NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Session I: Energy Goals and Features of the RSF

Moderator: Bill Glover

Panelists:

Tom Hootman

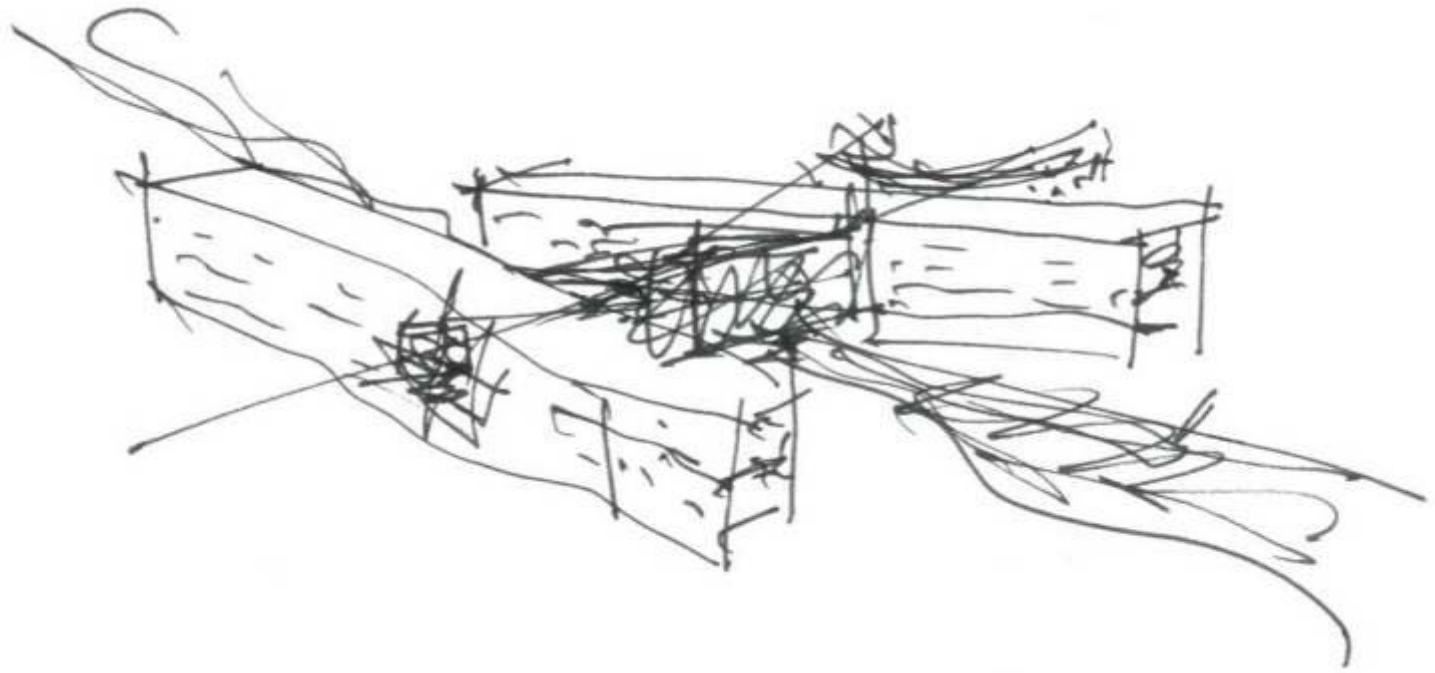
John Andary

Shanti Pless

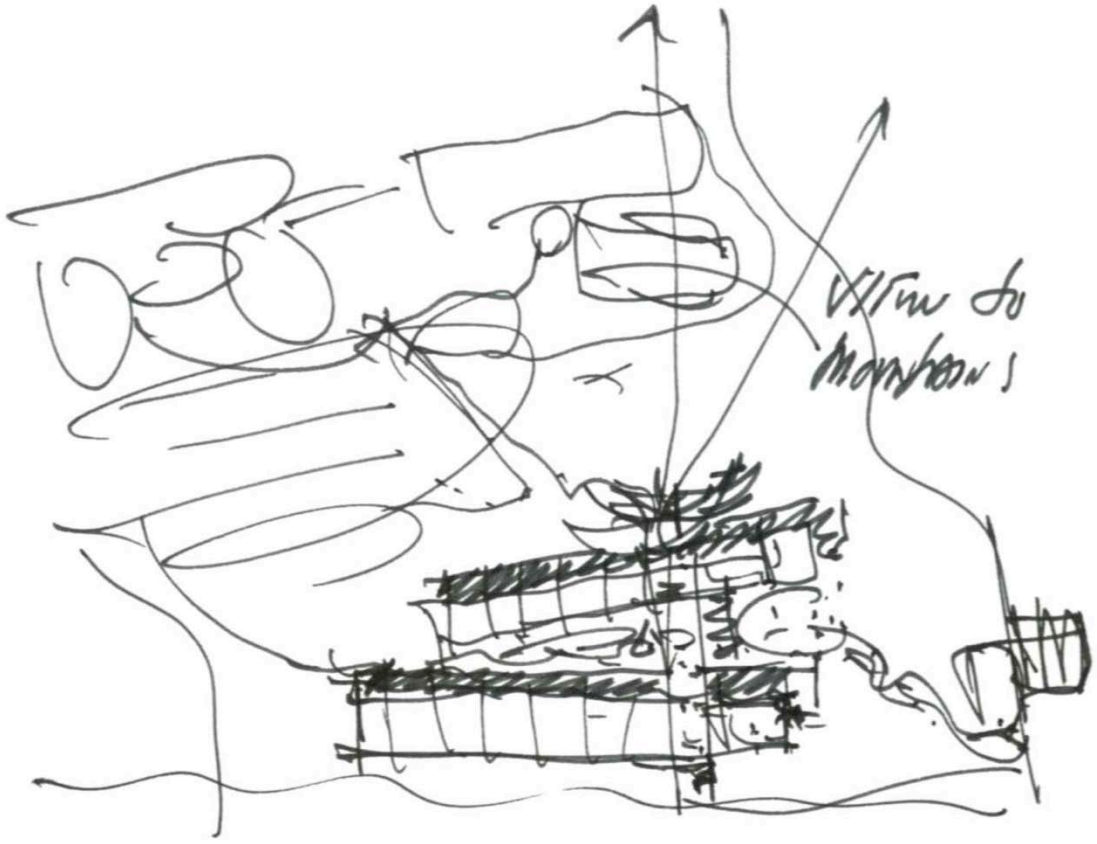
ARCHITECTURAL PERSPECTIVE

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

ARCHITECTURE +ENERGY



ARCHITECTURE +SUSTAINABILITY

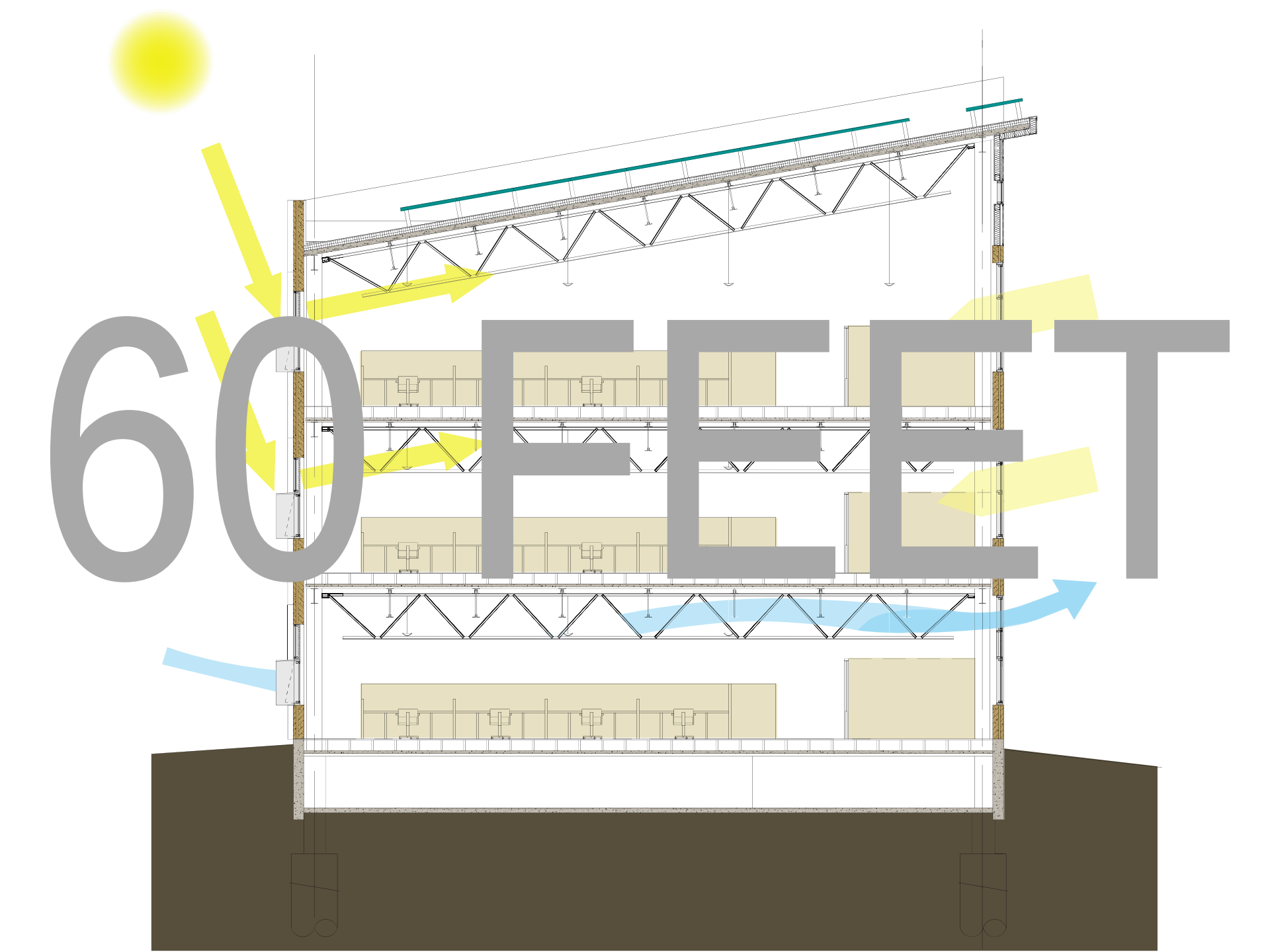


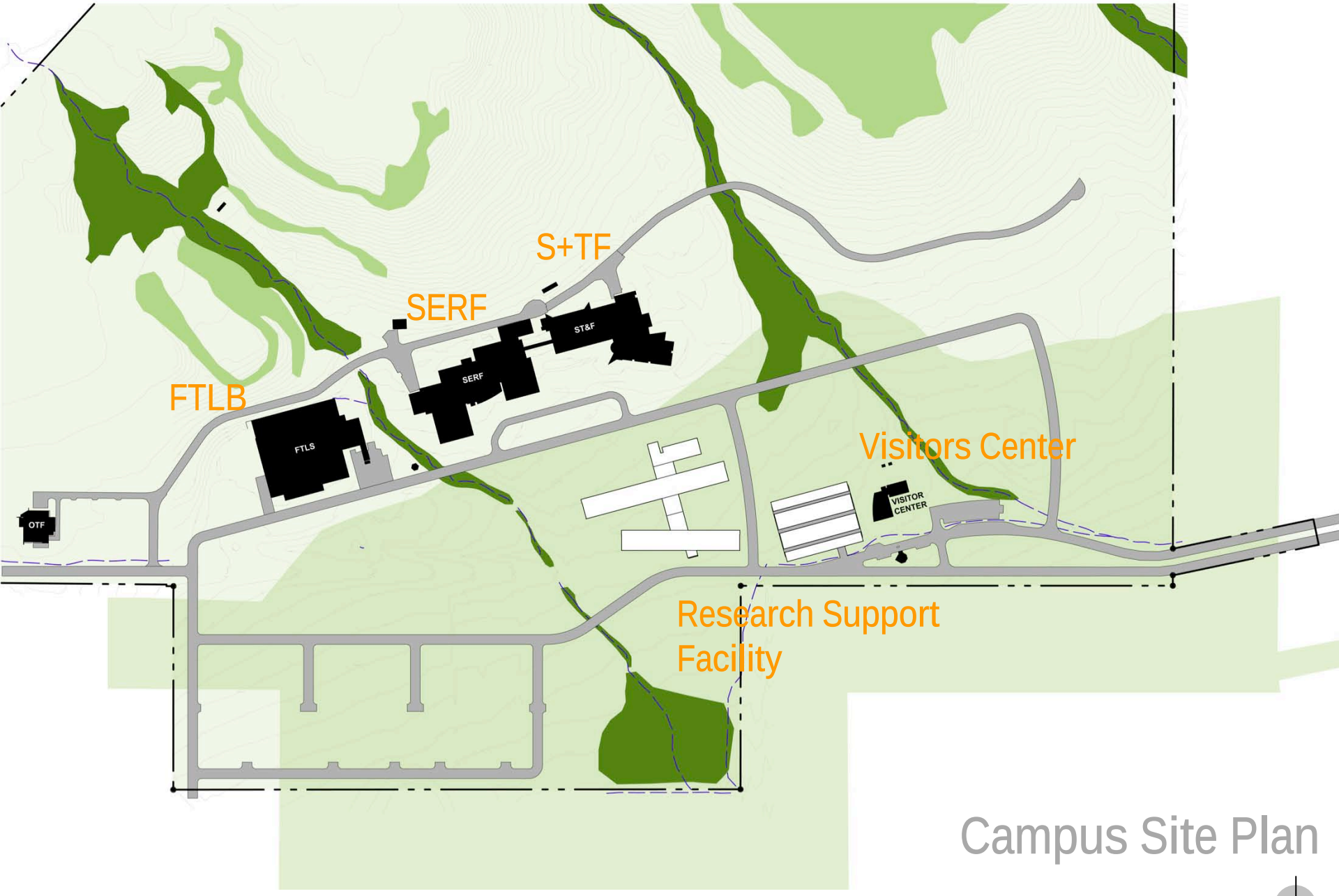

APPROACH
STRATEGIES
RESULTS


CLIMATE


SITE


PROGRAM


60 FEET



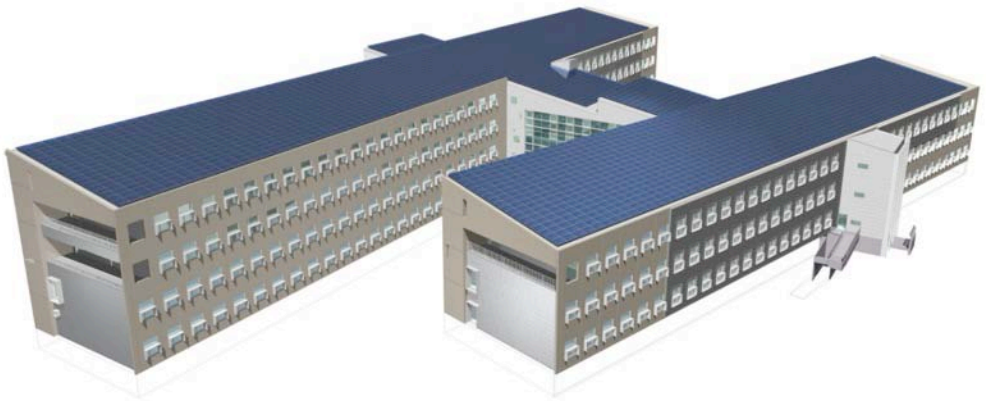
Campus Site Plan

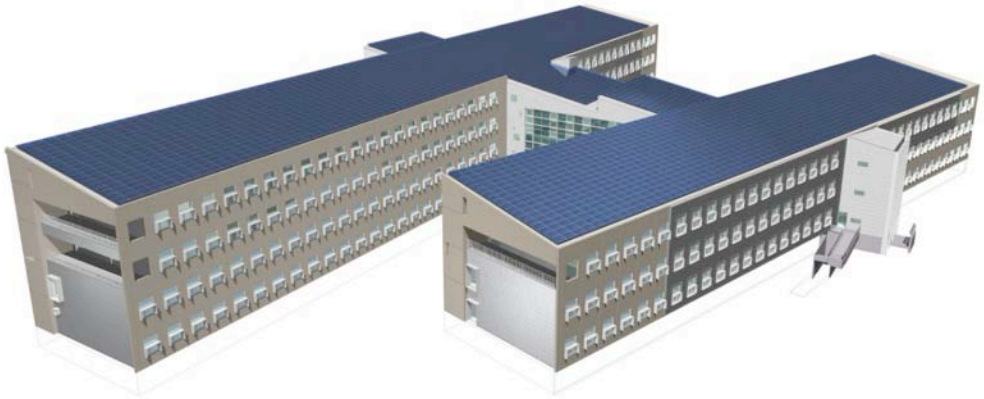
n

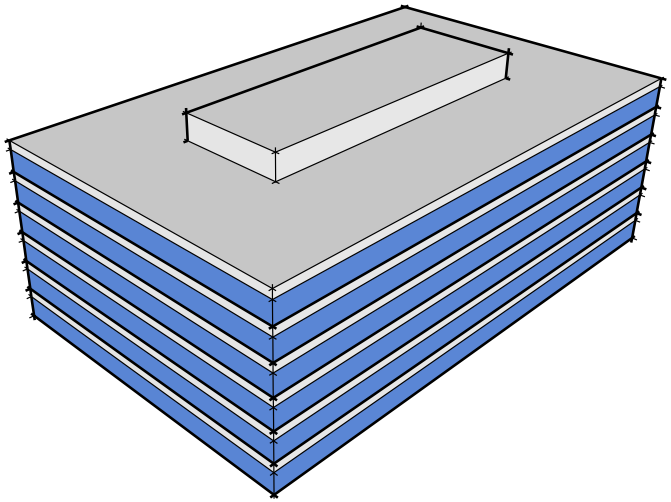

Level 2
Level 3
Level 4
Level 1
OPEN OFFICE AREA
BUILDING SUPPORT
ENCLOSED OFFICE AREA
CONFERENCE
PUBLIC SPACE
n

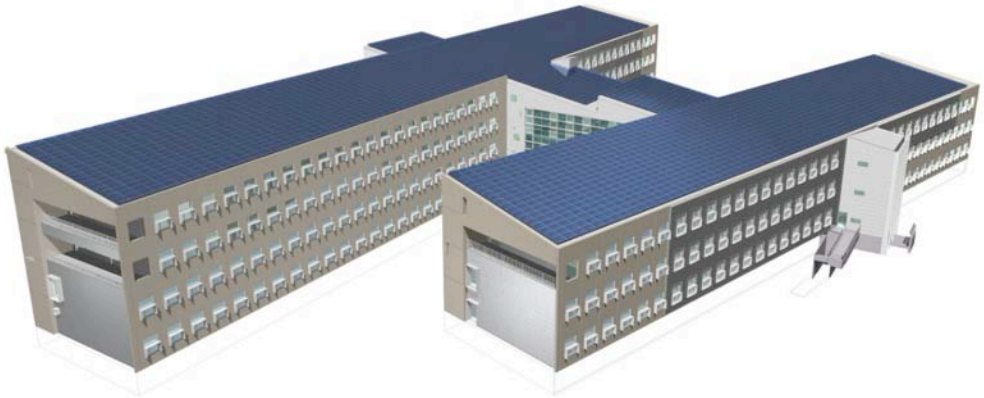
Floor Plans

ENERGY +FORM

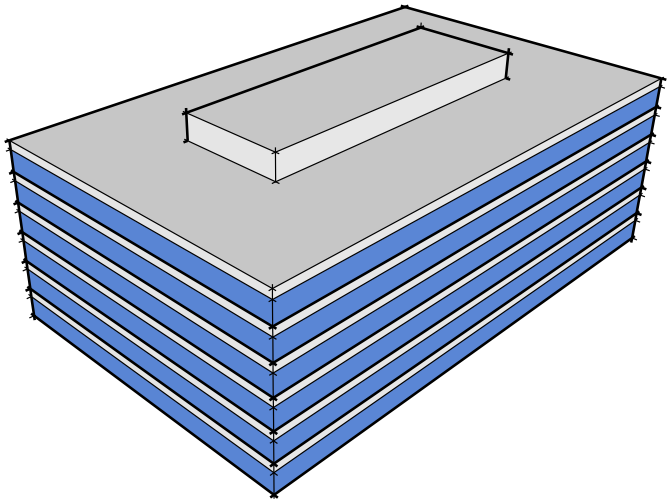








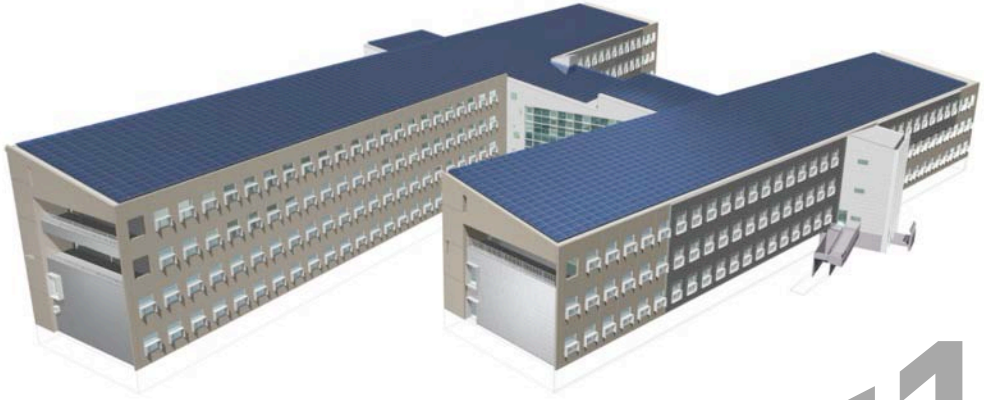
VS.

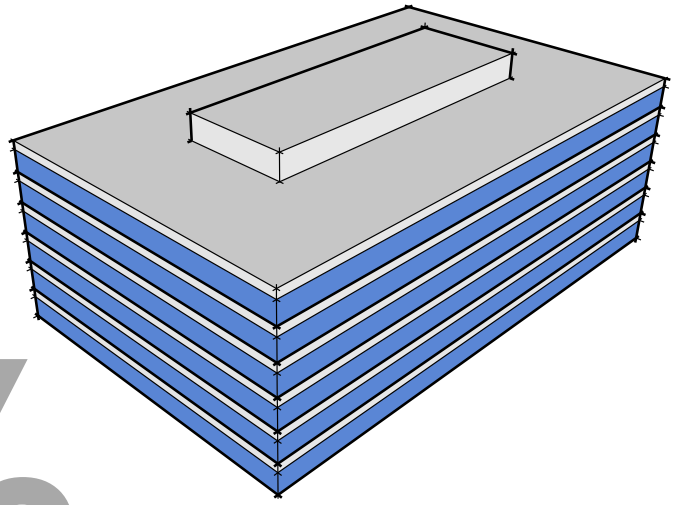


RSF

Evil Twin

FOOTPRINT



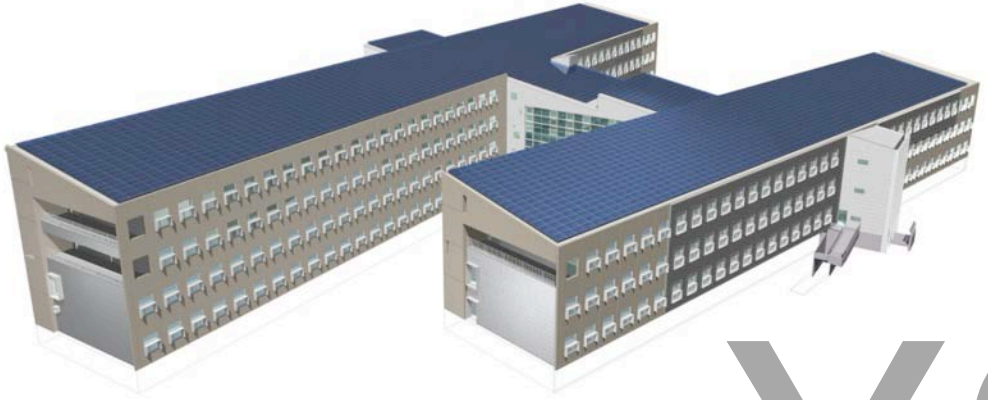


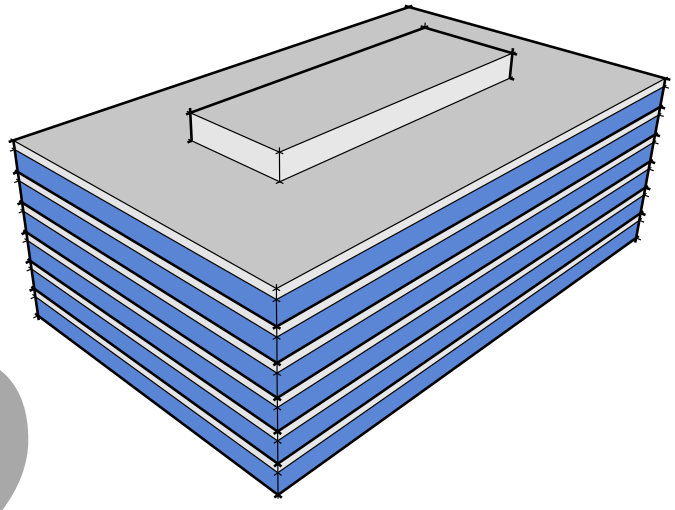
<1/2

60’ Wide Wings

150’ Wide

ENVELOPE



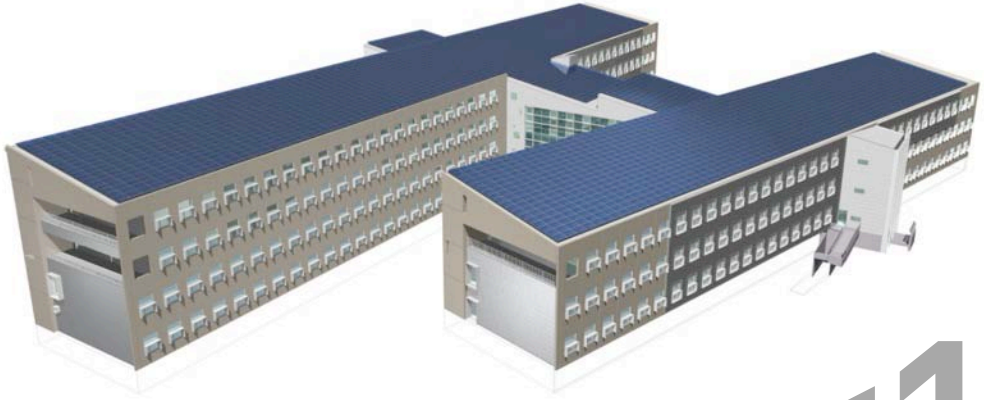


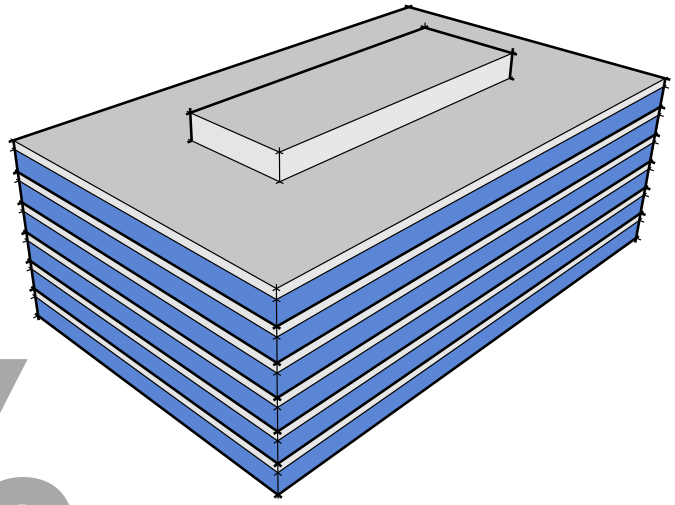
X2

Energy driven form
115,000 SF

Conventional form
65,000 SF

WINDOWS



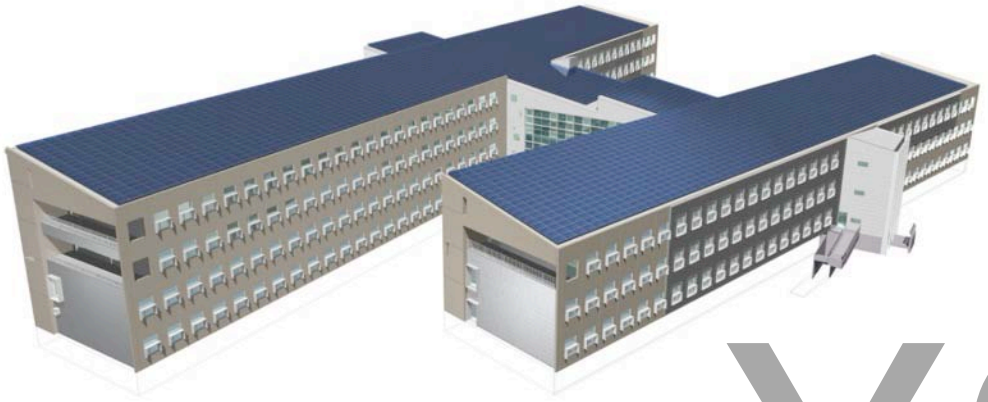


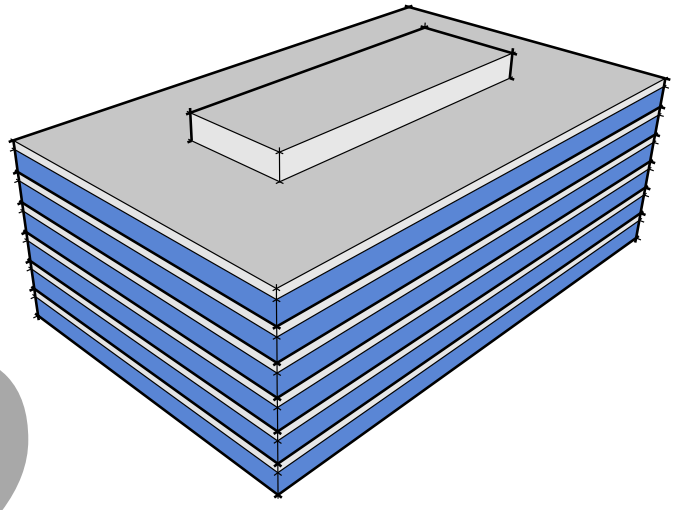
<1/2

<30%
Window to Wall Ratio

>70%
Window to Wall Ratio

ROOF(PV)

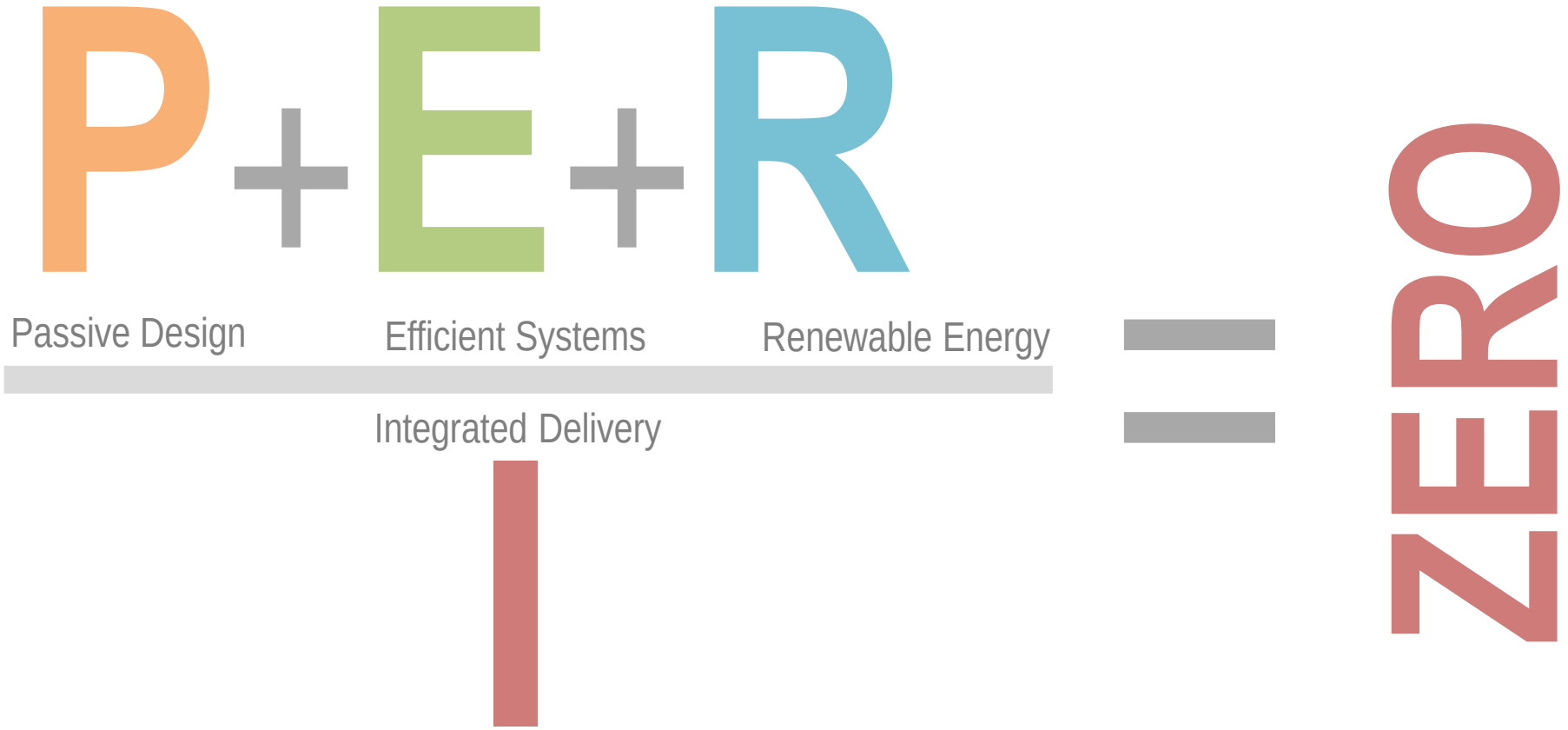




X2

70,000 SF

37,000 - Penthouse

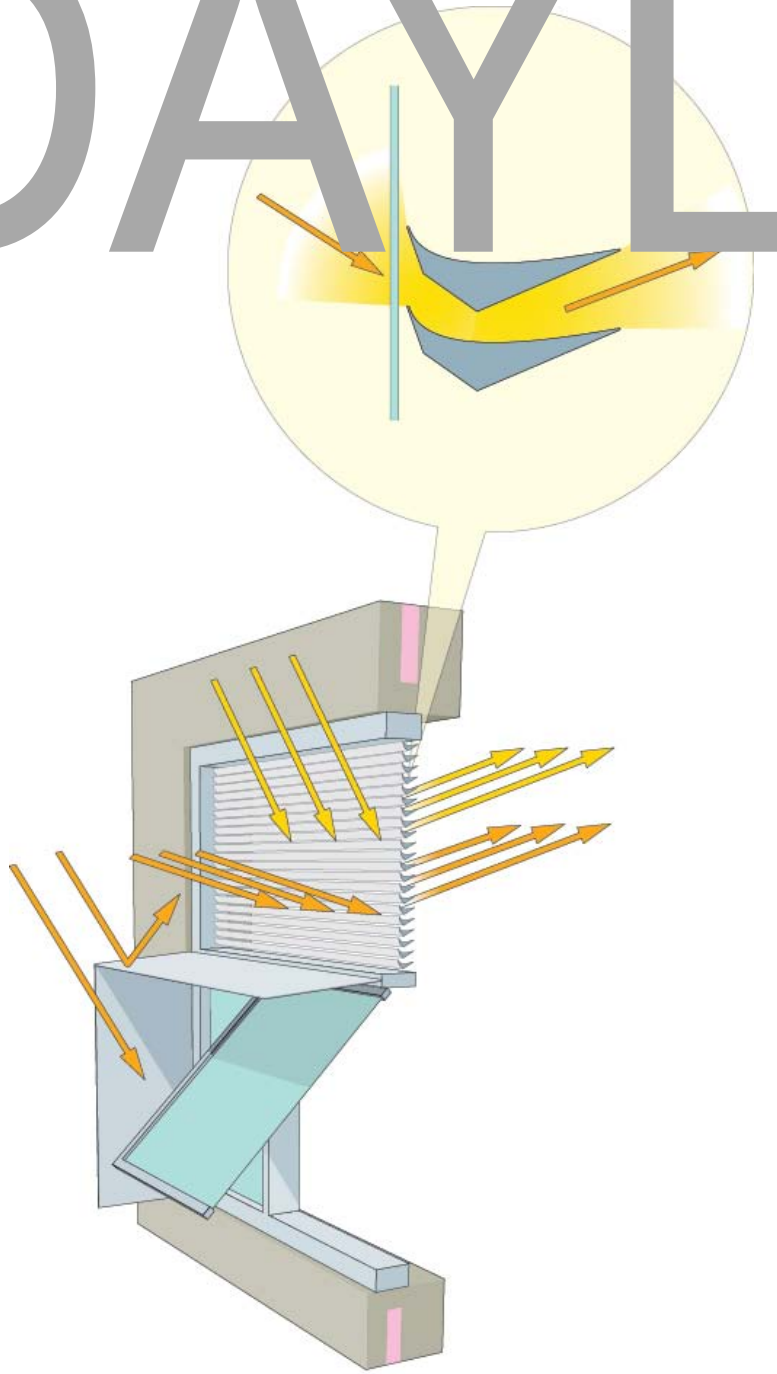

P+E+R
Passive Design
Efficient Systems
Renewable Energy
Integrated Delivery
I
=
ZERO

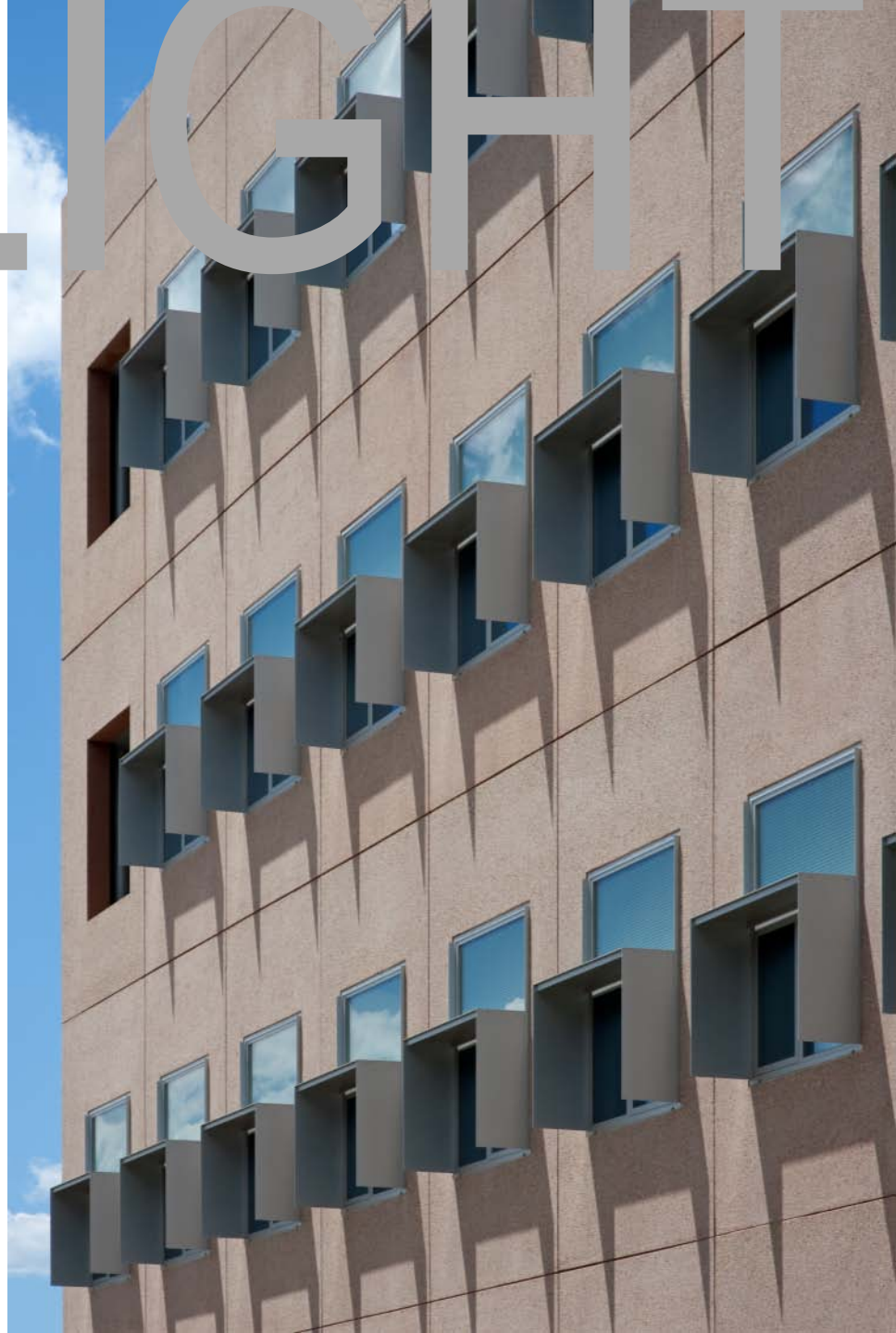
Orientation and 60’ Depth
PV Array
Solar Shading / Daylighting
>30% WWR
Radiant Cooling & Heating

Decoupled Ventilation with UFAD
Operable Windows
Thermal Mass
Transpired Solar Collector
Thermal Labyrinth

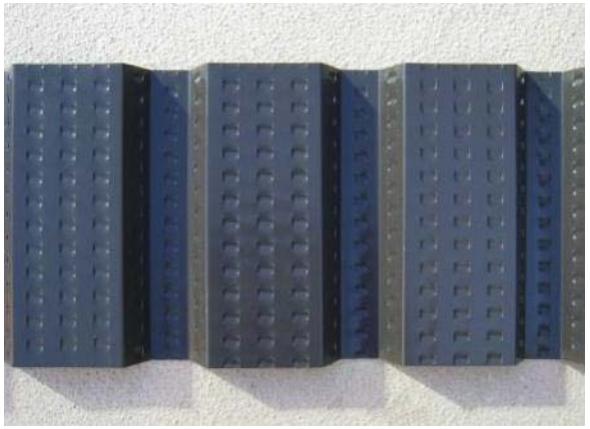
SOUTH

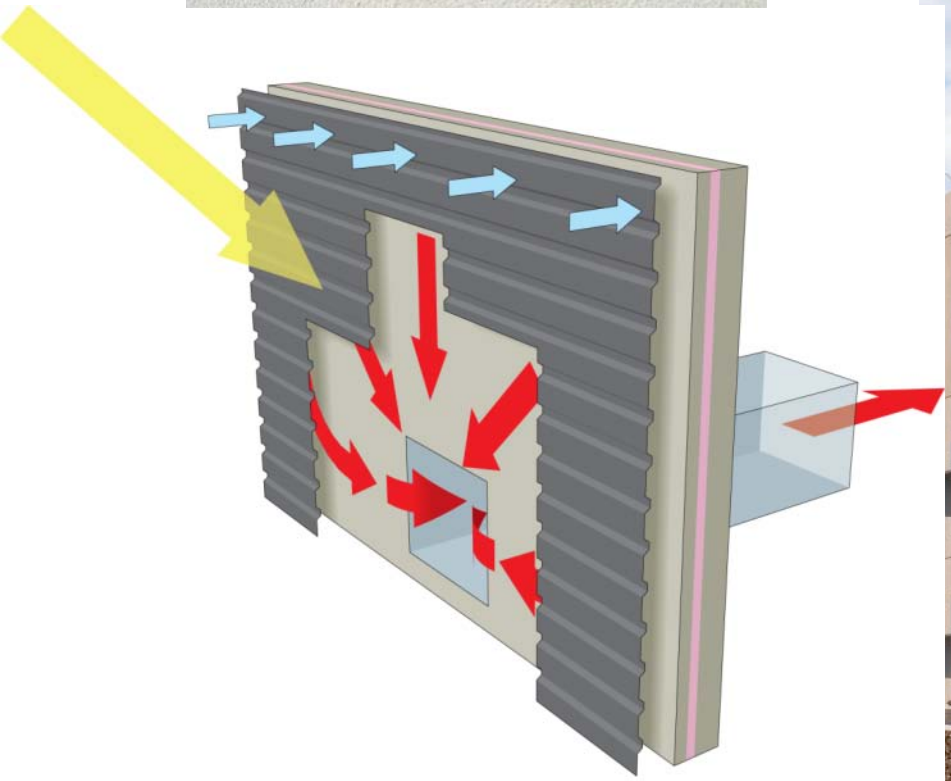
DAYLIGHT



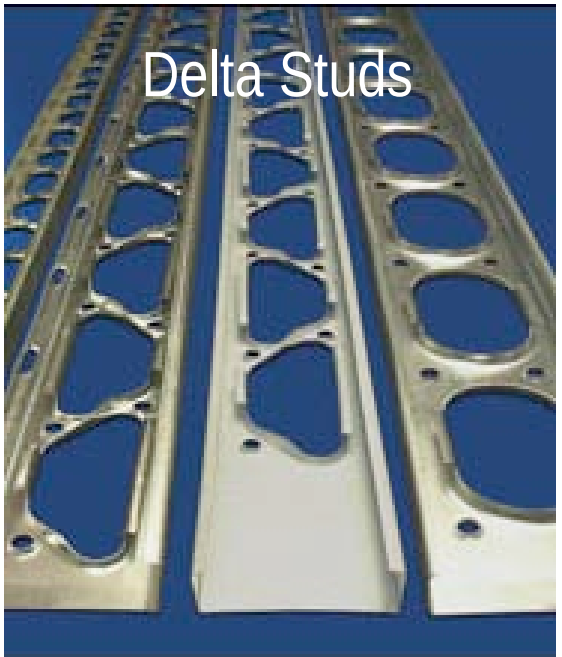


TRANSPIRED SOLAR

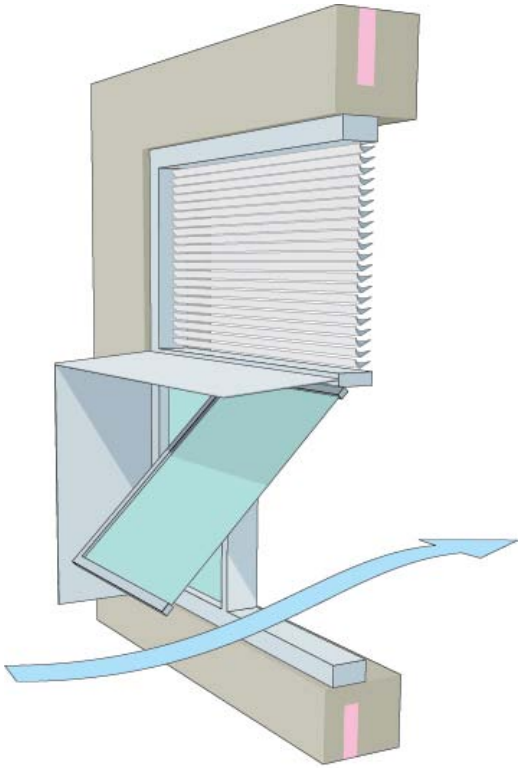




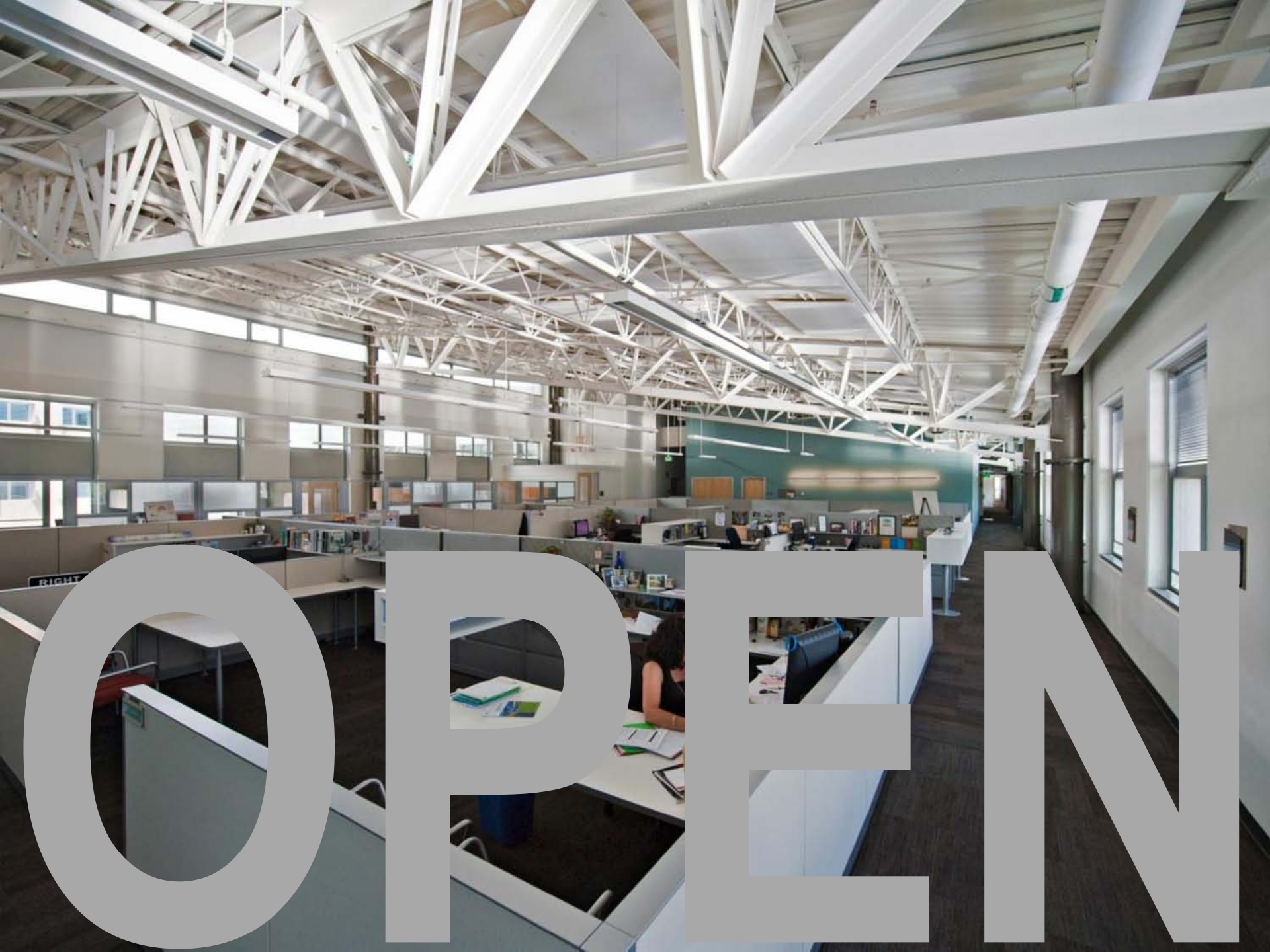
NORTH



NATURAL VENTILATION




WEST


OPEN


PHOTOVOLTAIC
ROOF

NET ZERO BOUNDARY

PLATINUM

Green Facts

NREL
Research Support Facility
Golden, Colorado

LEED-NC rating out of	69
Platinum*	**59**
Sustainable Sites	12
Water Efficiency	4
Energy & Atmosphere	17
Materials & Resources	7
Indoor Environmental Quality	14
Innovation & Design	5

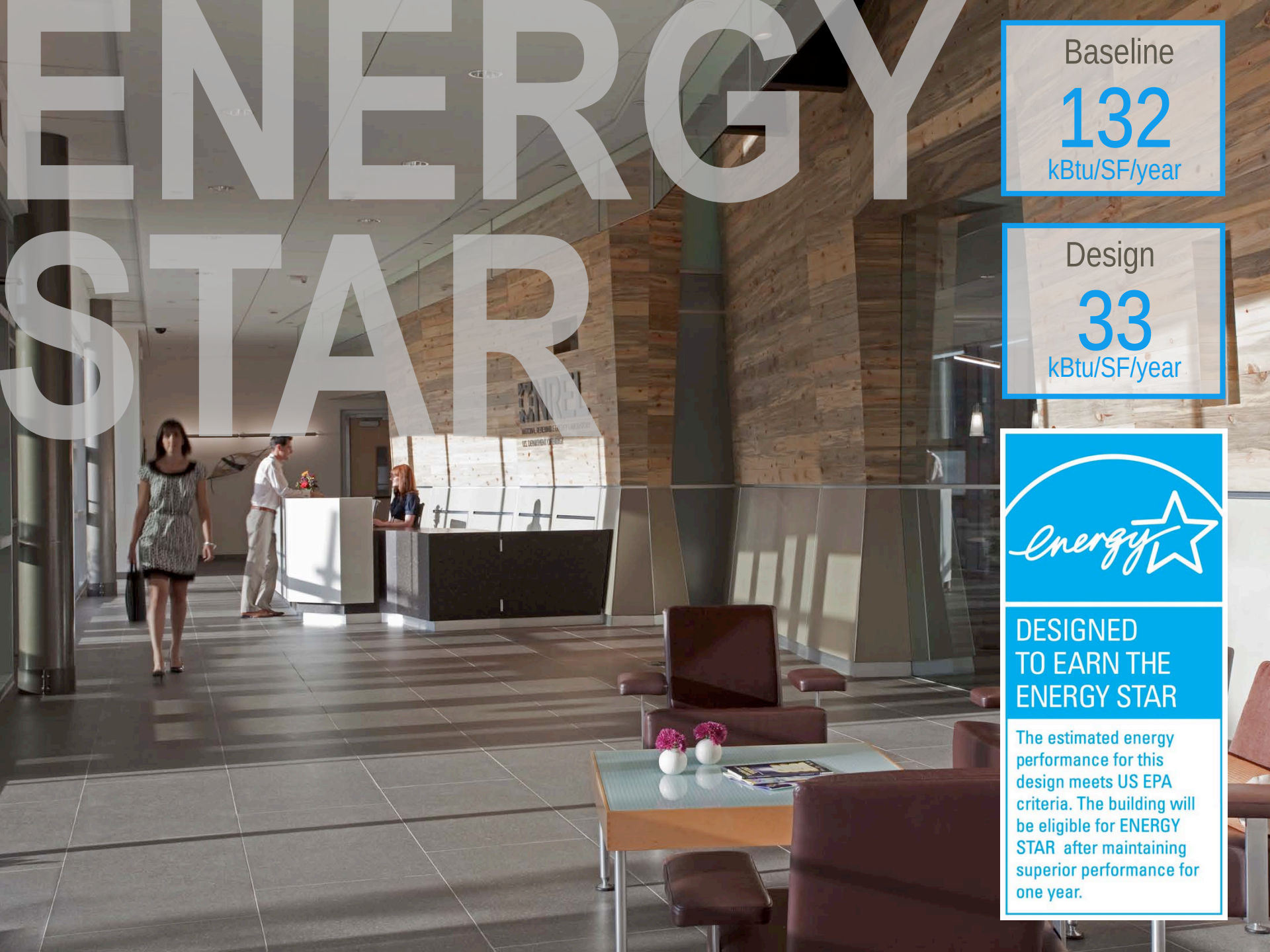
ENERGY & ATMOSPHERE

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

17/17

+1 Exemplary Performance Credit for EAc1

ENERGY STAR



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

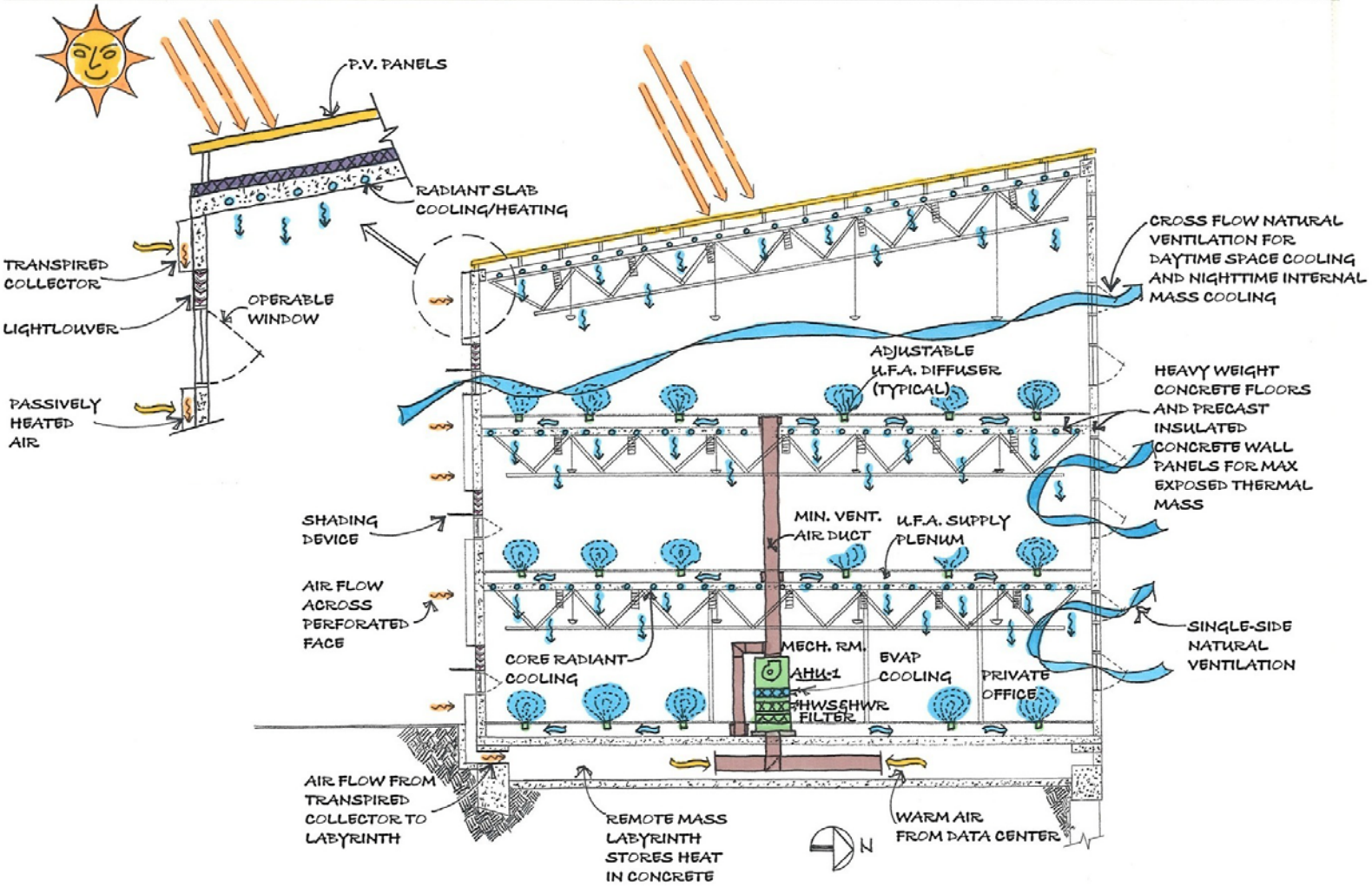
Net Zero Source Energy Building

Net Zero Energy Emissions Building

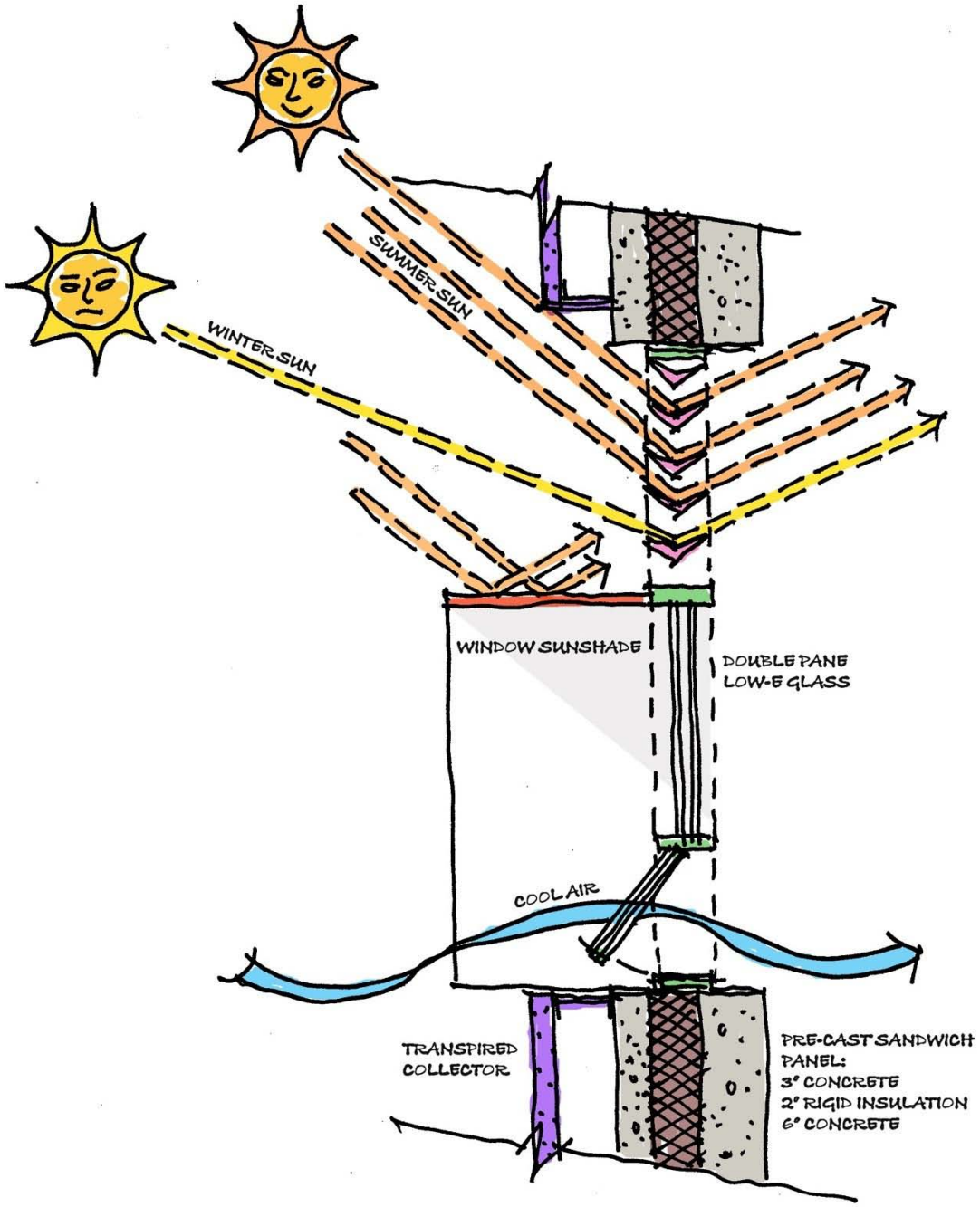
Net Zero Energy Cost Building

JOHN ANDARY, PE,
LEED AP

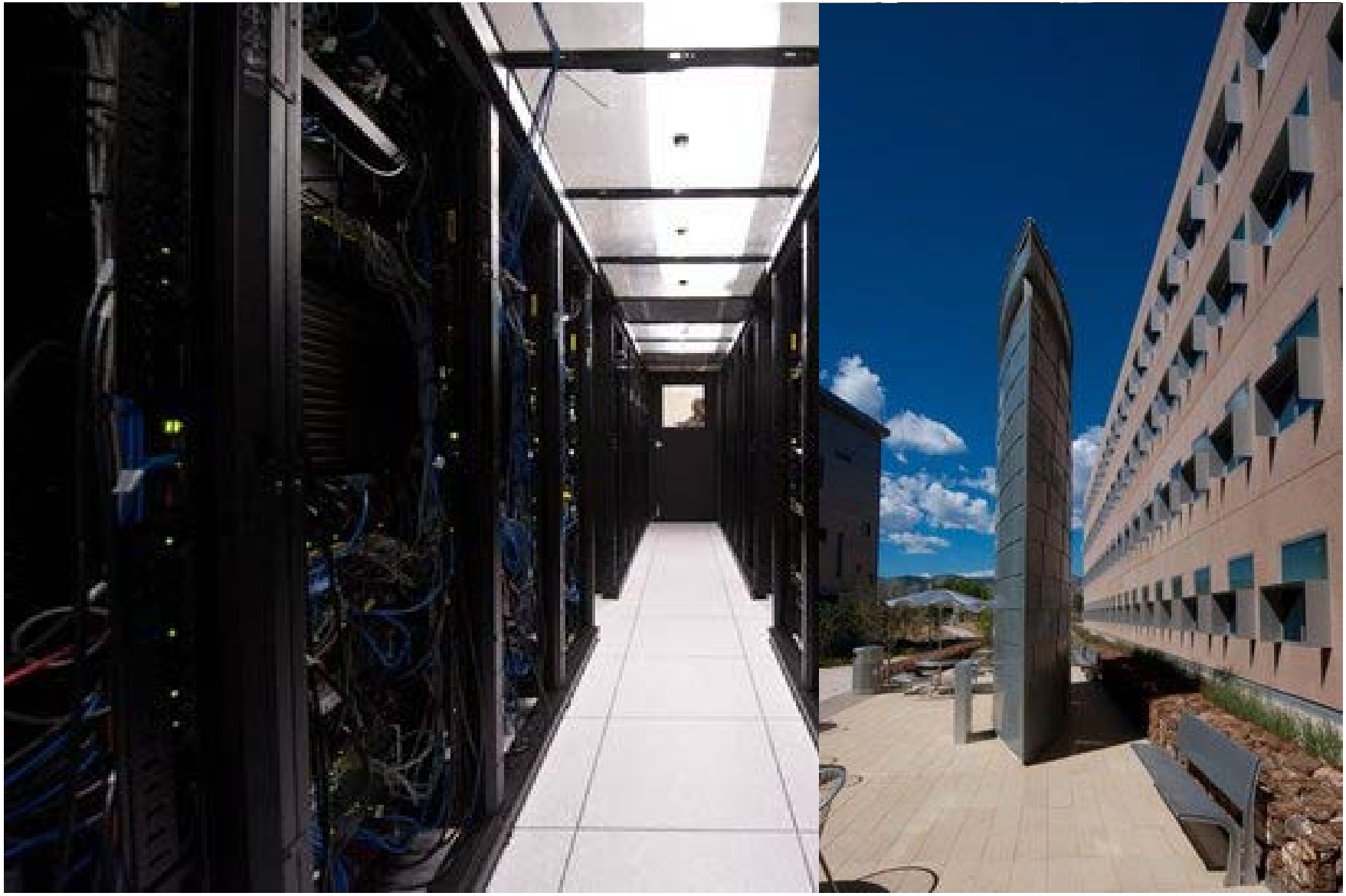
INTEGRAL GROUP


P.V. PANELS
RADIANT SLAB COOLING/HEATING
TRANSPIRED COLLECTOR
LIGHTLOUVER
OPERABLE WINDOW
PASSIVELY HEATED AIR
CROSS FLOW NATURAL VENTILATION FOR DAYTIME SPACE COOLING AND NIGHTTIME INTERNAL MASS COOLING
ADJUSTABLE U.F.A. DIFFUSER (TYPICAL)
HEAVY WEIGHT CONCRETE FLOORS AND PRECAST INSULATED CONCRETE WALL PANELS FOR MAX EXPOSED THERMAL MASS
SHADING DEVICE
MIN. VENT. AIR DUCT
U.F.A. SUPPLY PLENUM
AIR FLOW ACROSS PERFORATED FACE
SINGLE-SIDE NATURAL VENTILATION
CORE RADIANT COOLING
MECH. RM.
AHU-1
EVAP COOLING
PRIVATE OFFICE
HWS
CHWS
CHWR
FILTER
AIR FLOW FROM TRANSPIRED COLLECTOR TO LABYRINTH
REMOTE MASS LABYRINTH STORES HEAT IN CONCRETE
WARM AIR FROM DATA CENTER
N

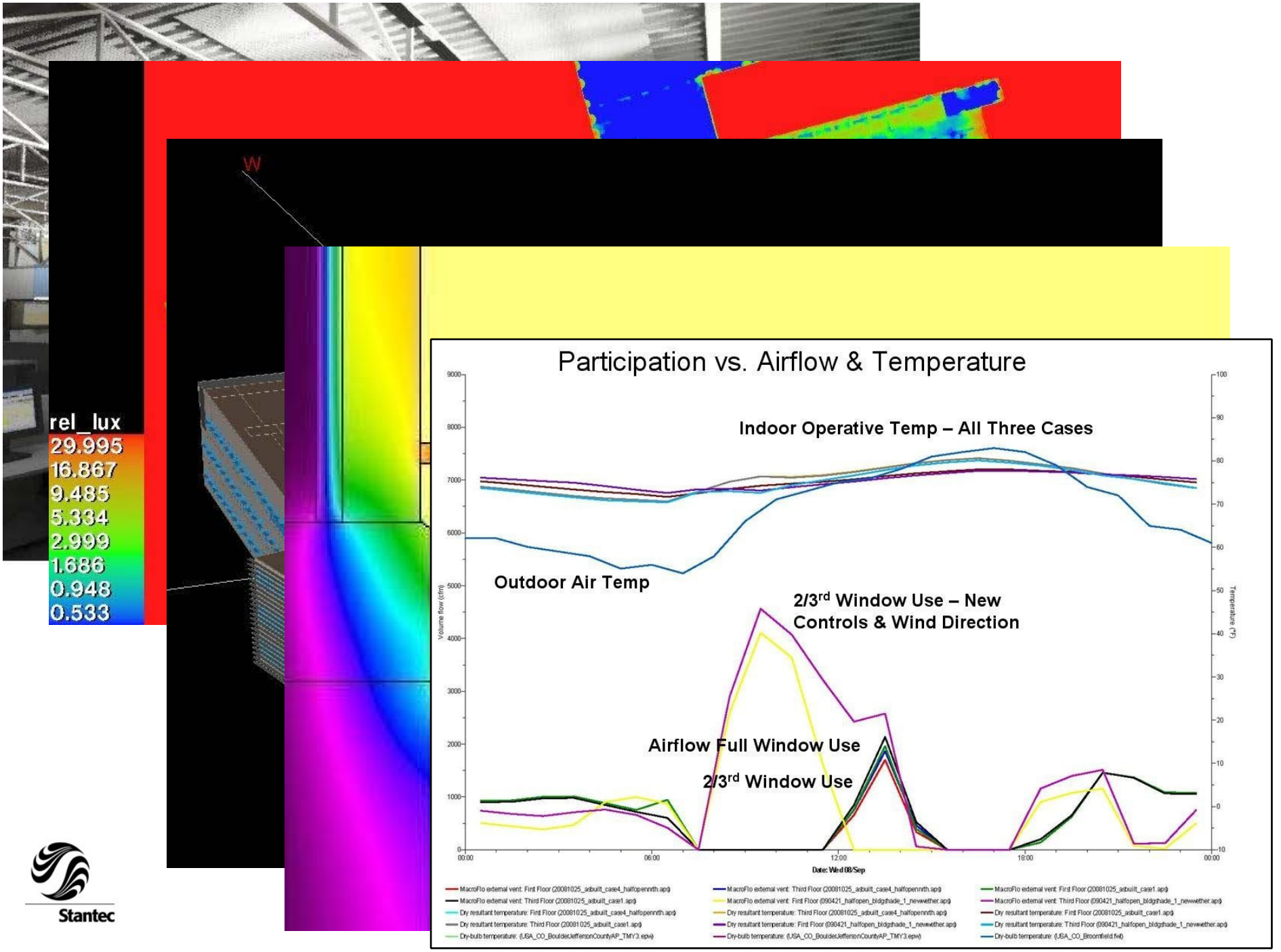
Stantec


SUMMER SUN
WINTER SUN
WINDOW SUNSHADE
DOUBLE PANE
LOW-E GLASS
COOL AIR
TRANSPIRED
COLLECTOR
PRE-CAST SANDWICH
PANEL:
3" CONCRETE
2" RIGID INSULATION
6" CONCRETE

Stantec




THERMAL SLAB SUPPLY
THERMAL SLAB RETURN


rel_lux
29.995
16.867
9.485
5.334
2.999
1.686
0.948
0.533
W
Participation vs. Airflow & Temperature
Indoor Operative Temp – All Three Cases
Outdoor Air Temp
2/3rd Window Use – New Controls & Wind Direction
Airflow Full Window Use
2/3rd Window Use
Volume flow (cfm)
Temperature (°F)
Date: Wed 08/Sep
MacroFlo external vent: First Floor (20081025_adbuilt_case4_halfopennrth.aps)
MacroFlo external vent: Third Floor (20081025_adbuilt_case4_halfopennrth.aps)
MacroFlo external vent: First Floor (20081025_adbuilt_case1.aps)
MacroFlo external vent: Third Floor (20081025_adbuilt_case1.aps)
MacroFlo external vent: First Floor (090421_halfopen_bldgshade_1_newwether.aps)
MacroFlo external vent: Third Floor (090421_halfopen_bldgshade_1_newwether.aps)
Dry resultant temperature: First Floor (20081025_adbuilt_case4_halfopennrth.aps)
Dry resultant temperature: Third Floor (20081025_adbuilt_case4_halfopennrth.aps)
Dry resultant temperature: First Floor (20081025_adbuilt_case1.aps)
Dry resultant temperature: Third Floor (20081025_adbuilt_case1.aps)
Dry resultant temperature: First Floor (090421_halfopen_bldgshade_1_newwether.aps)
Dry resultant temperature: Third Floor (090421_halfopen_bldgshade_1_newwether.aps)
Dry-bulb temperature: (USA_CO_BoulderJeffersonCountyAP_TMY3.epw)
Dry-bulb temperature: (USA_CO_BoulderJeffersonCountyAP_TMY3.epw)
Dry-bulb temperature: (USA_CO_Broomfield.fwt)

Stantec

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Innovation for Our Energy Future

NREL's Research Support Facility: An Operations Update

Shanti Pless

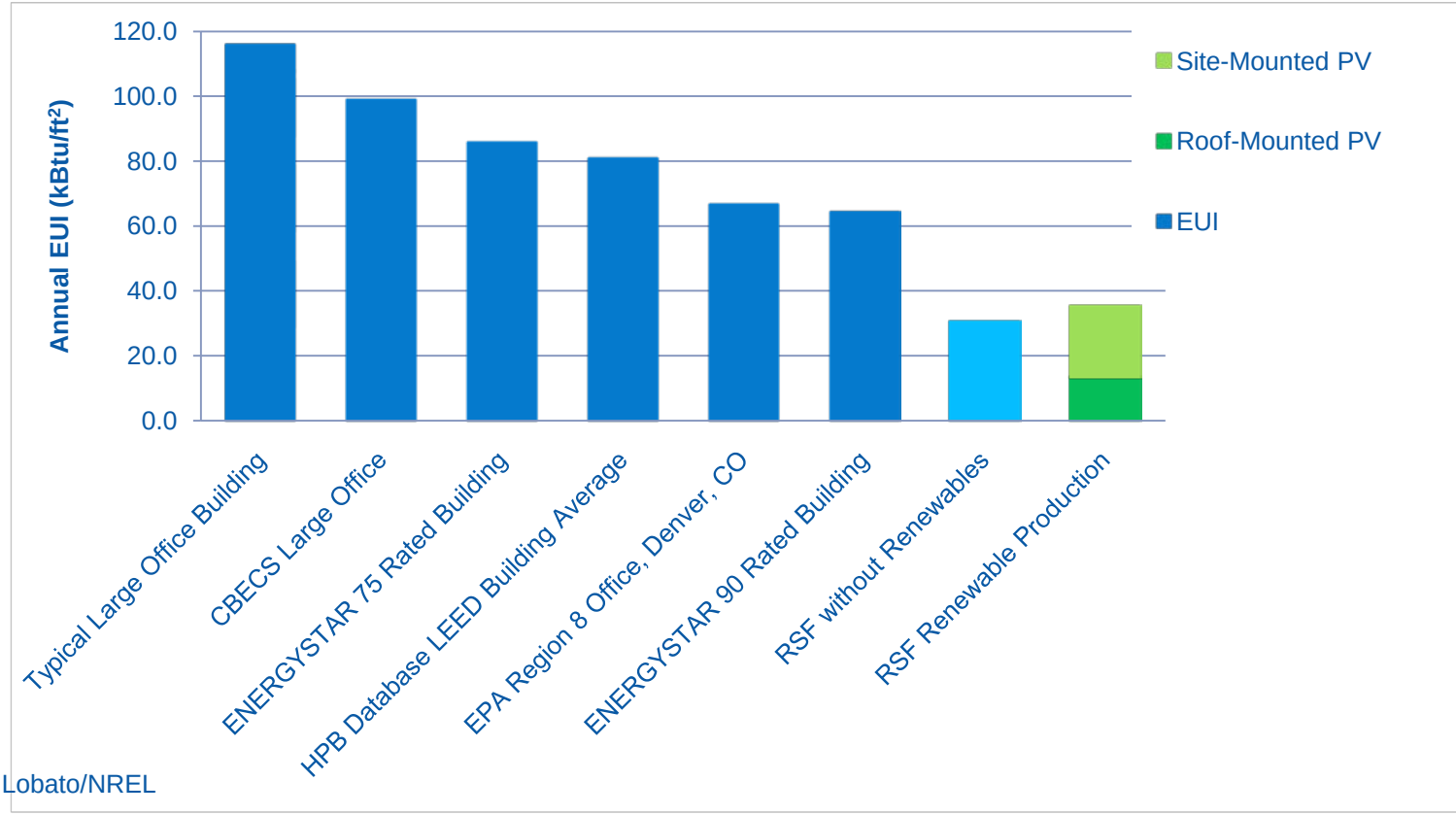
Senior Research Engineer

Commercial Buildings Research Group

July 2011

Design Requirements

- 25 kBtu/ft^2/yr for standard office space occupant density and data center loads
- Normalized up to 35.1 kBtu/ft^2/yr for better space efficiency and to account for full data center load

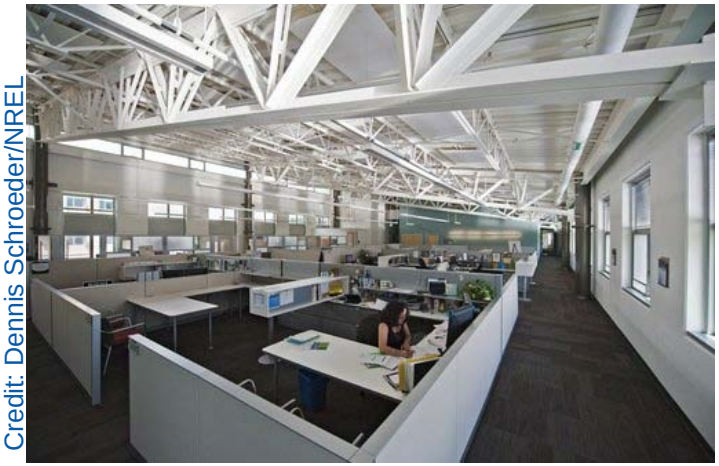


Credit: Chad Lobato/NREL

Photovoltaic System

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

RSF Complex Update



Credit: Dennis Schroeder/NREL

- 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

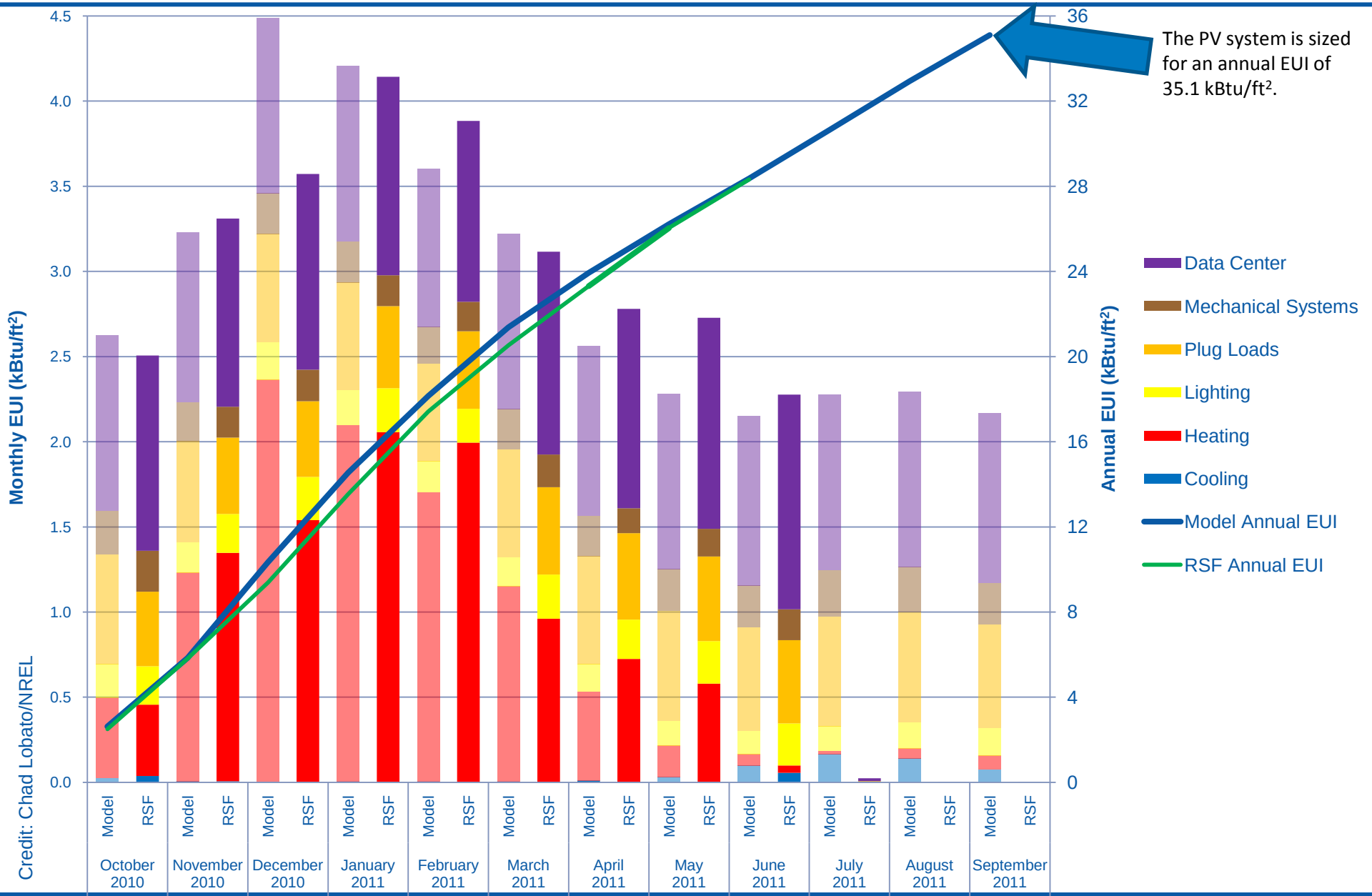
NREL/PIX 17845

So How Is It Performing?

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

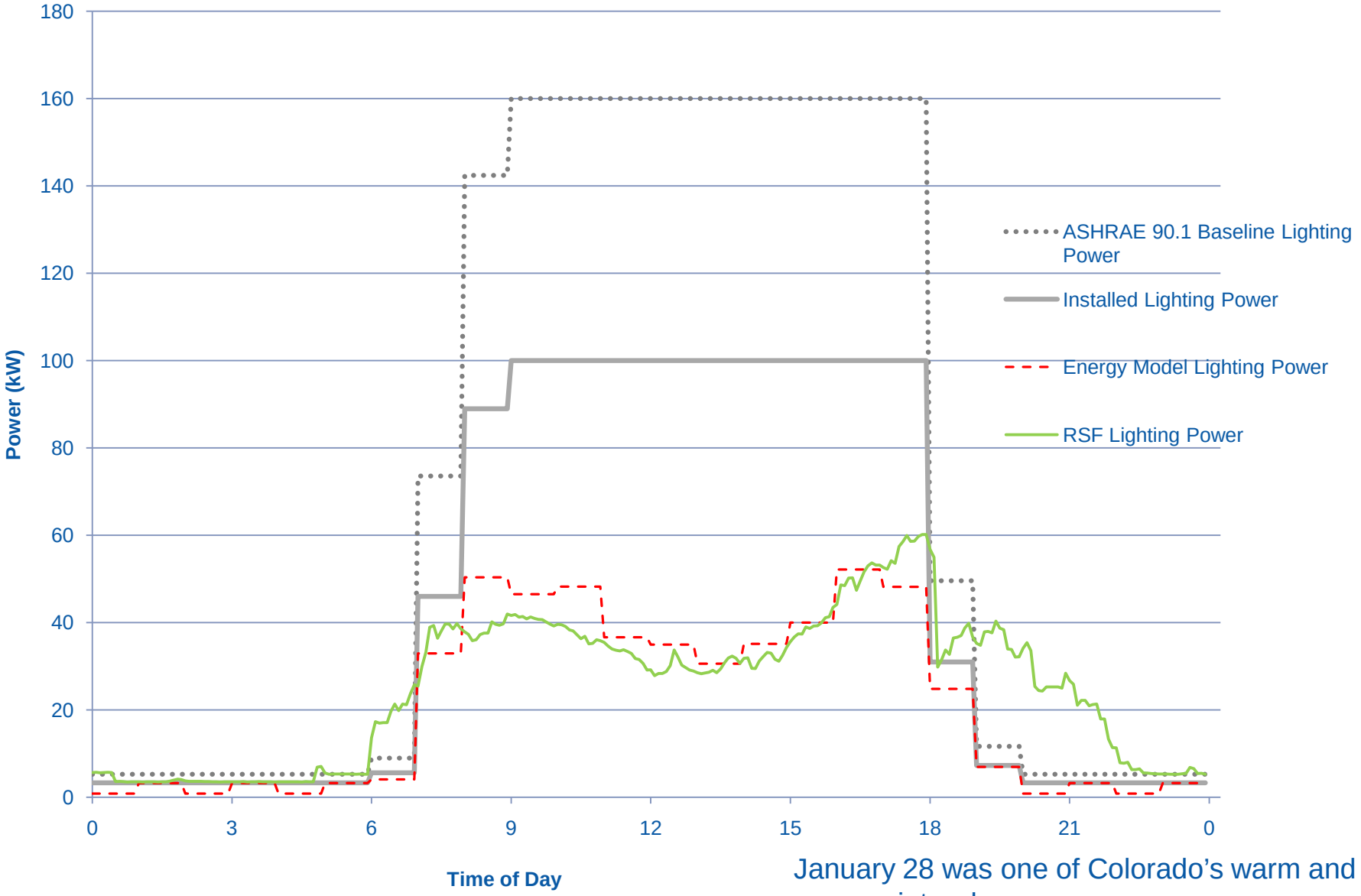
Measured Versus Modeled Monthly and Cumulative EUI



Operational Lessons - Daylighting

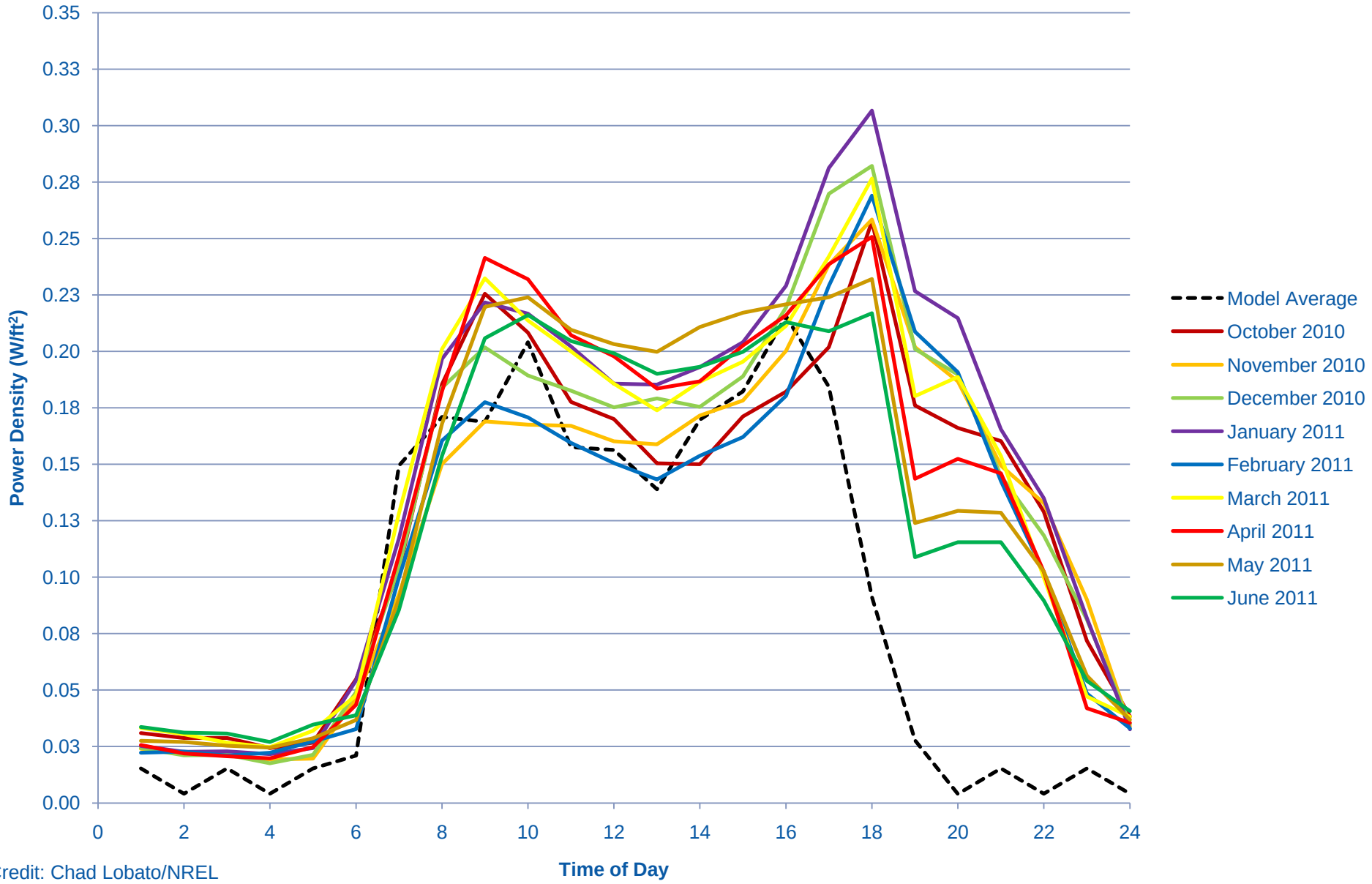
- Lights fully dimmed (10%) or off when sunny
- Move cleaning to daylit hours?
- Even with direct glare designed out, fully daylit buildings still have “indirect” glare
  - Bright spots on ceiling and light fixtures
  - Bright background
  - Glare self-evaluation checklist to ensure “indirect” glare 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, 2011 Lighting and Daylighting



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

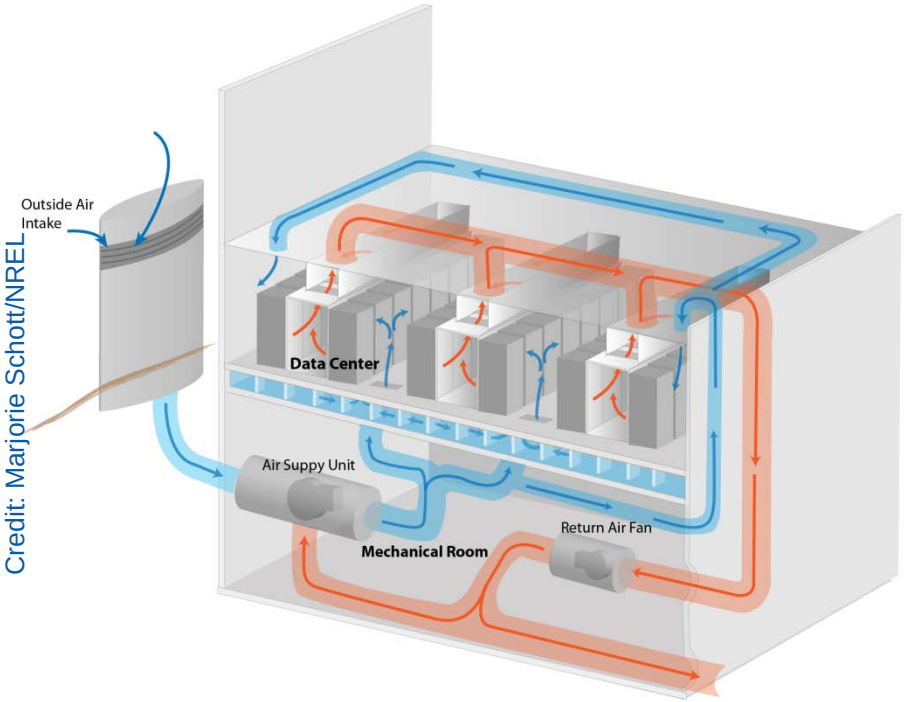
October 2010 – June 2011 Lighting Power Density



Credit: Chad Lobato/NREL

Operational Lessons- Datacenter

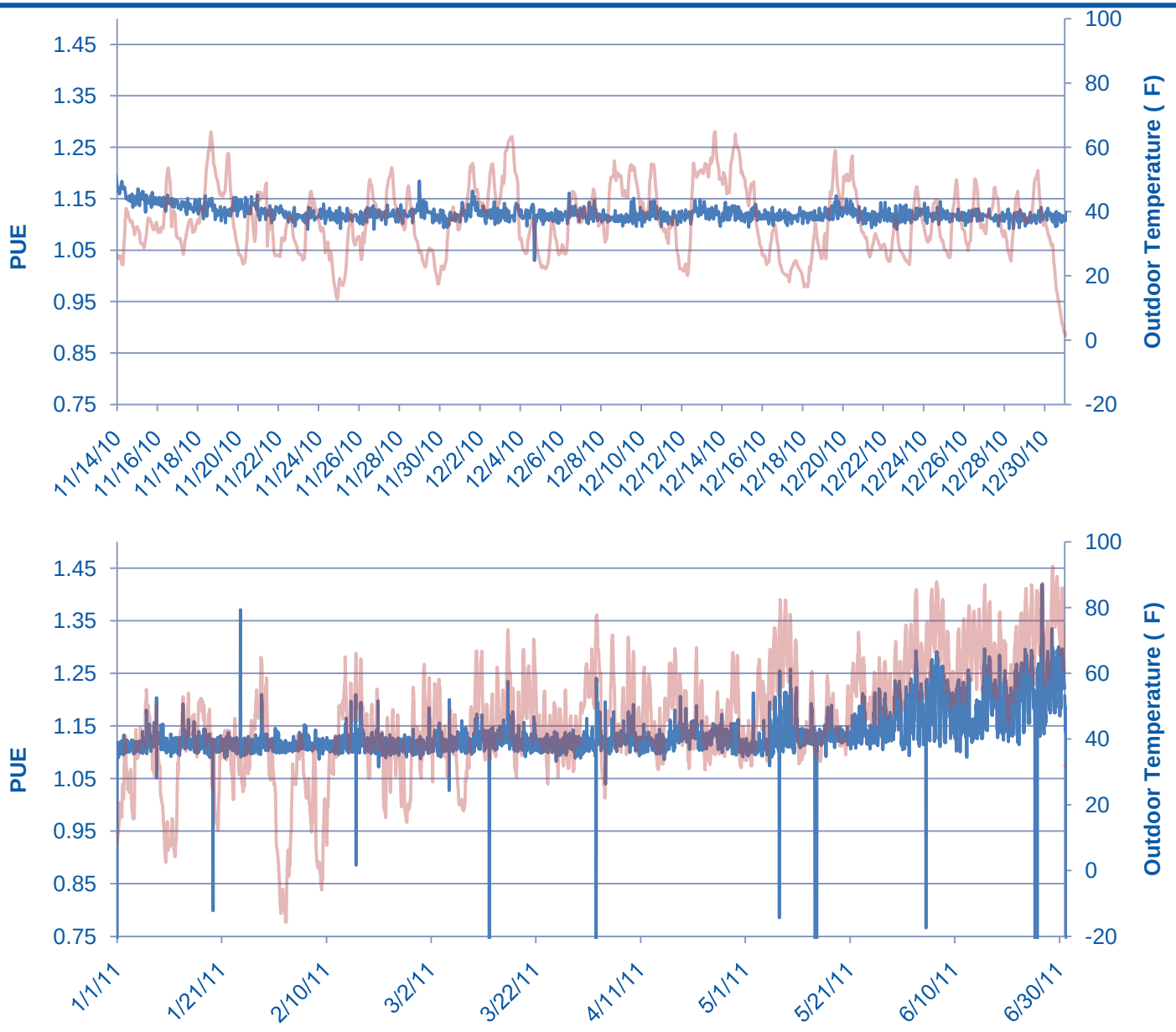
- Fully containing hot aisle difficult
  - Custom aisle floor and door seals
  - Ensure equipment designed for cold aisle containment
    - And installed to pull cold air
      - Not hot air…
- Have run ~1.1-1.15 PUE
  - A few hot spots were driving up PUE…
  - Summer time PUE of 1.20 because of increased cooling



Credit: Marjorie Schott/NREL

NREL/PIX 17897

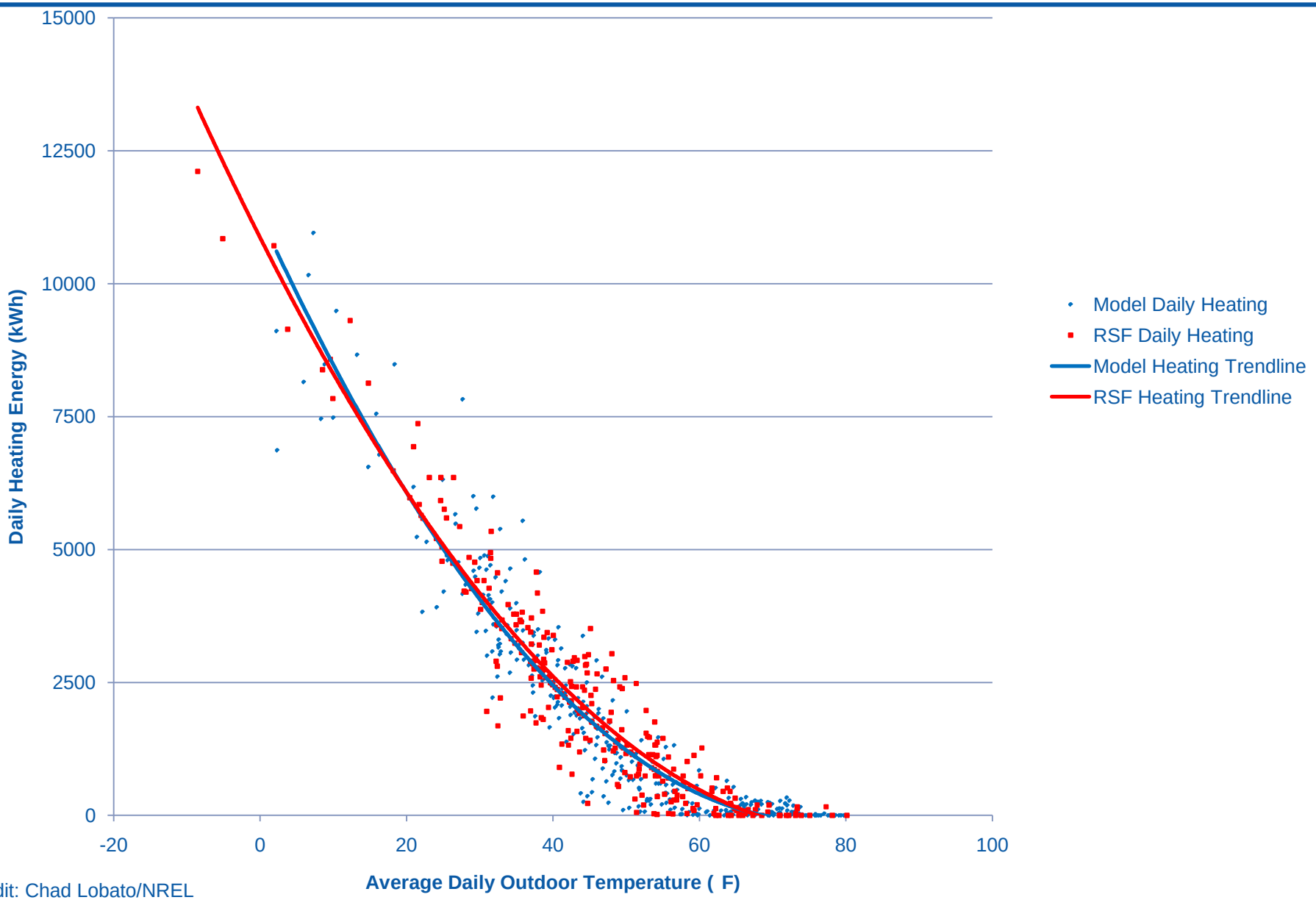
Data Center PUE



Data Center PUE

Outdoor Temperature

October 2010 – June 2011 Daily Heating Energy

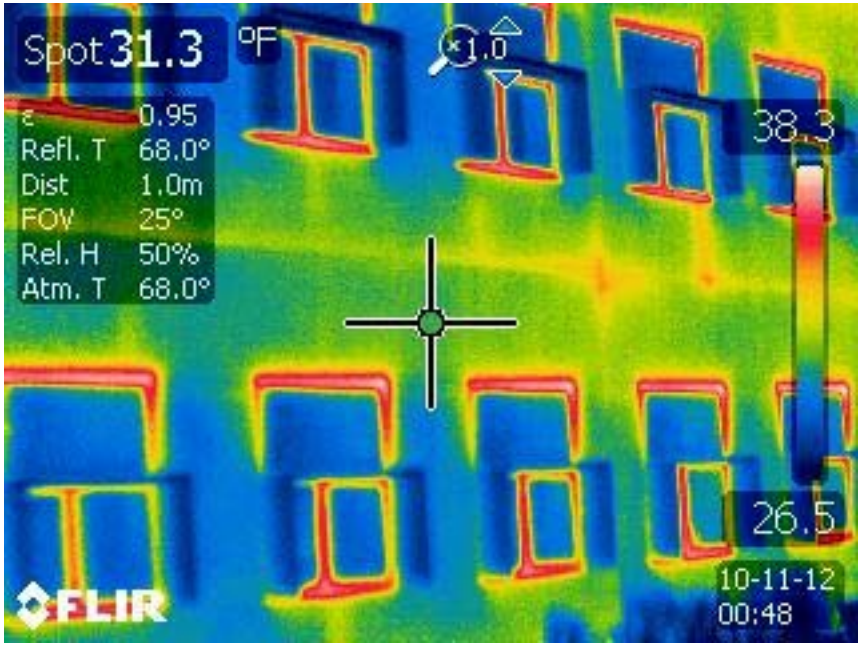


Credit: Chad Lobato/NREL

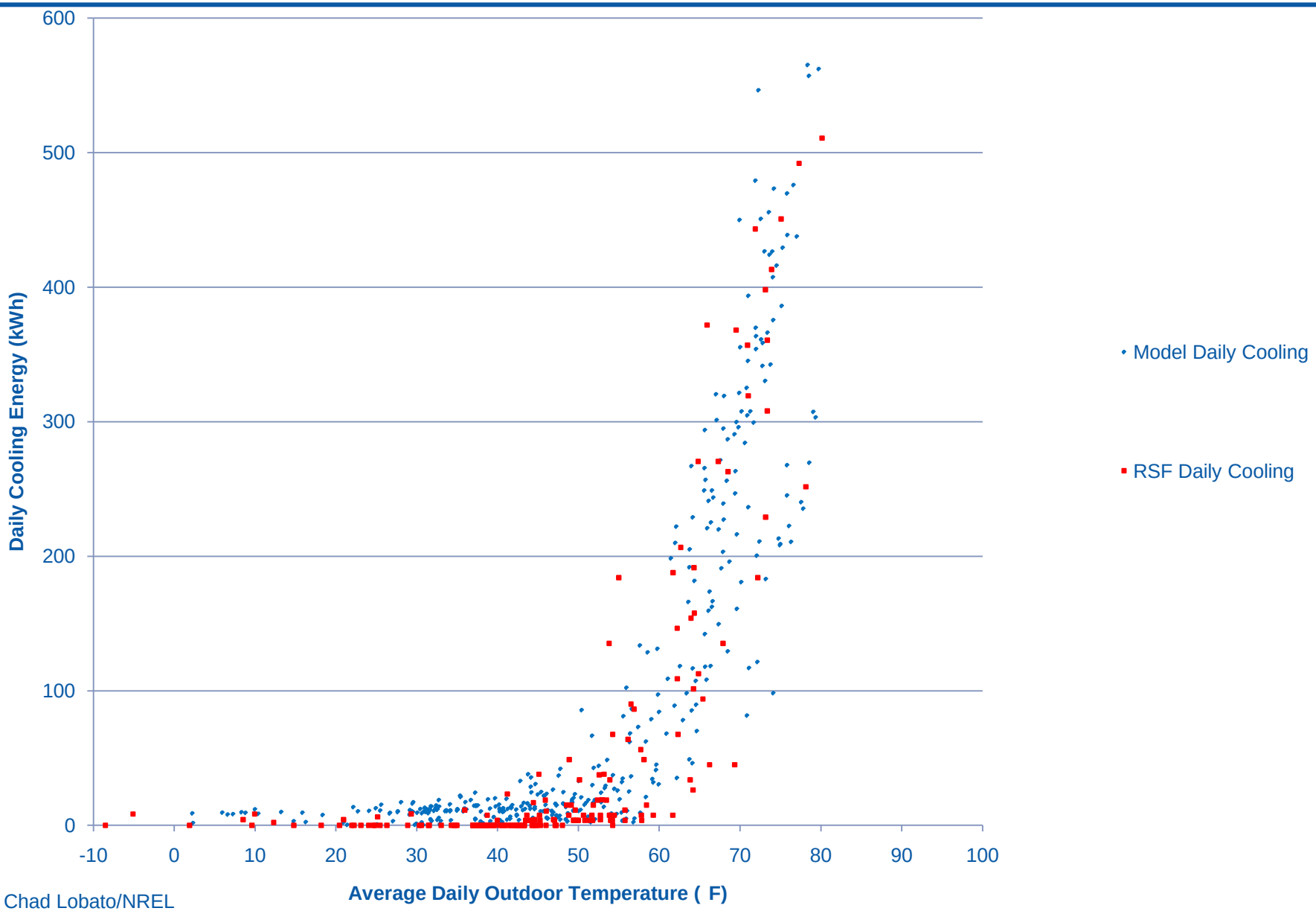
Need better window frames!

Window frames the weak point in the thermal envelope!

Even thermally broken frames



2011 YTD Daily Cooling Energy

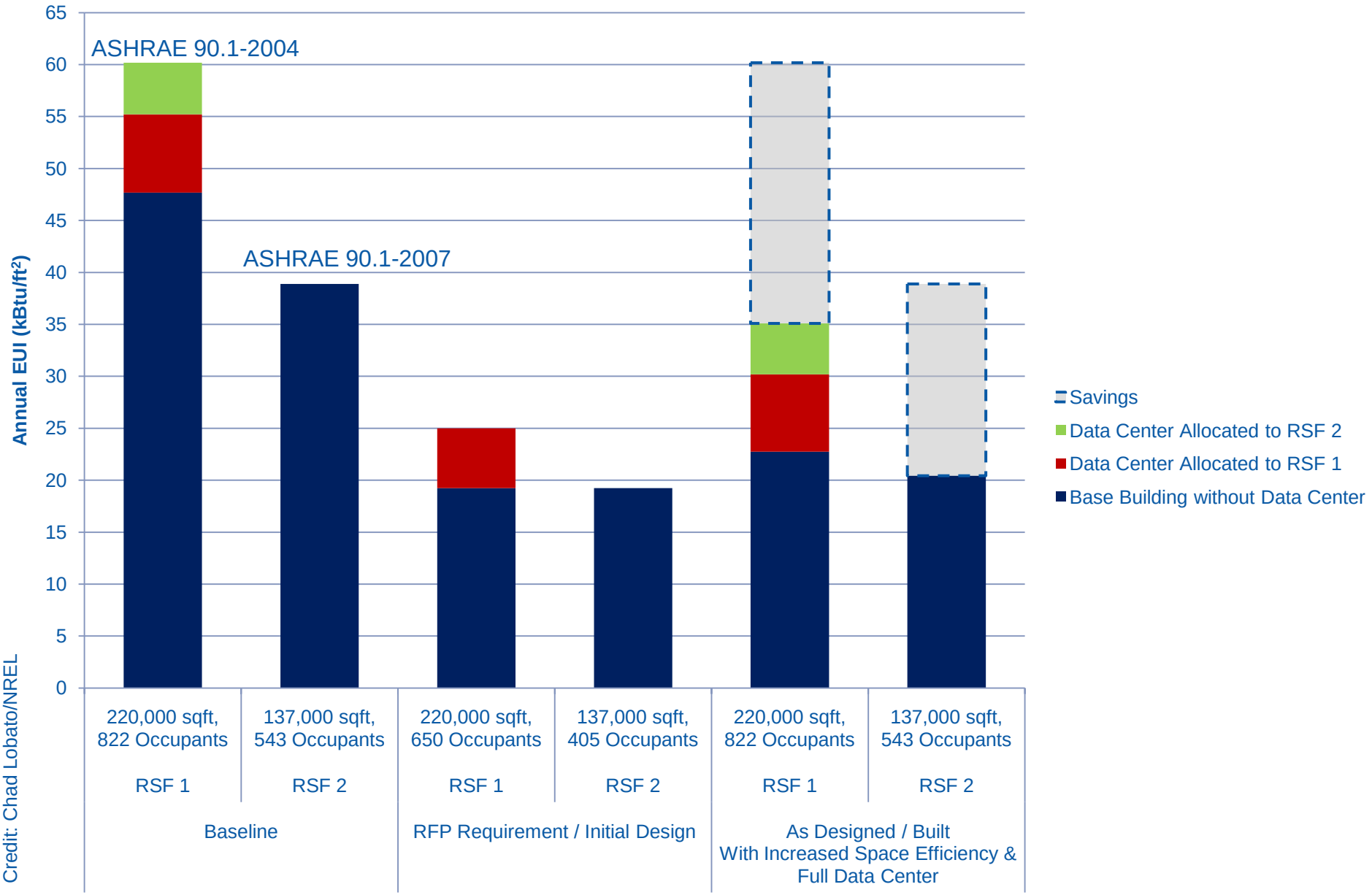


Credit: Chad Lobato/NREL

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



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.