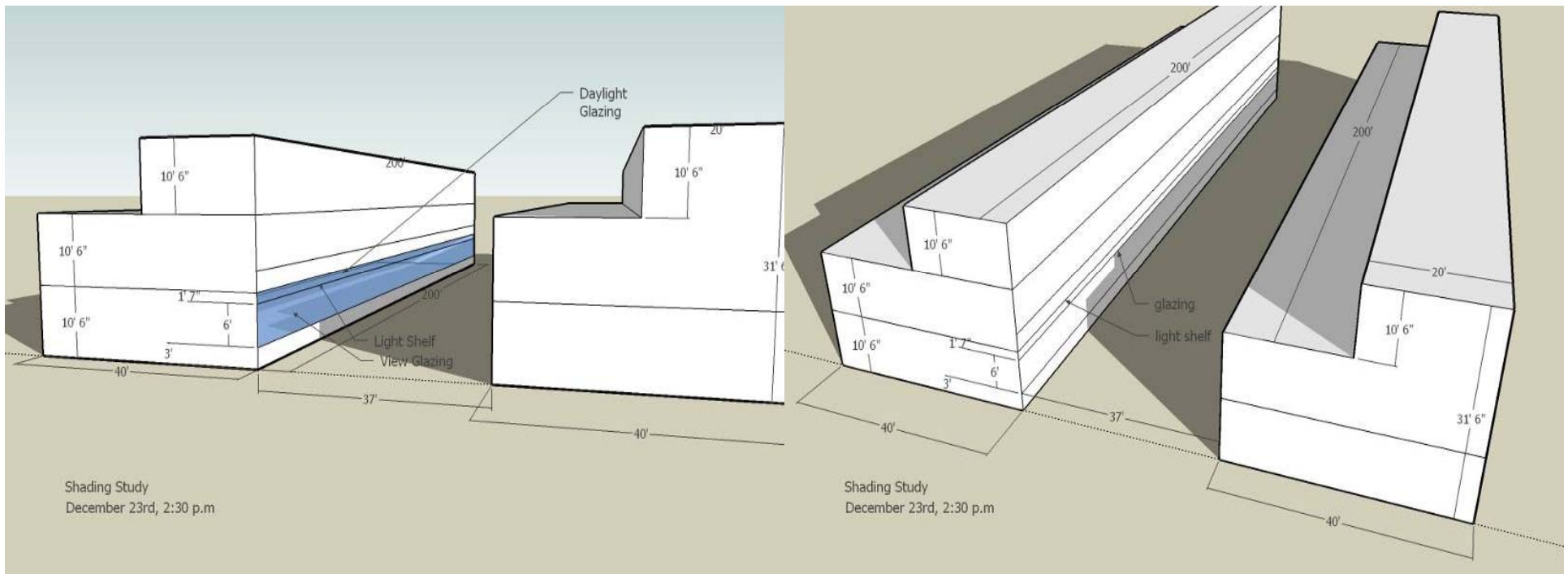
Modeling Performance - Tools

- **Demand Side Energy Modeling – eQuest software**

Full building integrated energy analysis:

- Thermal Modeling – IES Virtual Environment, ASHRAE comfort tool
 - ✓ Thermal comfort and energy savings of natural ventilation
 - ✓ Underfloor air, mass effects of radiant heating/cooling
 - Daylighting – Radiance
 - Thermal Labyrinth and Transpired Collector performance, waste heat recovery from data center – proprietary Excel application
 - Thermal breaks, envelope analysis – Therm
- **Production Side – PVWatts (PV system production)**

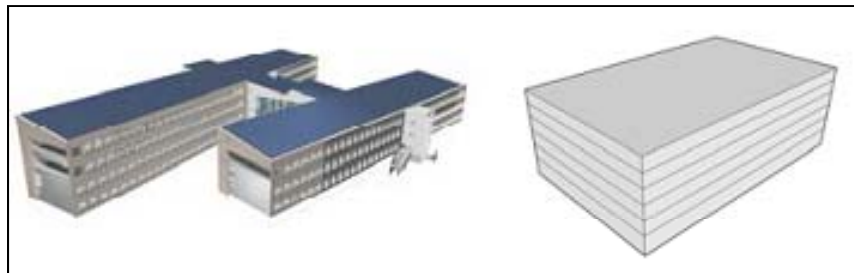
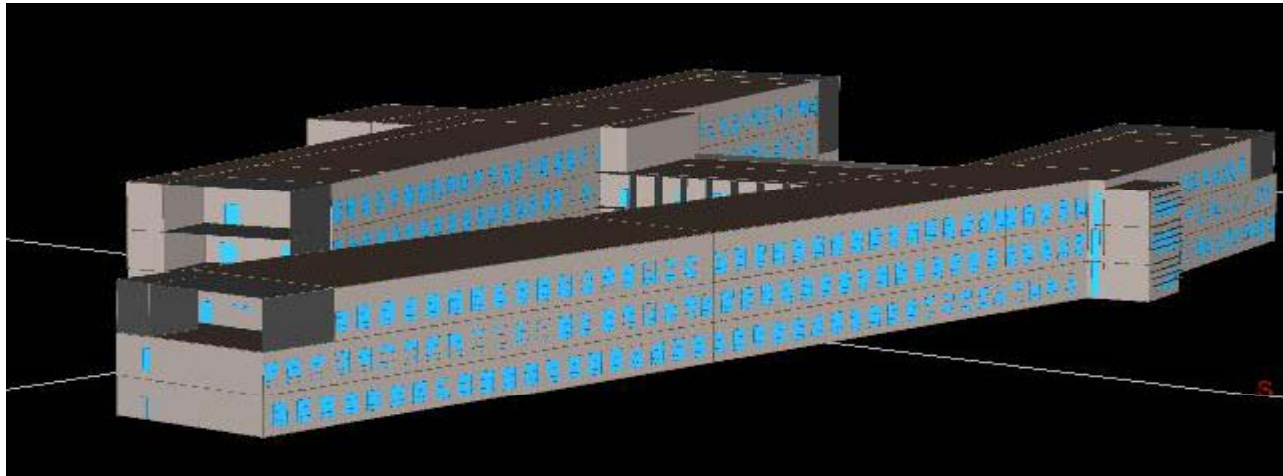
Pre-Charette Work: Reality Check



Internal engineering brainstorm
Daylight study
Initial energy calcs
Initial recommendations

Credit: David Okada/Stantec

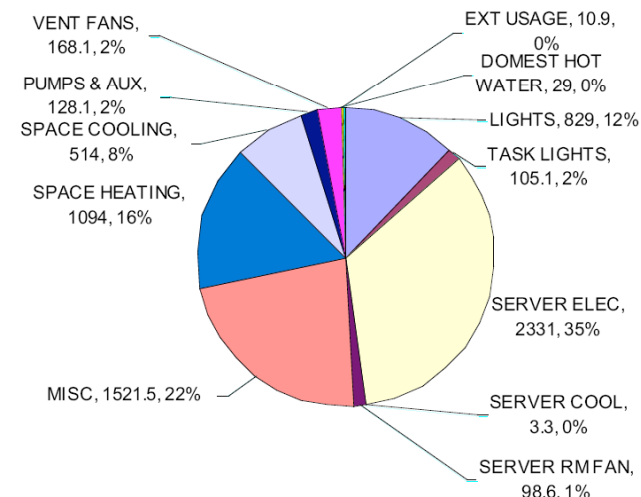
Whole Building Energy Modeling



Energy-driven

Conventional

Current Results



**CALCULATED
ANNUAL
ENERGY USE**
6 830 MBTU

GOAL
8 260 MBTU

Credit: Roger Hedrick/AEC

Daylight Modeling & Office Layout



N

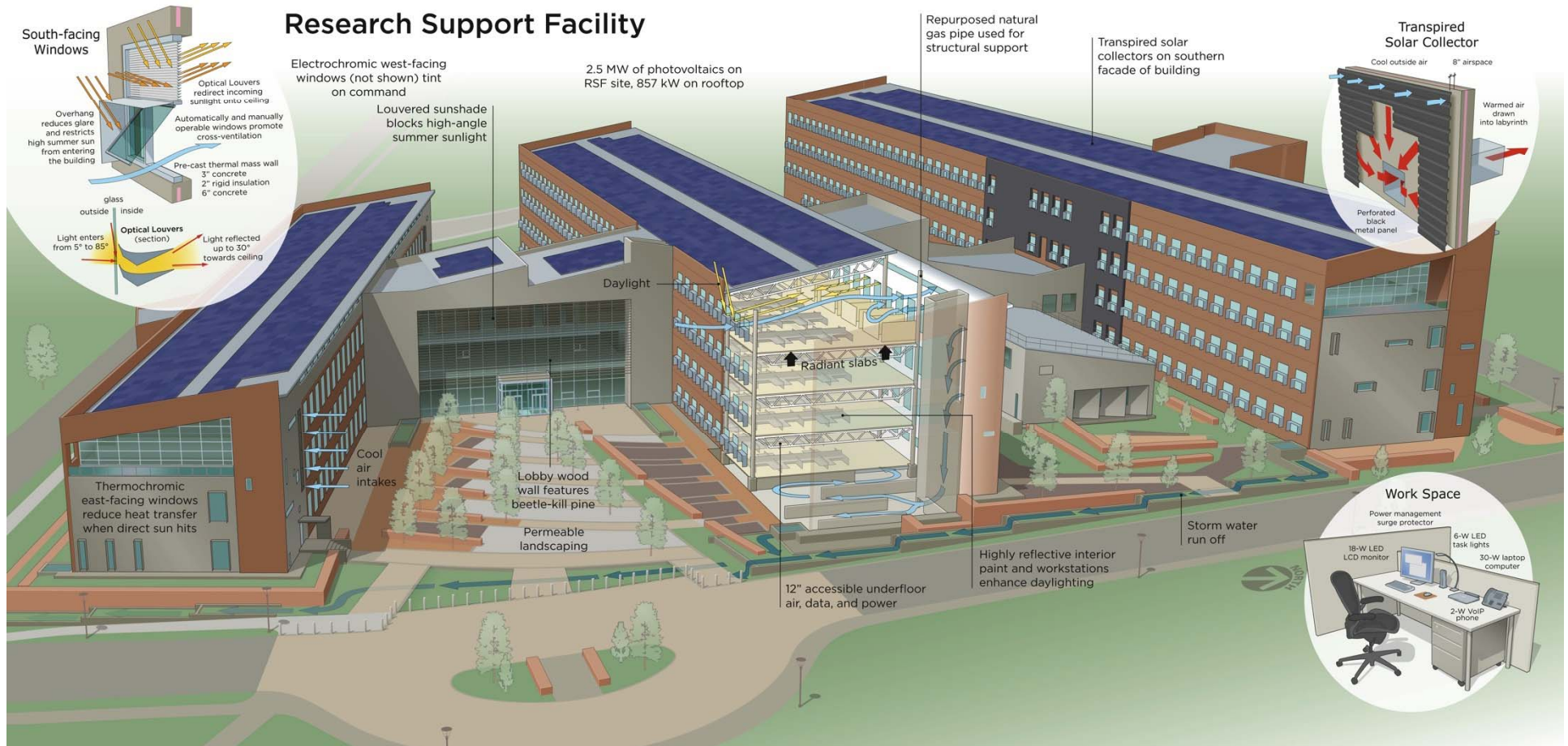


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Credit: Rob Guglielmetti/AEC

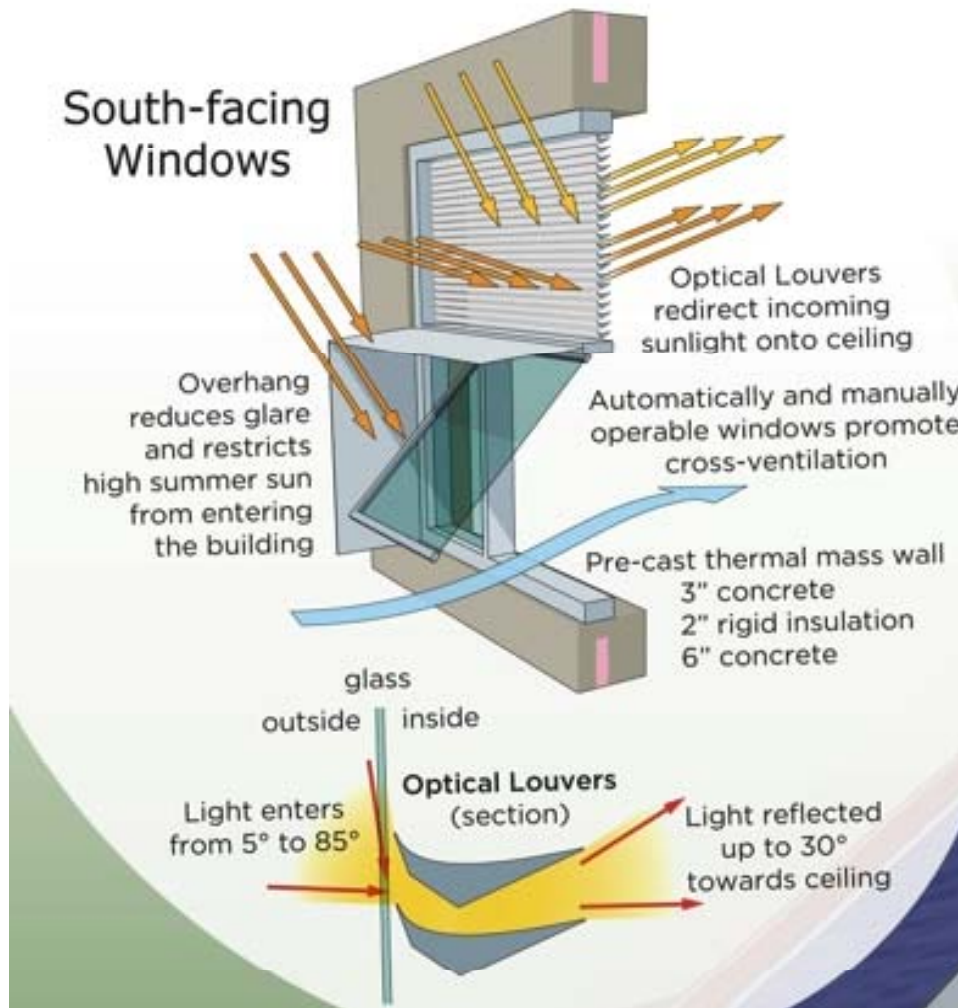
NATIONAL RENEWABLE ENERGY LABORATORY

Solutions Galore



Credit: NREL PIX

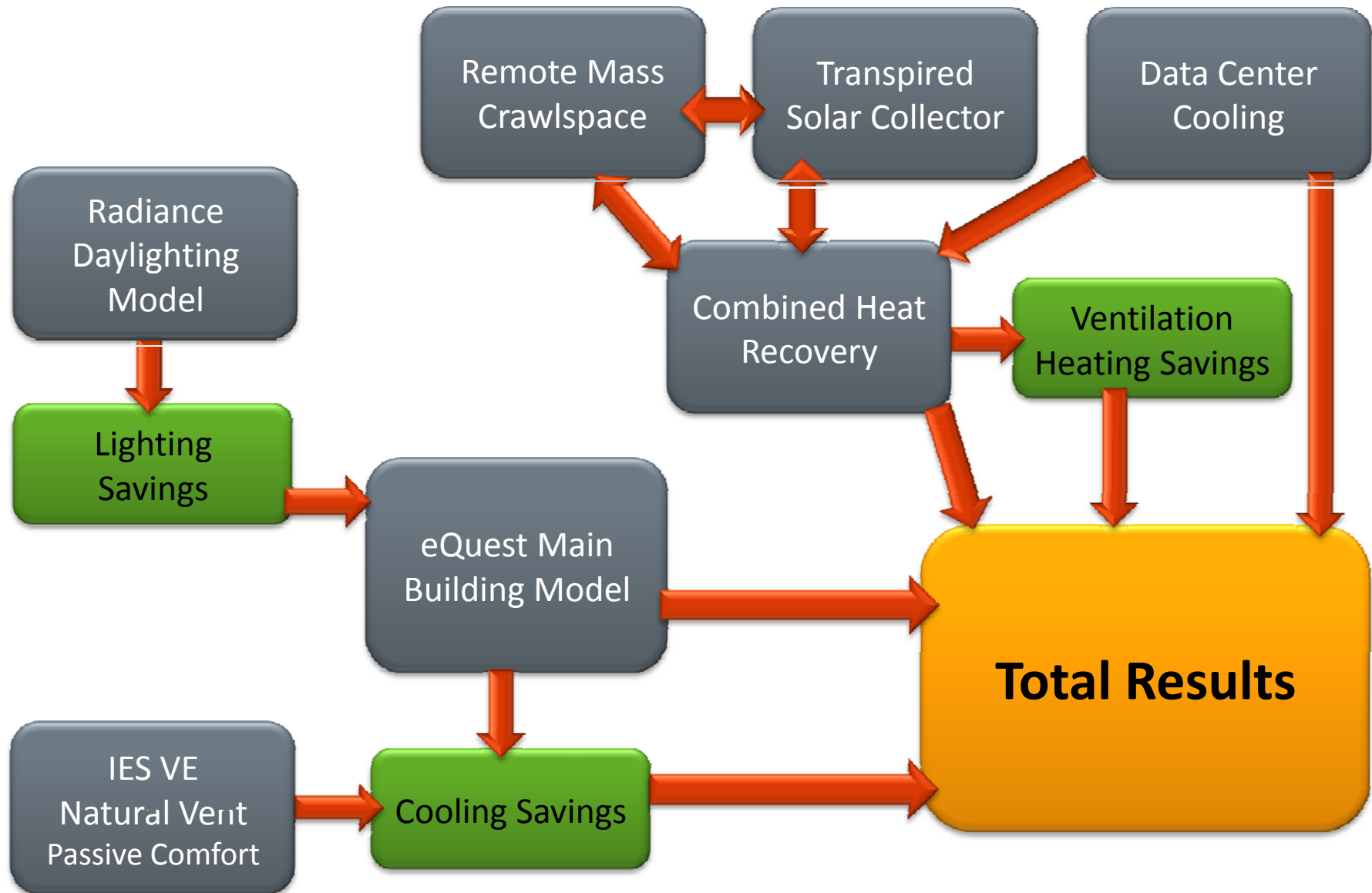
Daylighting & Natural Ventilation



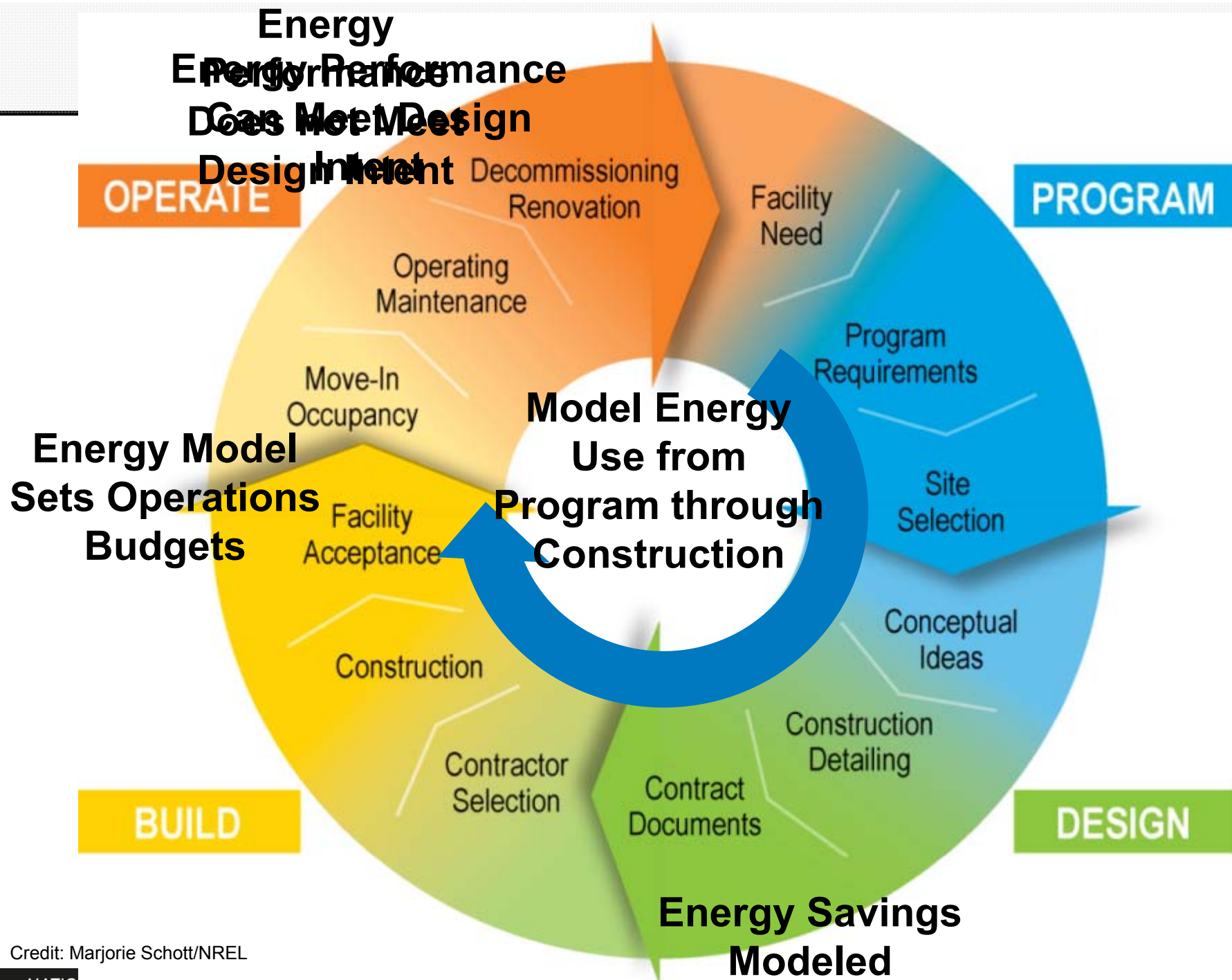
Credit: NREL/PIX



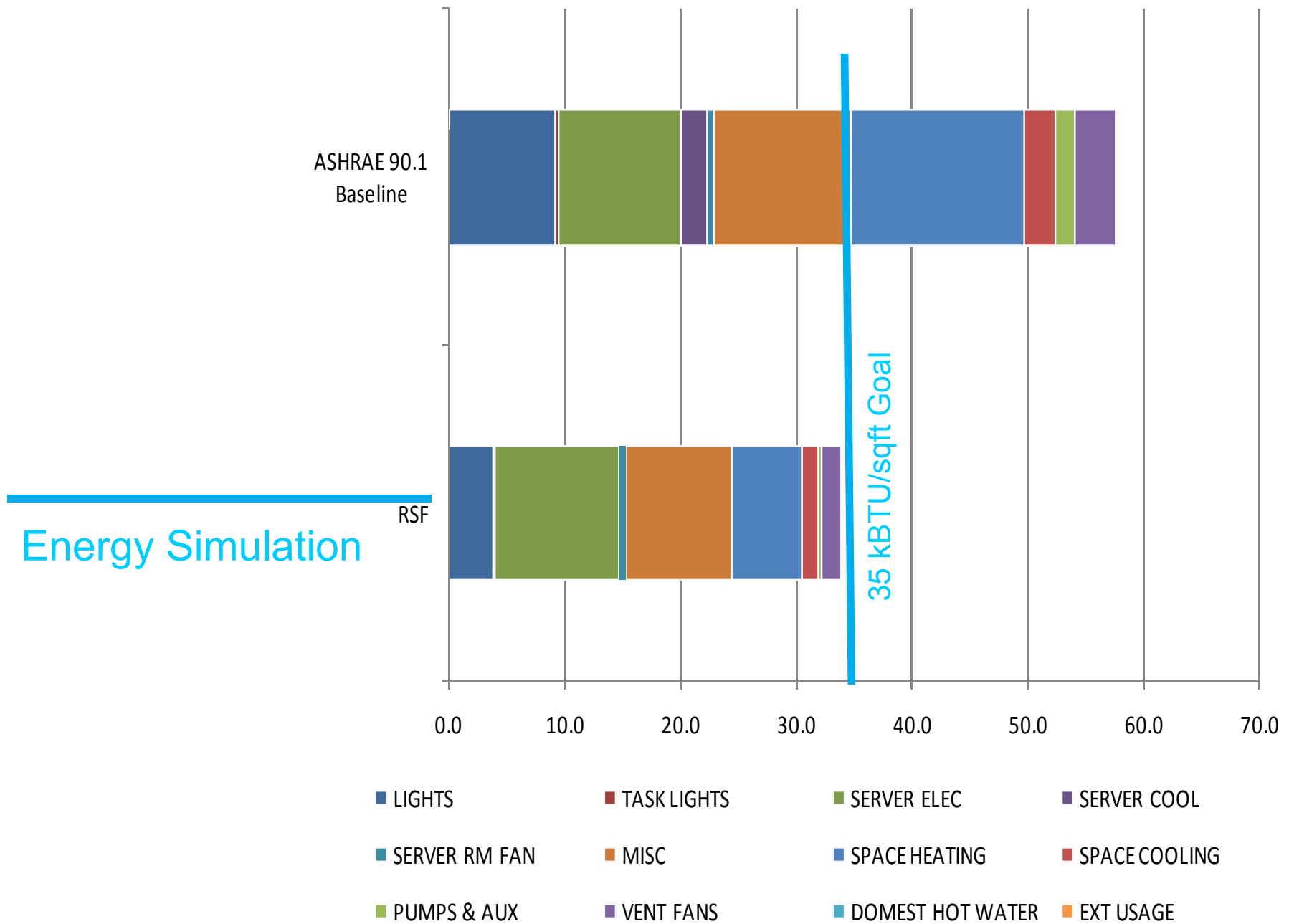
Model, Models, Models → Uber-Model!



Credit: Shanti Pless/NREL



Credit: Marjorie Schott/NREL

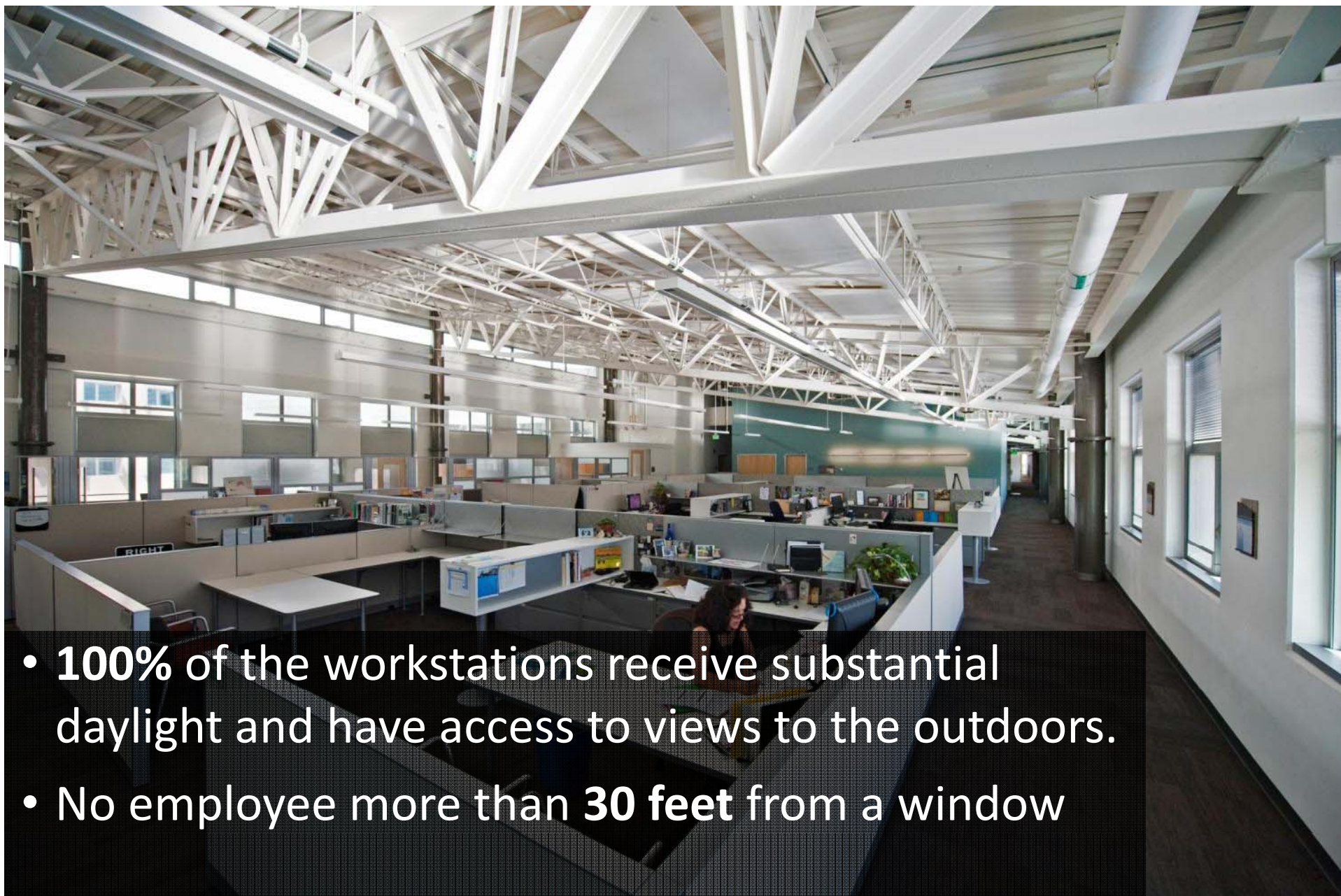


Credit: David Okada/Stantec

So How Is It Performing?

NREL has 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 meeting the model predictions during cooler months**
 - PUE of 1.1 - 1.15 during cooler months
 - Average PUE of 1.21 for summer 2011
 - Refining hot aisle containment strategy to reduce data center chilled water use
- **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 below the model prediction
 - Total cooling, including additional datacenter chilled water use, is slightly higher than predicted



- **100%** of the workstations receive substantial daylight and have access to views to the outdoors.
- No employee more than **30 feet** from a window

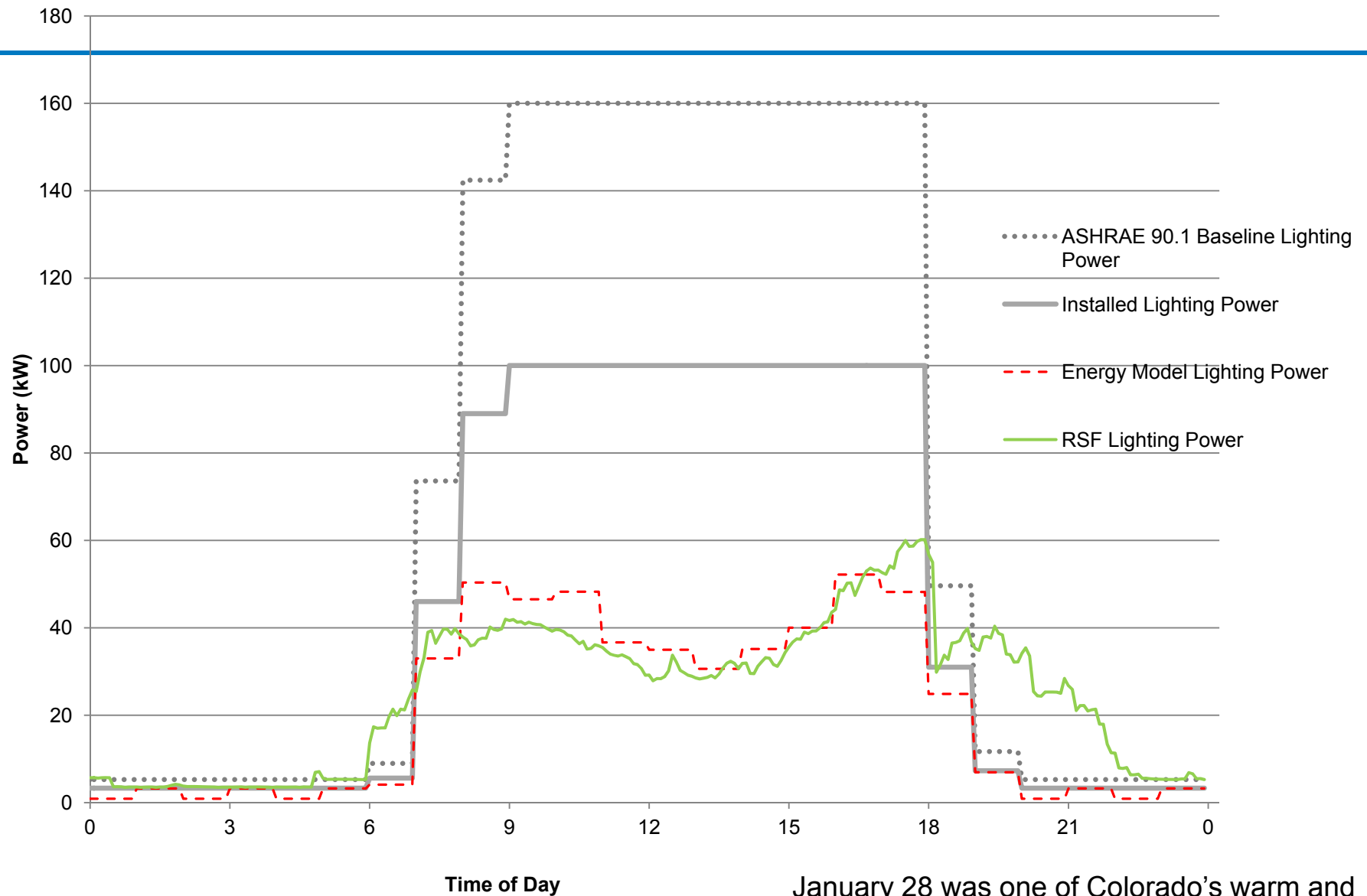
Credit: NREL/PIX

Prediction and Reality



Credit: Rob Guglielmetti/NREL

January 28, 2011 Lighting and Daylighting

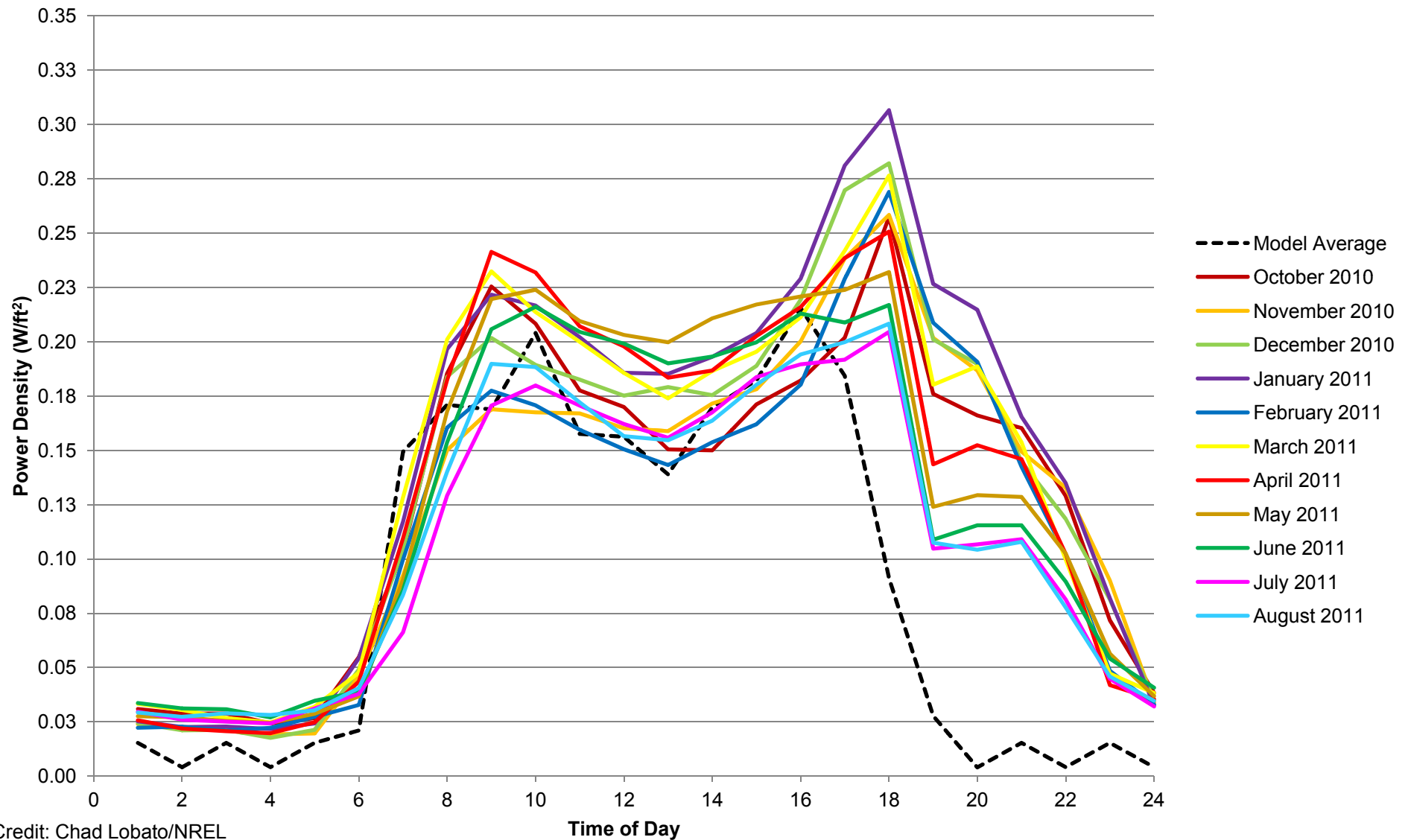


Credit: Rob Guglielmetti/NREL

January 28 was one of Colorado's warm and sunny winter days.

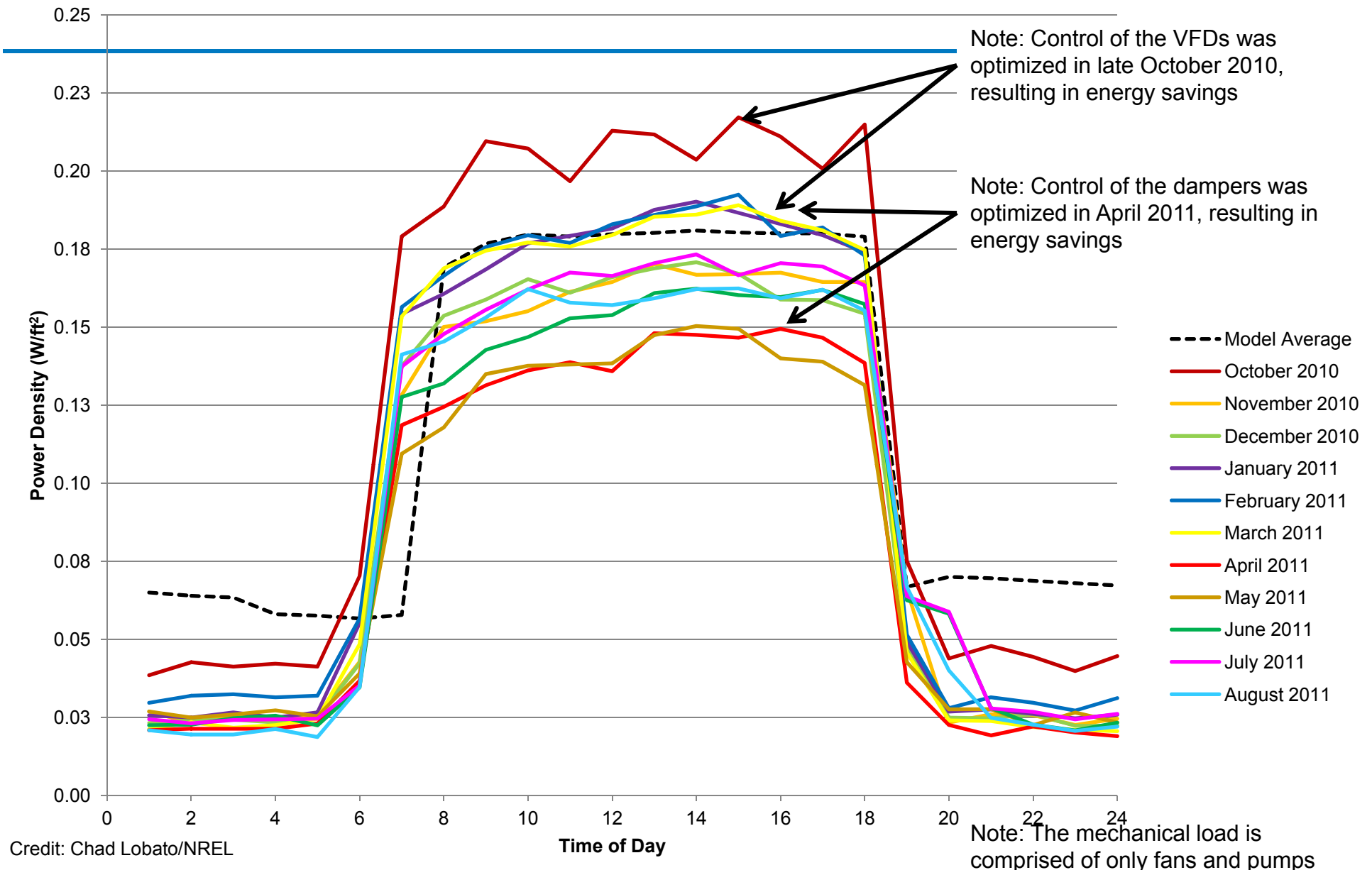
October 2010 – August 2011 Lighting Power Density

RSF Weekday Lighting Power Density



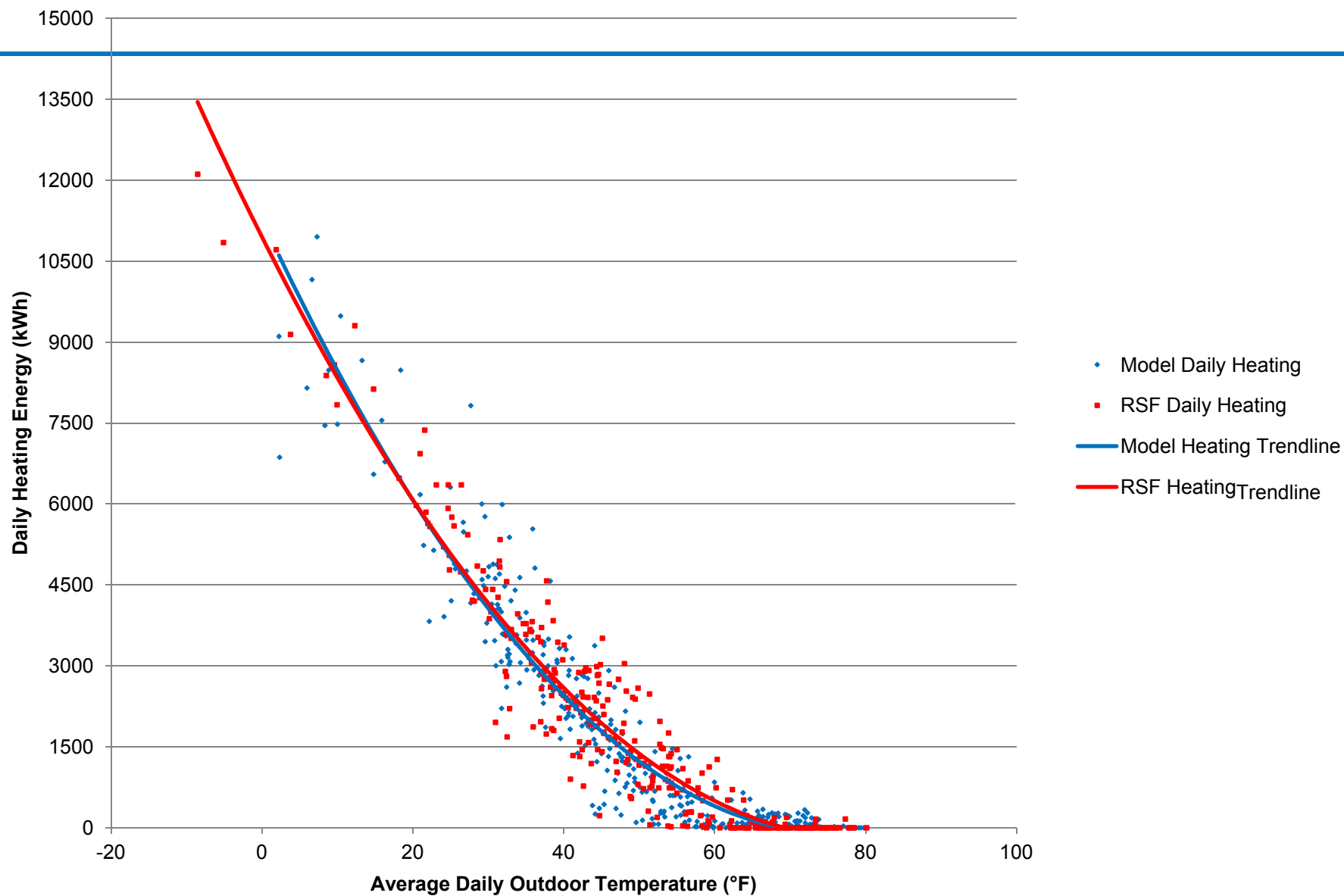
Credit: Chad Lobato/NREL

October 2010 – August 2011 Mechanical System Power Density



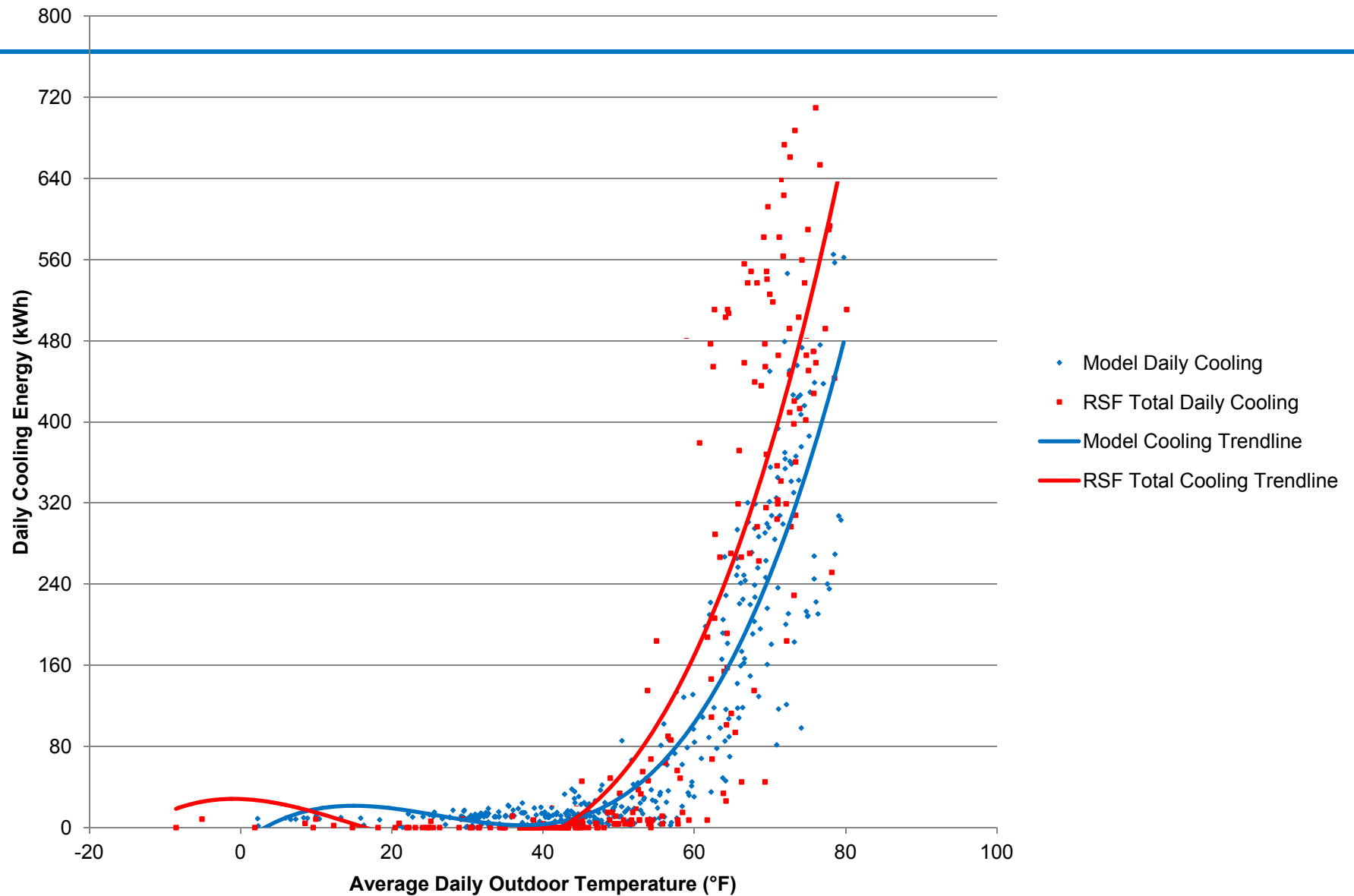
Credit: Chad Lobato/NREL

October 2010 – August 2011 Daily Heating Energy



Credit: Chad Lobato/NREL

2011 YTD Daily Cooling Energy

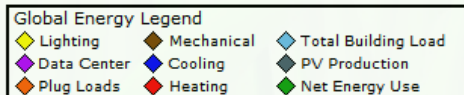
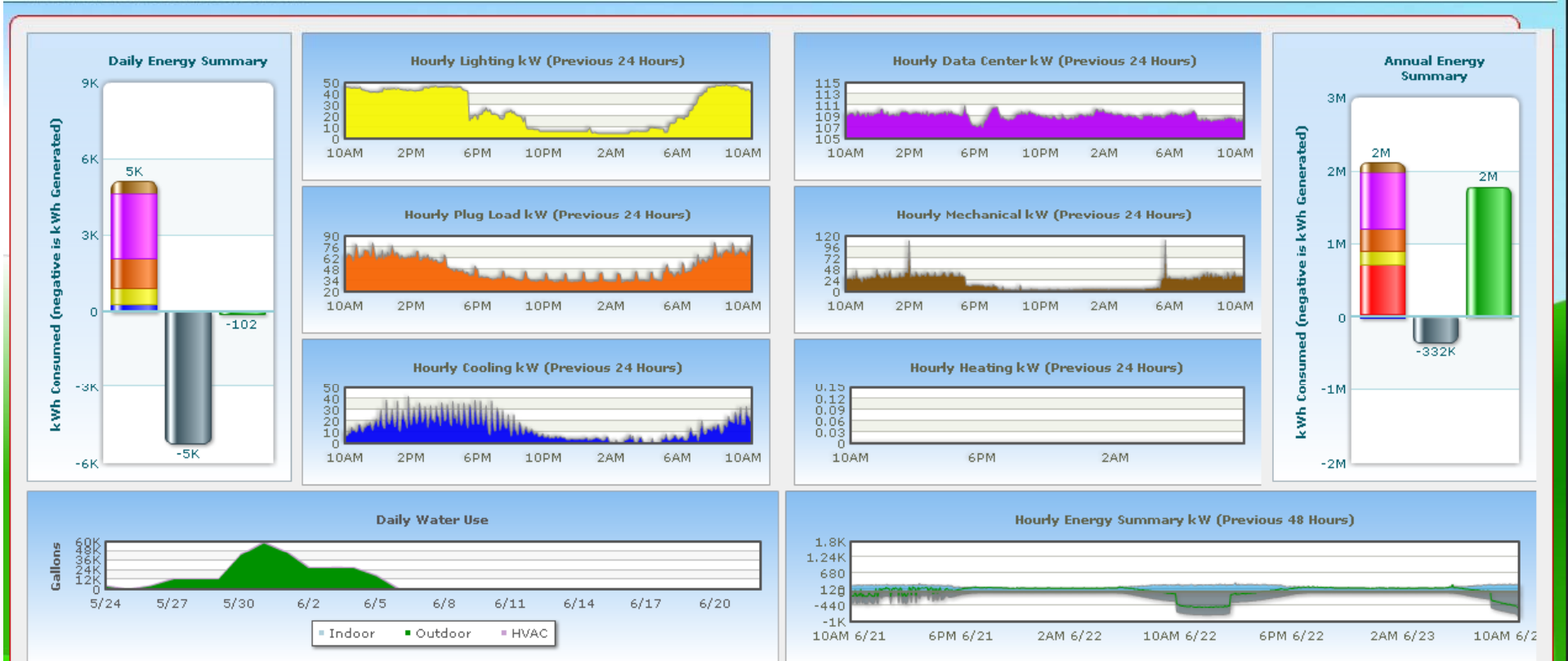


Credit: Chad Lobato/NREL

First day of Net Zero – June 23, 2011



RSF Energy Monitoring



Outside Temperature: 78.3 °F
Outside Relative Humidity: 25.9 %RH

Wind Speed: 2.4 mph
Wind Direction: SE

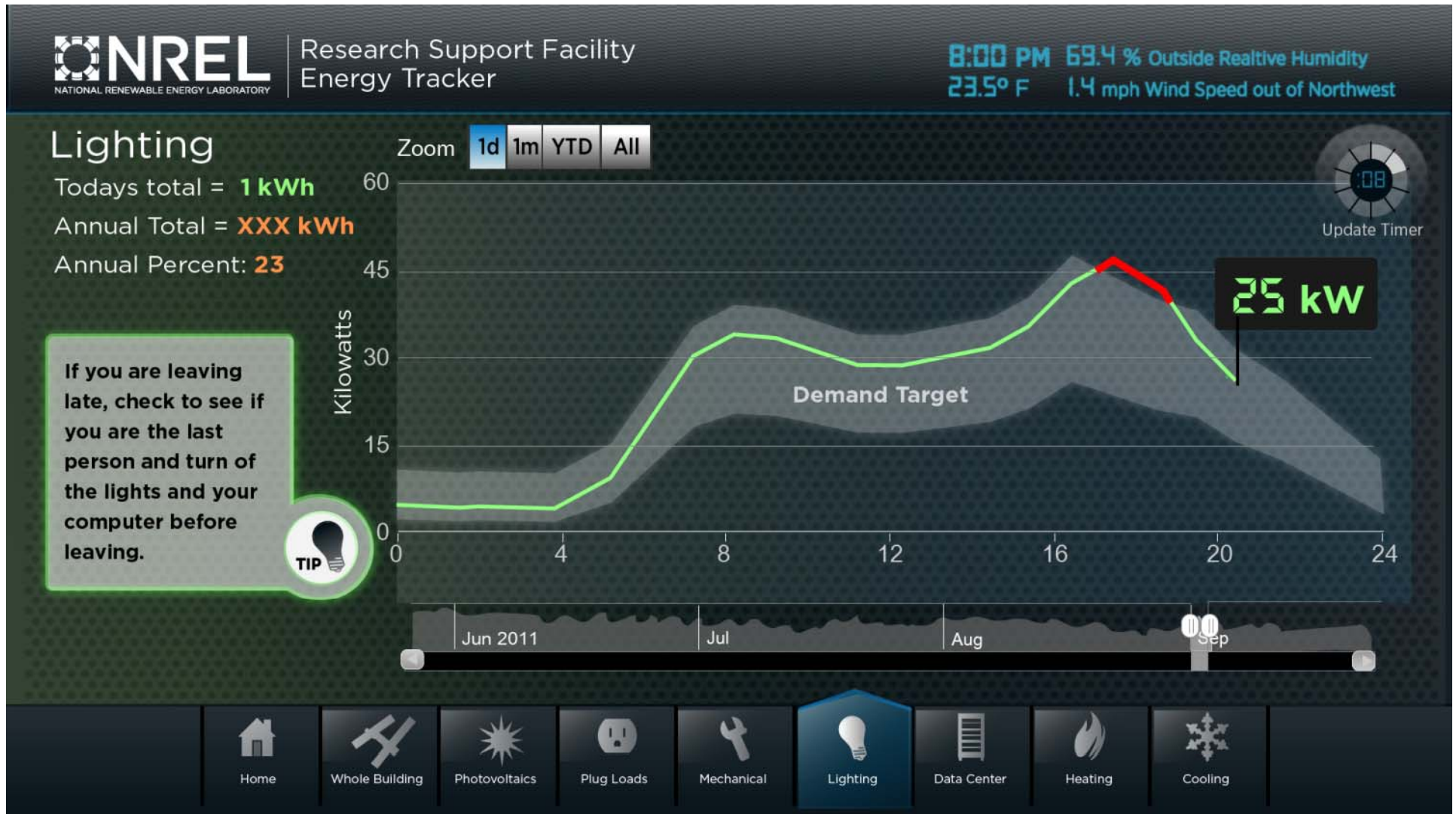
Credit: NREL

New Dashboard - Single Building View



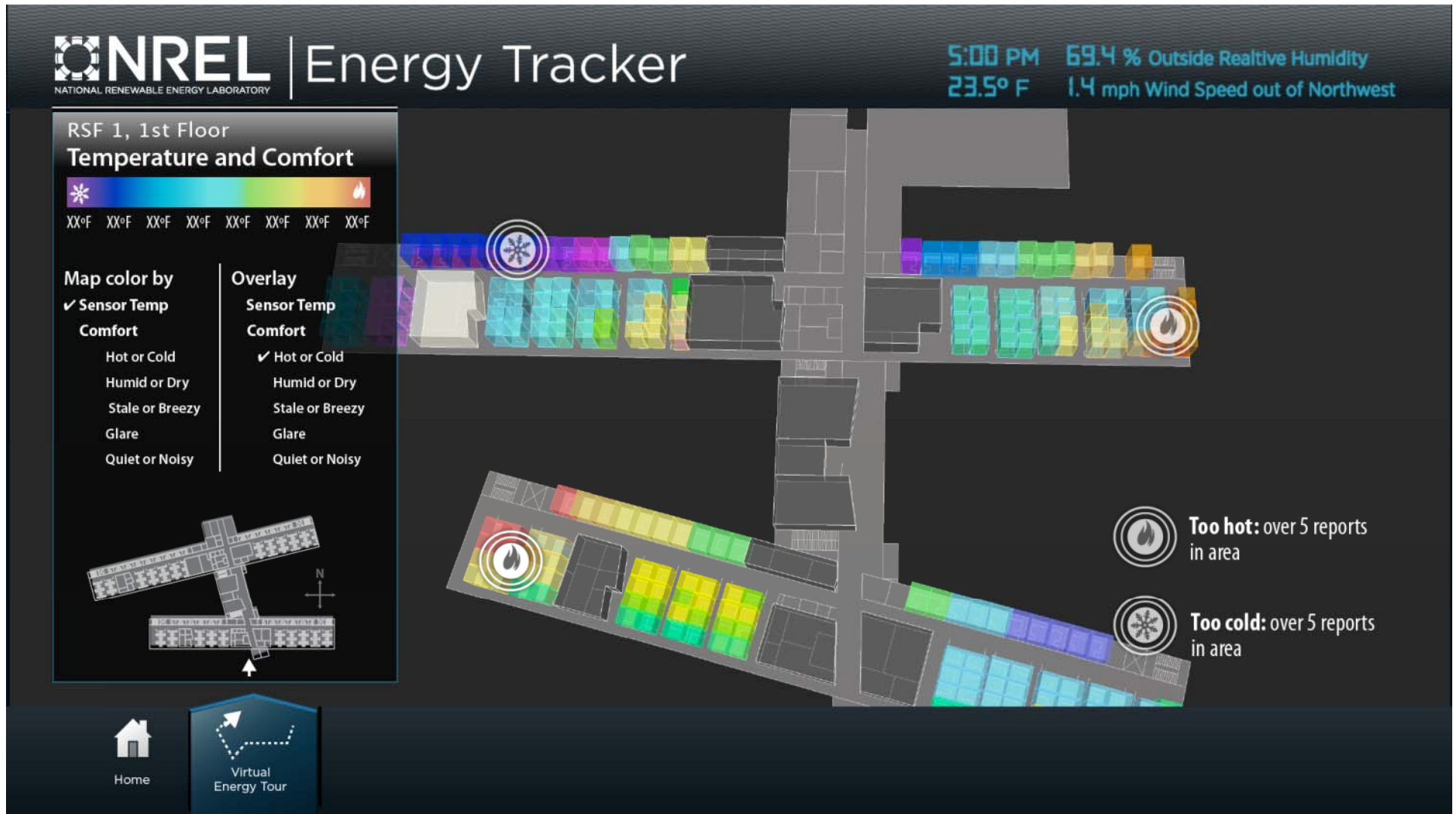
Credit: Marjorie Schott/NREL

New Dashboard - End Use View



Credit: Marjorie Schott/NREL

New Dashboard - Heat Maps



Credit: Marjorie Schott/NREL

Energy Modeling in Net-Zero Projects

How is it different?

- Front loading: model early, model often
- Predictive modeling sets energy budgets for operations
 - Also needed to size renewables
- Models include *all* loads in buildings and associated operations
- The updated model to as-built conditions can be used for fault detection during M&V
 - Can also be used to verify all model input assumptions (that are typically assumed) - forces you to understand how buildings are actually used. These details can help fine-tune/fix systems and future models
- Energy model output (energy use) is equally important as cost and schedule
- Every design decision now has a cost, schedule **AND** energy impact

Thank you! Questions?

