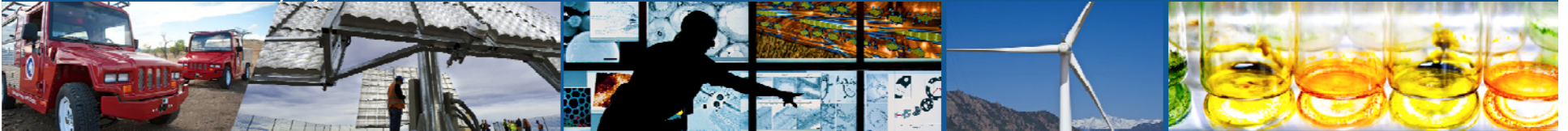




U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy



Owner Commitment: *Sustainable NREL*



Frank Rukavina
Director of Sustainability

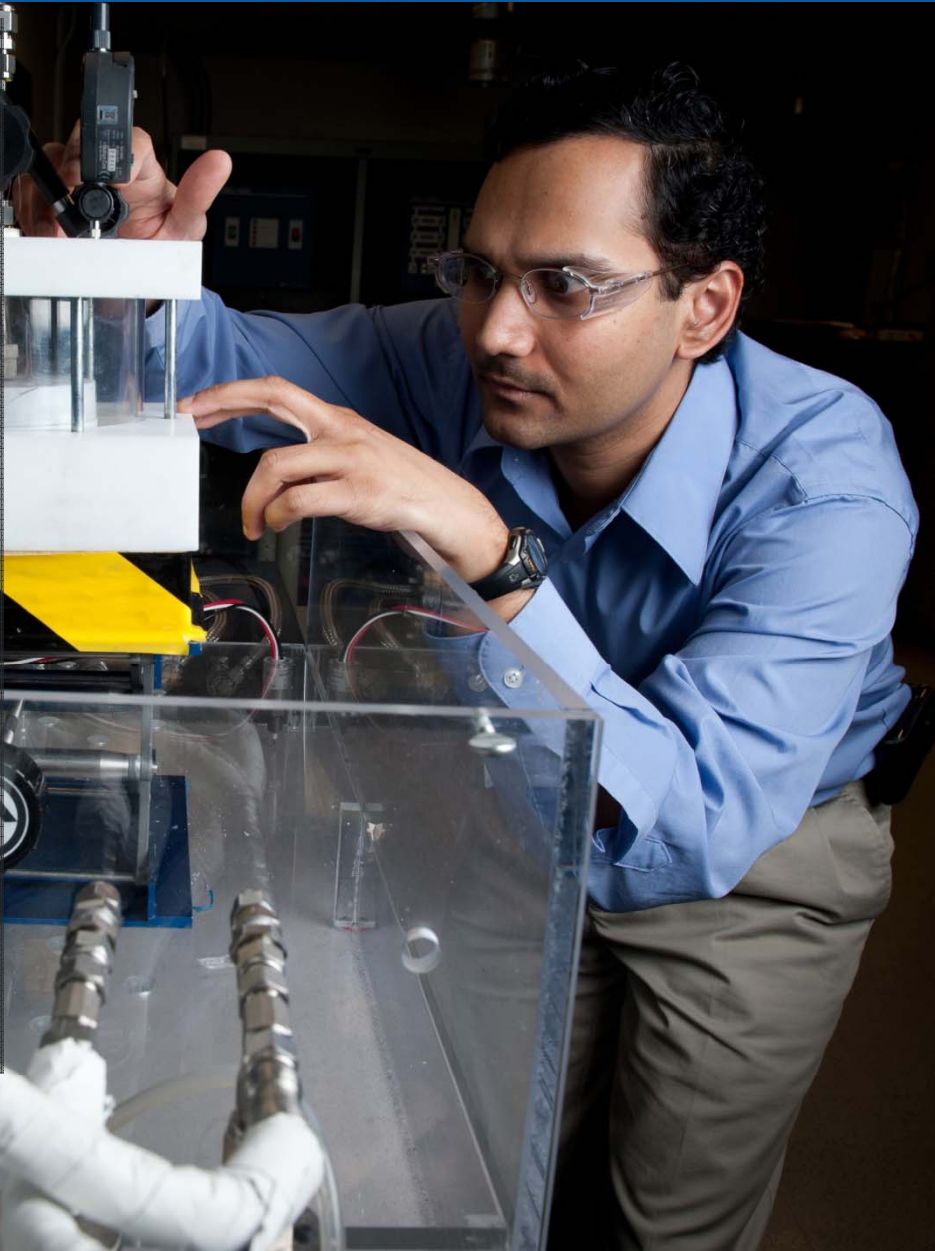
June 5, 2012

Overview



NREL Mission

- **Develop renewable energy and energy efficiency technologies and practices**
- **Advance related science and engineering**
- **Transfer knowledge and innovations to address the nation's energy and environmental goals**



NREL Program Portfolio

Strategic Analysis



Energy Efficiency

Vehicle Technologies
Building Technologies

Renewable Resources

Wind and Water
Solar
Biomass
Hydrogen
Geothermal

Systems Integration

Grid Infrastructure
– SmartGrid and RE Grid
Battery and
Thermal Storage

Federal Energy Management; Integrated Deployment; International; Other Intergovernmental

Foundational Science

NREL Snapshot of Two Campuses

South Table Mountain and National Wind Technology Center

- **Staff: 2500**
 - Countries represented: 70
 - Languages: 30
 - Degrees: 1,300 BAs; 800 MAs; 450 PhDs and JDs
- **Extensive Partnerships**
 - Commercial companies
 - Research organizations worldwide
 - Wind, PV manufacturing, biofuels
 - Reducing risk prior to introduction of technology



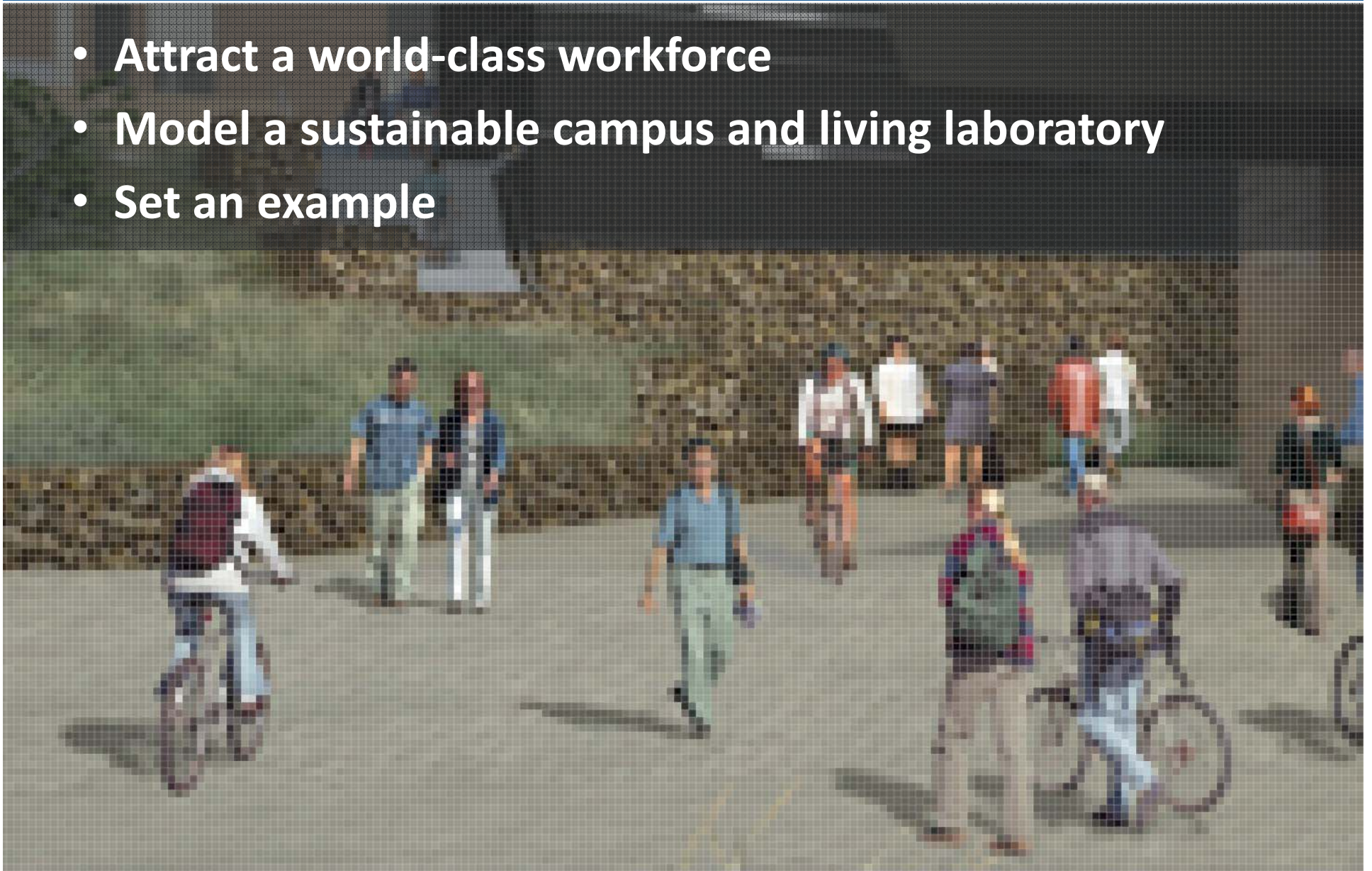
South Table Mesa Campus



National Wind Technology Center

Sustainable Campus Initiatives

- Attract a world-class workforce
- Model a sustainable campus and living laboratory
- Set an example



Sustainable Campus Attributes

Sustainability defined at NREL

- **Maximize the benefits of our research**
 - Minimize use of resources (energy, materials, and water) while receiving maximum value from resources used
- **Minimize the impact of doing business**
 - Balance environmental, economic, and social impacts

*Maximize the benefits of our research
Minimize the impacts of doing business*

Campus of the Future



Long-Term Goals

- Net Zero Energy campus
- Carbon neutral
- Sustainable transportation and commuting
- Pedestrian-friendly amenities
- Sustainable regional and community connection

NREL Mission Drives Sustainability

Executive Champion

“I am fully convinced that our mission is both enabled and enhanced by our leadership in sustainability. The employees of NREL and I are committed to incorporating sustainable principles in our work, and we encourage application of these same principles by our stakeholders. Through our actions we can establish a new benchmark for what is possible.”

NREL Director Dr. Dan Arvizu

Executive Order 13514



Federal Leadership in Environmental, Energy and Economic Performance

The Federal Government shall lead by example in creating a clean energy economy. Federal agencies shall:

- Increase energy efficiency
- Measure, report, and reduce their GHG emissions
- Conserve and protect water resources
- Eliminate waste, recycle, prevent pollution
- Leverage agency acquisition to foster markets for sustainable technologies and environmentally preferable materials, products, and services
- Design, construct, maintain, and operate high performance sustainable buildings in sustainable locations
- Strengthen the vitality and livability of communities in which federal facilities are located
- Inform federal employees about and involve them in achieving these goals

Early Leader in Sustainability

- First formal sustainability program established in 2000
- Began reporting GHG emissions in 2002
- Staff of five; reports to NREL's Chief Operating Officer



Sustainable NREL Initiatives

Long Term Planning

- **Site Sustainability Plan**
 - Strategy for exceeding E.O. 13514 goals
- **Five Year Site Plan Support**
- **Ten Year Site Plan Support**
- **Annual Sustainability Report**
- **Greenhouse Gas Management**
- **Onsite Renewable Energy**
 - PV Power Purchase Agreements & ARRA
 - Biofuels: wood and proposed bio-NG
 - Potential off-site wind purchase
- **High Performance Buildings**
 - LEED Platinum: Research Support Facility, Science and Technology Facility
 - LEED Gold: Integrated Biorefinery Research Facility



Site Sustainability Plan

- **Scope 1,2, and 3 Greenhouse Gas Emissions Inventory and Reductions**
 - Energy Intensity Reduction
 - Increase Renewable Energy Consumption
 - Increase Alternative Fuels Vehicles for Fleet
 - Metering
 - Cool Roofs
 - Training
 - Behavior Change
- **High Performance Sustainable Design**
 - New Construction
 - Existing Buildings
- **Regional and Local Planning**
- **Water Use Efficiency and Storm Water Management**
- **Pollution Prevention**
- **Sustainable Acquisitions**
- **Electronic Stewardship and Data Centers**
- **Return on Investment Evaluation**
- **Site Sustainability Transformation Team**
- **Management and Funding**
- **Adding Renewable Energy and Purchasing Renewable Energy Certificates (RECs)**



Greenhouse Gas Management

- **Early Leadership in GHG Management since 2002**
- **EPA Climate Leaders**
 - First federal facility to join EPA's Climate Leaders Program
 - One of the first seven Climate Leaders Partners
 - Set and achieved two GHG reduction goals
- **Sharing Expertise**
 - With national laboratories, federal and state agencies, and other interested stakeholders
- **Contracted by DOE-FEMP to support development of federal guidance for GHG accounting**

Onsite Renewable Energy

- Integrate renewable energy technologies into campus growth
- Utilize Power Purchase Agreements (PPA)
- Purchase RECs to offset remaining Scope 2 electricity purchases



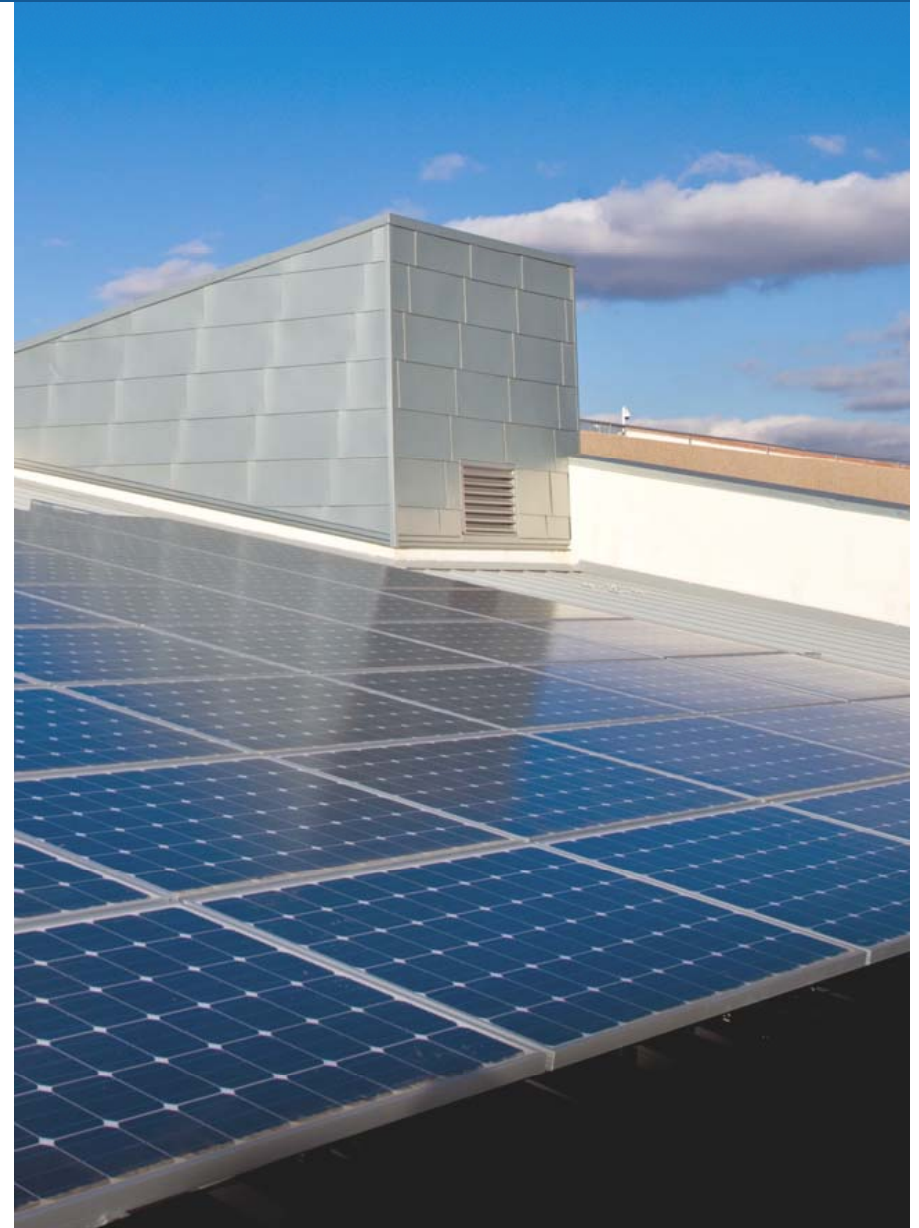
Photovoltaic Power Purchase Agreements



South Table Mountain Campus Onsite PV

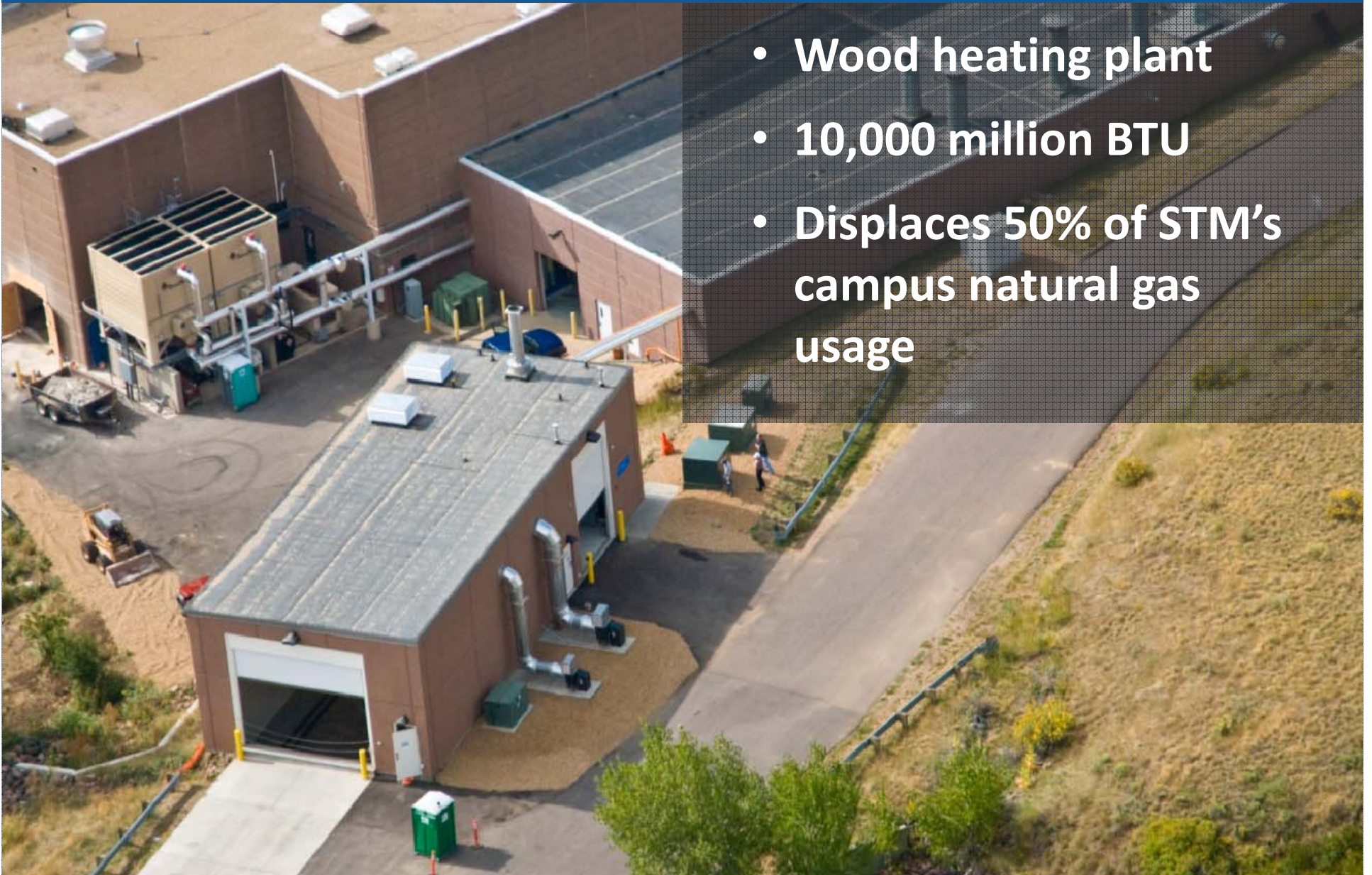
- Research Support Facility I (RSF) 449 kW
- RSF II 408 kW
- Visitor parking lot 554 kW
- Parking garage 1,264 kW
- IBRF (roof to be PV ready)

Once completed, NREL STM will generate 32% of its electricity from PV.

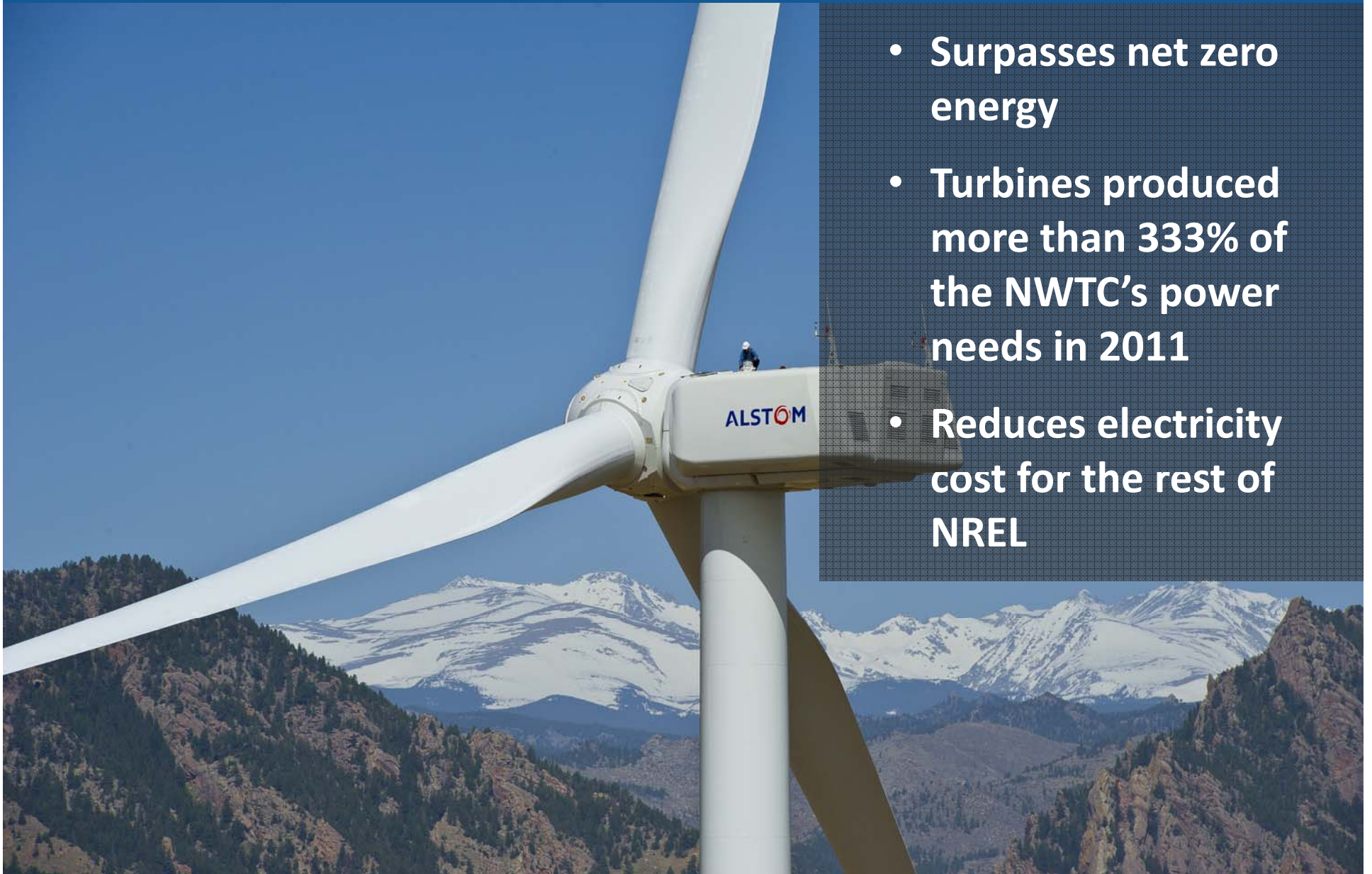


Renewable Fuel Heat Plant

- Wood heating plant
- 10,000 million BTU
- Displaces 50% of STM's campus natural gas usage



NREL's National Wind Technology Center



- Surpasses net zero energy
- Turbines produced more than 333% of the NWTC's power needs in 2011
- Reduces electricity cost for the rest of NREL

NWTC Wind Turbines

Alstom 3 MW



Gamesa 2 MW



Siemens 2.3 MW



Sustainable Synergy

Renewable Energy Technologies

The STM and the NWTC campuses demonstrate the effectiveness and value of implementing cutting-edge renewable energy technologies.

Energy Efficiency Technologies

Energy efficiency is essential for modeling leadership in federal and private research facilities:

- U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED)
- Platinum- and Gold-certified facilities

High Performance Buildings

U.S. Green Building Council LEED Certification (Leadership in Energy and Environmental Design)

LEED Platinum

- **Science & Technology Facility**
 - 71,000 ft² completed in FY 2006
 - First federal LEED-certified building
 - 1 of 28 LEED platinum buildings globally in 2006
 - 1 of 3 LEED platinum laboratories globally in 2006



High Performance Buildings

LEED Gold

- **Integrated Biorefinery Research Facility (IBRF)**
 - 27,400 ft² completed in FY 2012
 - \$33.5M two-stage expansion



High Performance Buildings

LEED Gold (expected) Cafeteria

- 12,200 ft² completion May 2012
- Sustainable food service, waste, and water management
- Energy Star rated kitchen appliances



High Performance Buildings

Solar Radiation Research Laboratory (SSRL) Building Expansion

- Ground source heat pump



High Performance Buildings

LEED Platinum (expected)

- **South Entrance Building**

- 1,500 ft² completed in May 2012
- Net-zero energy building



High Performance Buildings

LEED Platinum (expected)

- **Energy Systems Integration Facility (ESIF)**
 - Approximately 183,900 ft², 200 researcher, completion October 2012
 - Integrated energy systems testing for generation, storage, distribution, and utilization
 - High Performance Computing Facility
 - Outdoor pads for testing larger multi-megawatt scale equipment and systems



High Performance Buildings

LEED Platinum

- **Research Support Facility—Phase I** (Platinum expected for Phase II)
 - LEED Platinum rating (version 2.2) = 59 points
 - Uses 50% less energy than current commercial building codes
 - So energy efficient that its 885 occupants consume only the amount of energy generated by renewable power on and near the building
 - RSF increases NREL's South Table Mountain square footage by more than 50% but increase campus energy use by only 10%.

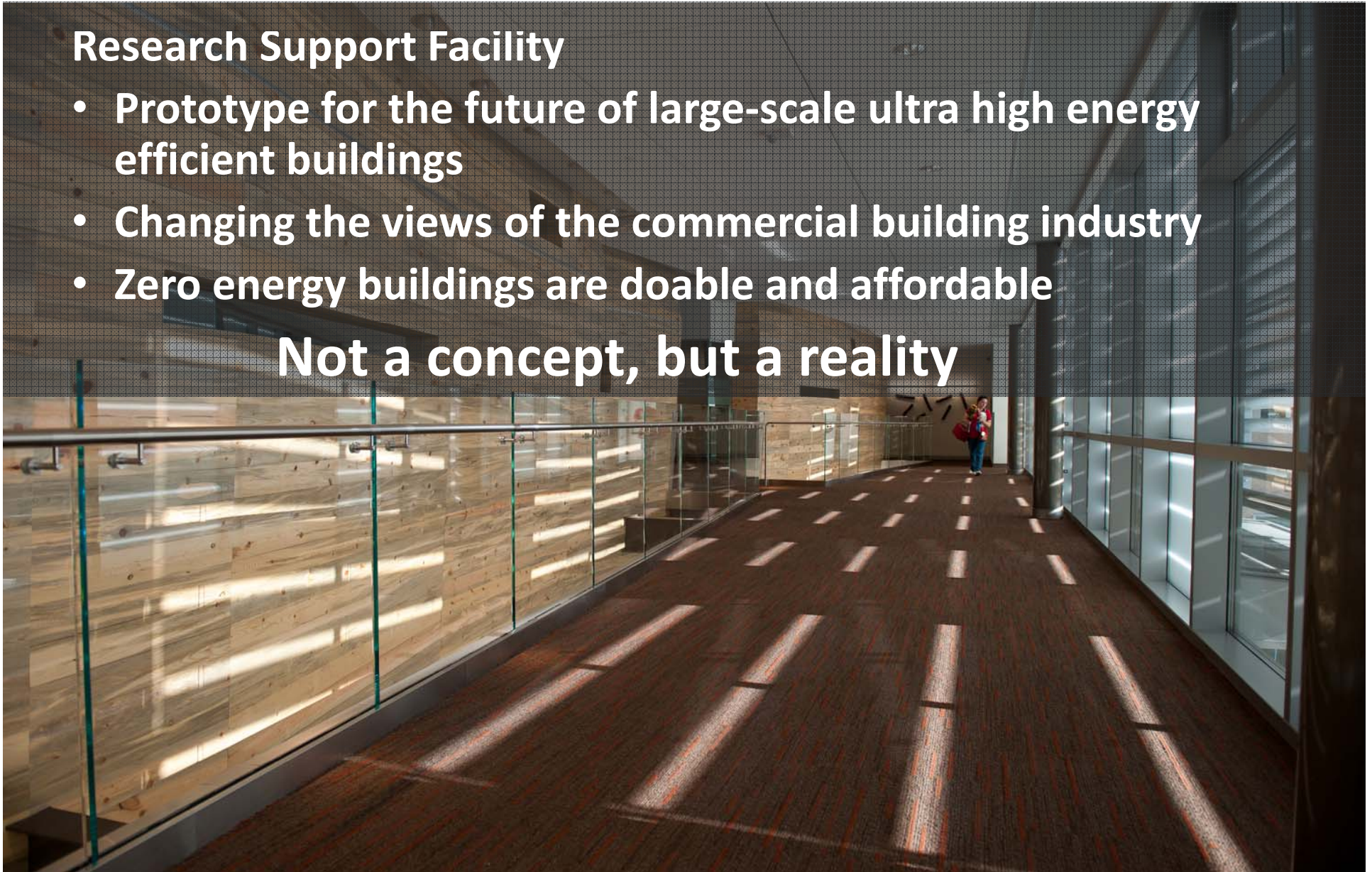


High Performance Buildings

Research Support Facility

- Prototype for the future of large-scale ultra high energy efficient buildings
- Changing the views of the commercial building industry
- Zero energy buildings are doable and affordable

Not a concept, but a reality

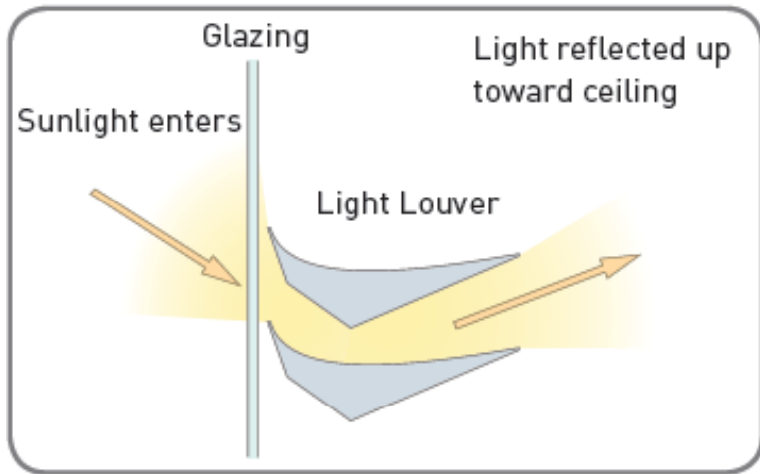


RSF Key Design Strategies

- **Optimal orientation and office space layout**
- **Fully daylight office wings with high-performance electrical lighting**
- **Continuous insulation precast wall panels with thermal mass**
- **Operable windows for natural ventilation**
- **Radiant heating and cooling**
- **Outdoor air preheating**
 - Transpired solar collector
 - Data Center waste heat
 - Exhaust air heat recovery
 - Crawl space thermal storage
- **Aggressive plug load control strategies**
- **Data Center outdoor air economizer with hot aisle containment**
- **Roof top- and parking lot-based PV**



RSF Key Design Strategies

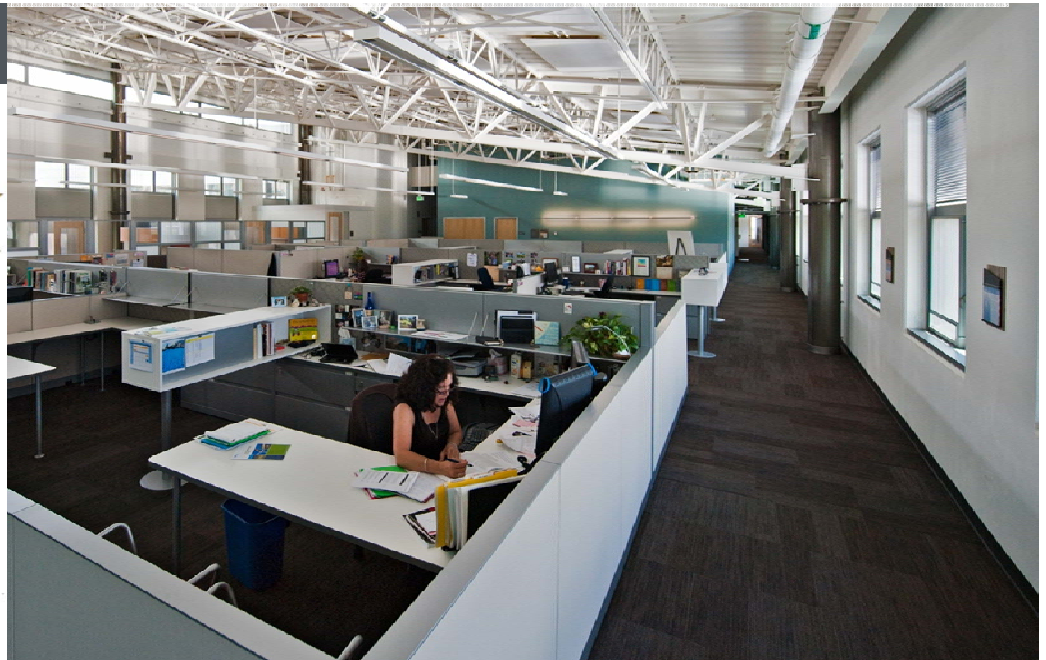
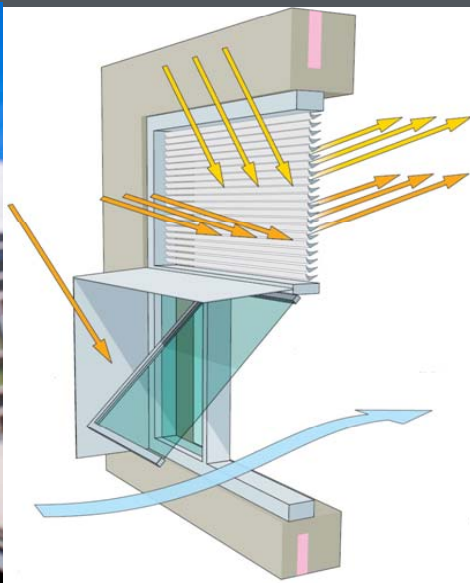


Daylighting

East/west orientation of 60 ft-wide building wings maximizes daylighting reduces electrical lighting load.

A light louver system reflects sunlight to the ceiling, creating an indirect lighting effect.

Fixed sunshades limit excess light and glare.



RSF Key Design Strategies

Transpired Solar Collector

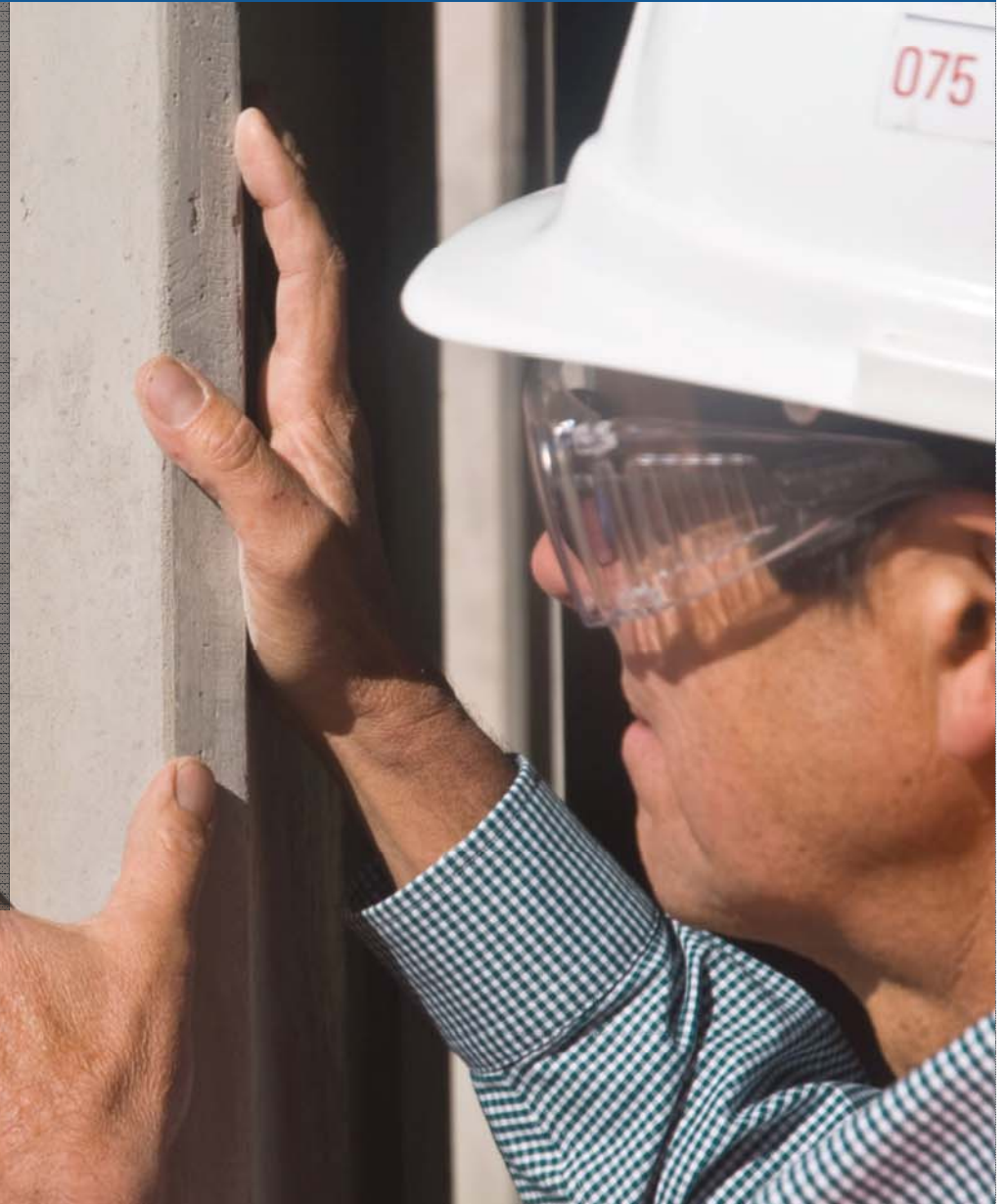
- Passive heating technology developed at NREL
- Pre-heats incoming air
- Captures up to 80% of the energy from sunlight striking the collector



RSF Key Design Strategies

Thermal Mass

- Incorporates many passive heating and cooling techniques
- A pre-cast thermal mass wall—3” concrete, 2” rigid insulation, 6” concrete—helps moderate internal temperatures year round.
- Nighttime purges in summer months trap cool air inside, keeping temperatures comfortable for the warm summer days.



RSF Key Design Strategies

Radiant Heating and Cooling

- 42 miles of radiant heating tubes run through the ceilings throughout the building.
- Office wings are hydronically heated and cooled using radiant ceiling slabs.
- Five zones in each wing of the building are controlled by the Radiant Zone Control Valves.



Thermal Mass

- Nighttime purges in summer months trap cool air inside, keeping temperatures comfortable for the warm summer days.

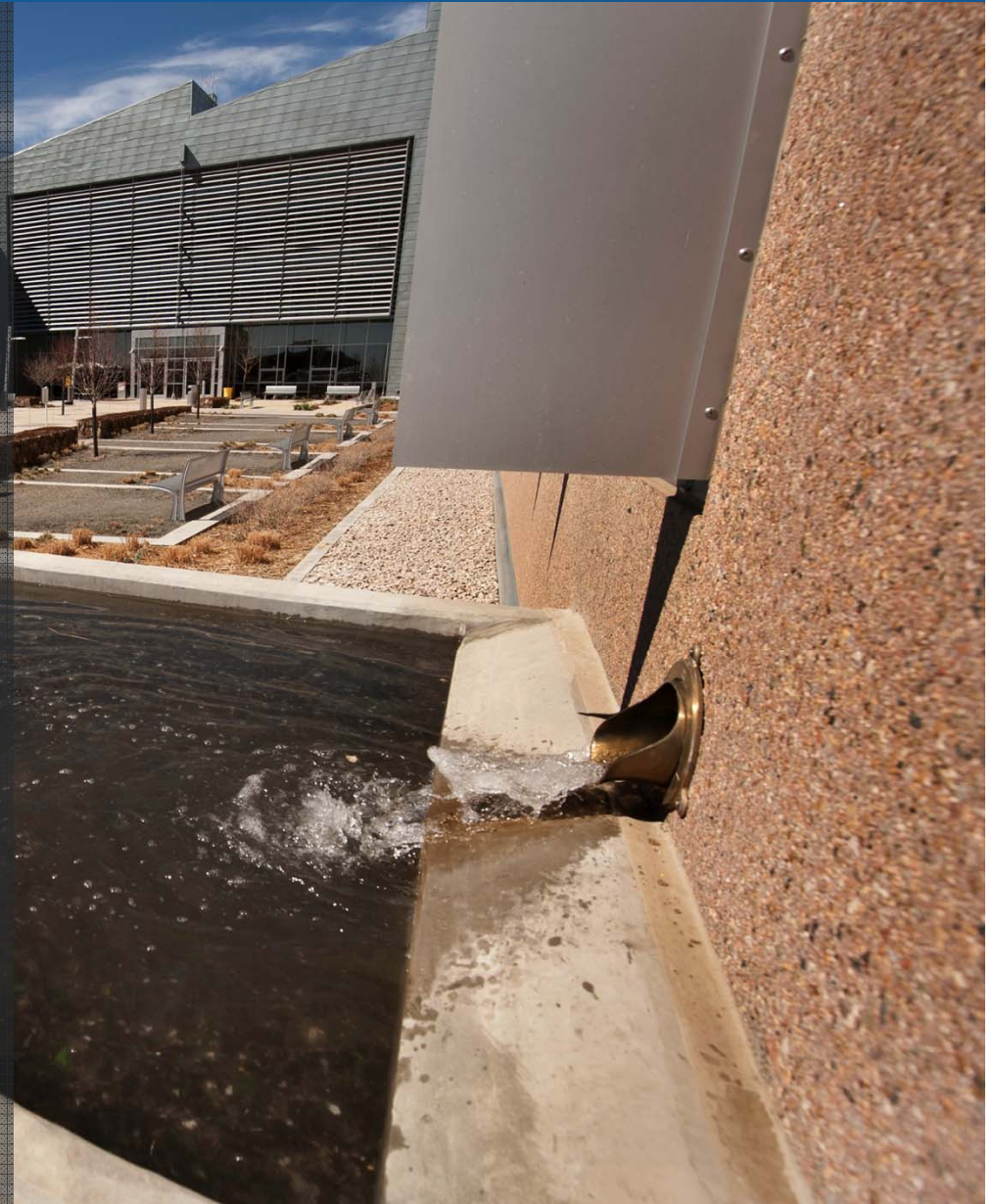
Natural Ventilation

- During mild weather, operable windows allow for natural ventilation.
- Automatic windows are controlled and operated primarily to support nighttime precooling.
- Occupants are notified when conditions allow for manual windows to be opened.

RSF Key Design Strategies

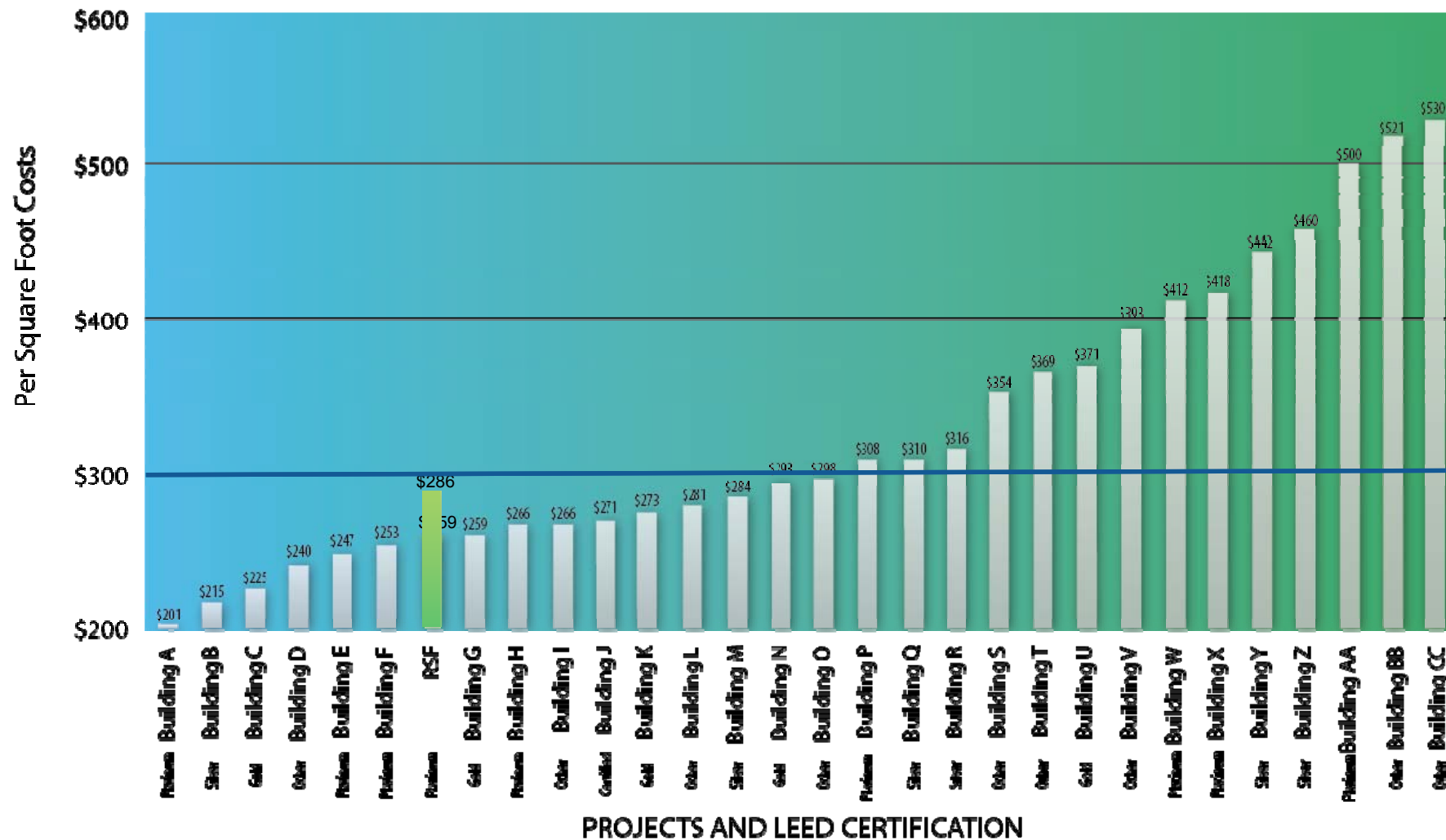
Reclaimed Materials

- Aggregate in the foundations and slabs came from the demolition of Denver's previous airport.
- Crushed recycled glass used in the storm water management basins outside the building.
- Reclaimed natural gas piping serves as support for the building.
- The lobby and other common areas feature beetle-kill pine from Western forests.



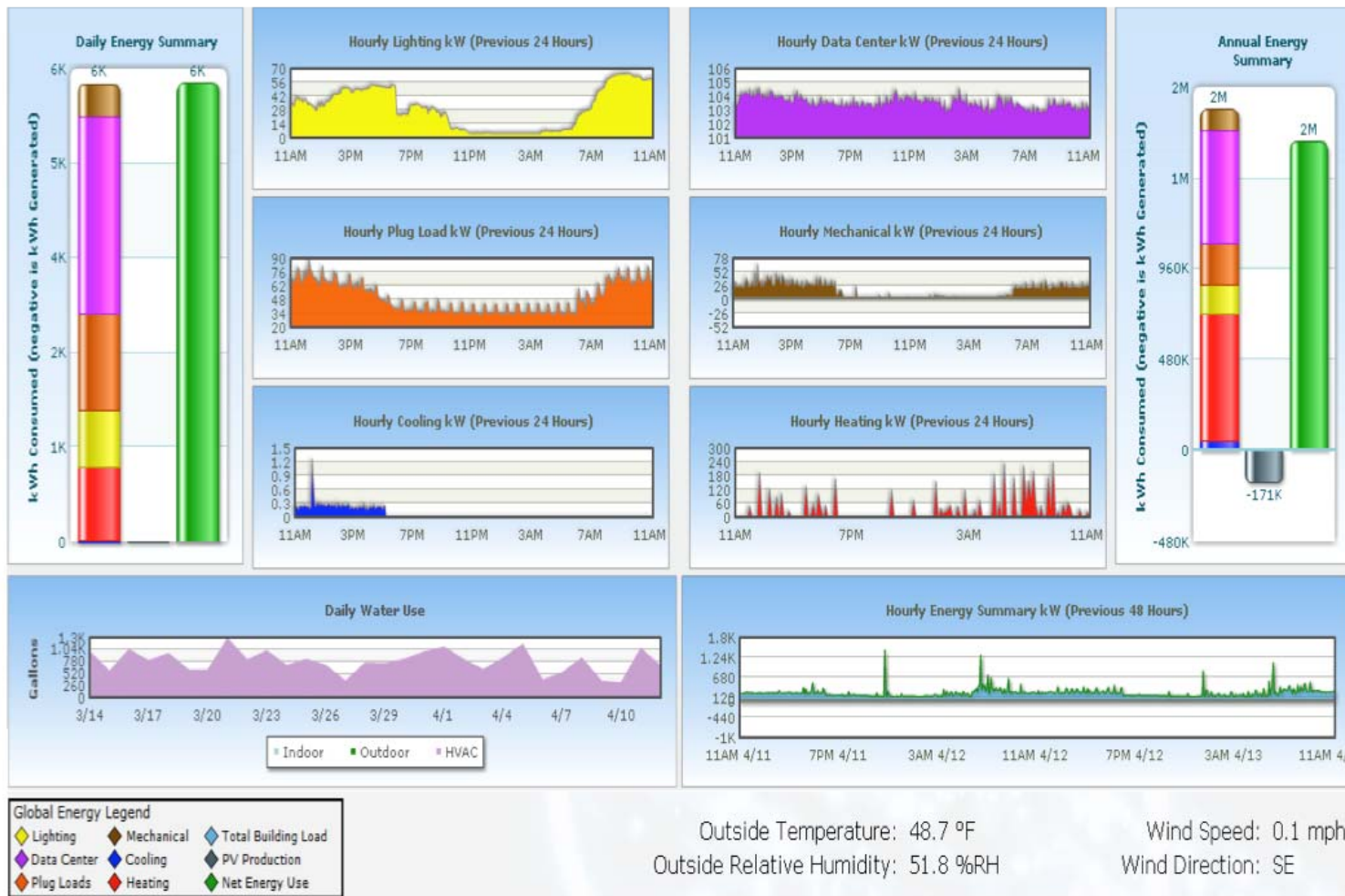
Construction Costs

COMMERCIAL CONSTRUCTION BUILDING COSTS - By Cost Per Square Foot



Energy Monitoring

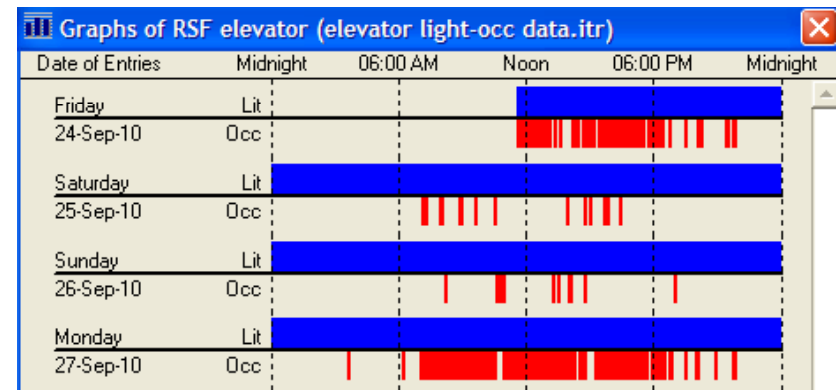
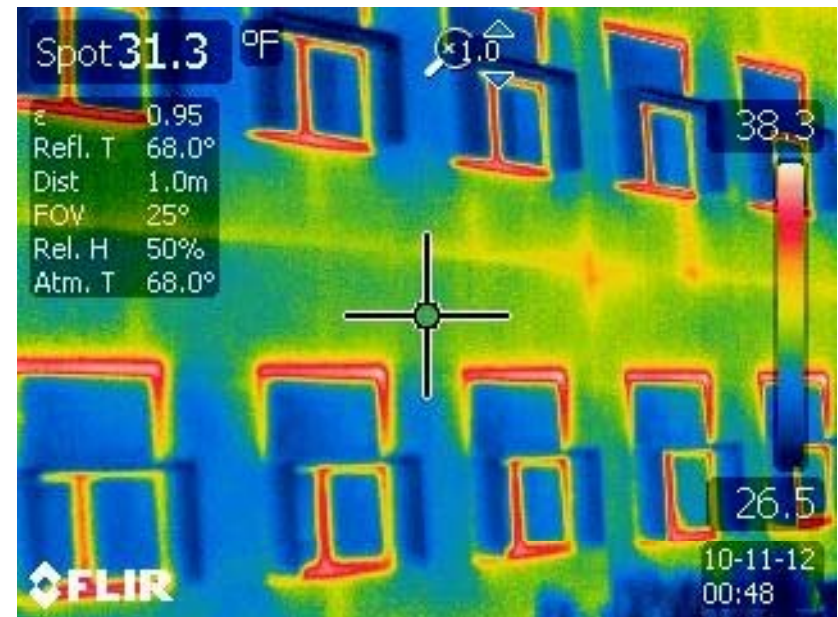
The RSF is a living laboratory—energy usage is continuously studied and adjusted as needed.



Energy Usage and Data

What are we monitoring?
EVERYTHING!

- Lighting
- Heating
- Cooling
- Plug Loads
- Data Center
- Daylighting
- Mechanical System Power Density
- Outdoor Air Temperature
- Monthly End Use Energy Consumption
- Elevator Lighting
- PV Output



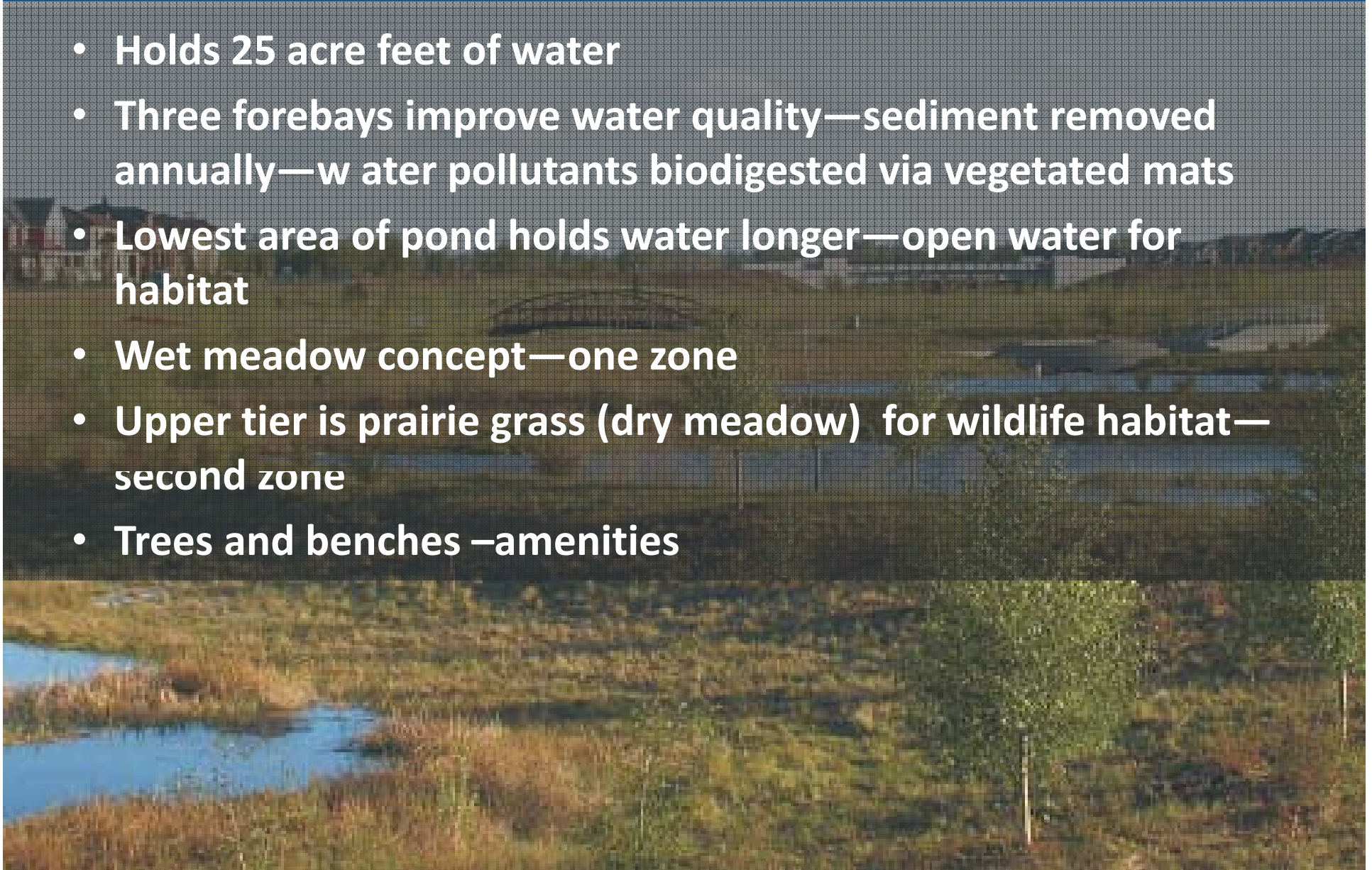
RSF Landscaping

- **Sustainable Sites Landscape Pilot Project (SITES)**
 - Native plants use little water, but still need periodic irrigation.
 - A controller receiving satellite weather data allows irrigation during extreme heat or drought conditions.
- **Courtyards that enable staff interaction**



100 Year Detention Pond

- Holds 25 acre feet of water
- Three forebays improve water quality—sediment removed annually—water pollutants biodigested via vegetated mats
- Lowest area of pond holds water longer—open water for habitat
- Wet meadow concept—one zone
- Upper tier is prairie grass (dry meadow) for wildlife habitat—second zone
- Trees and benches –amenities



Energy Efficient Workspace

24" LCD Energy Efficient
Monitors
18 Watts

Typical 19"-24" Monitors
30-50 Watts

Laptop
30 Watts

Desktop Computer (Energy Star)
300 Watts

Sensor-controlled LED task
lights 3 Watts

Fluorescent task lights 35 Watts

iGo Power Smart Towers

Reduces "vampire" energy use

VOIP phones 2 Watts

Removing personal Space Heater
saves 1500 Watts

Multi-function Devices
100 Watts (continuous)

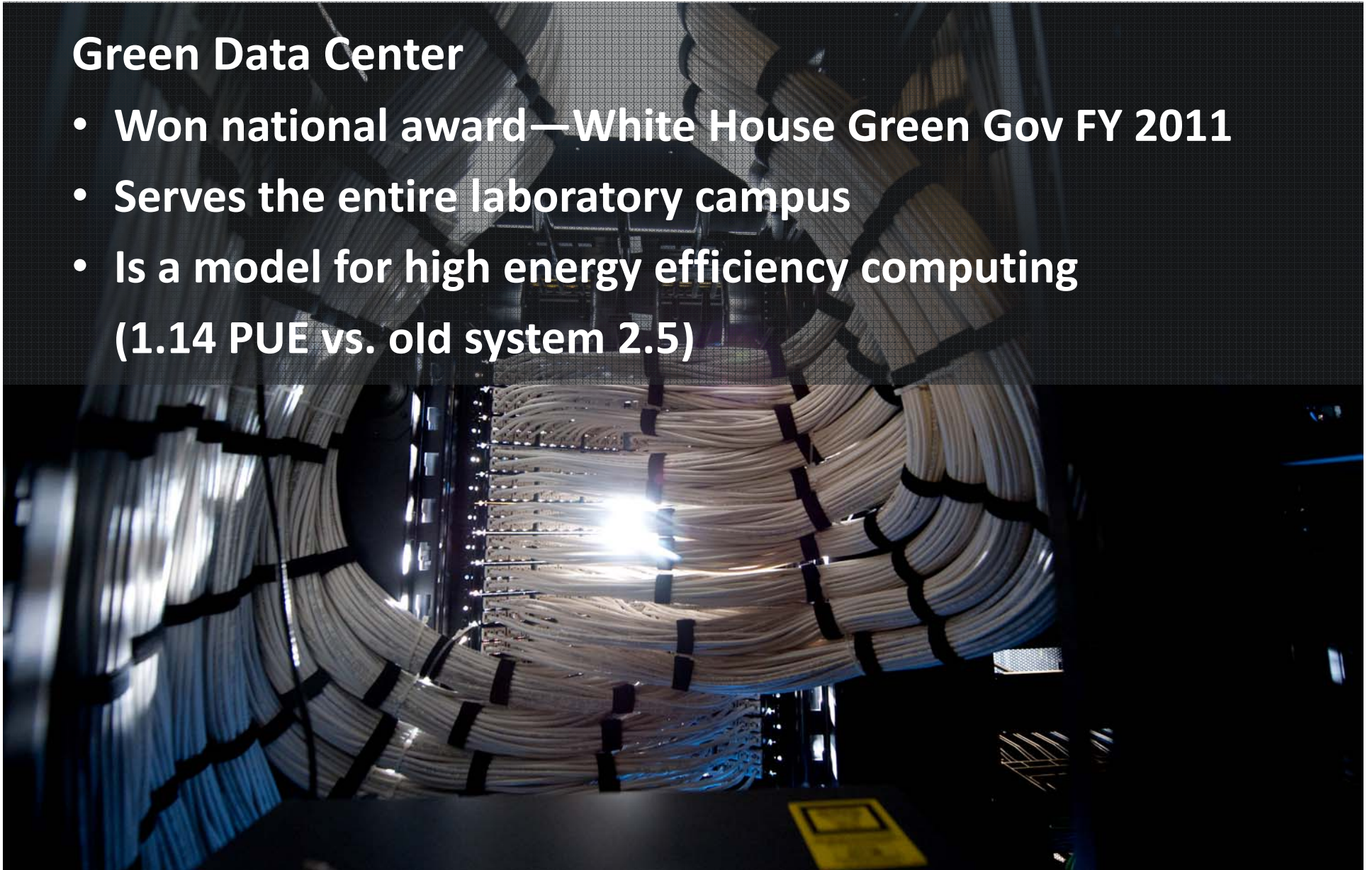


Removing Desktop
Printers Saves
~460 Watts/Printer

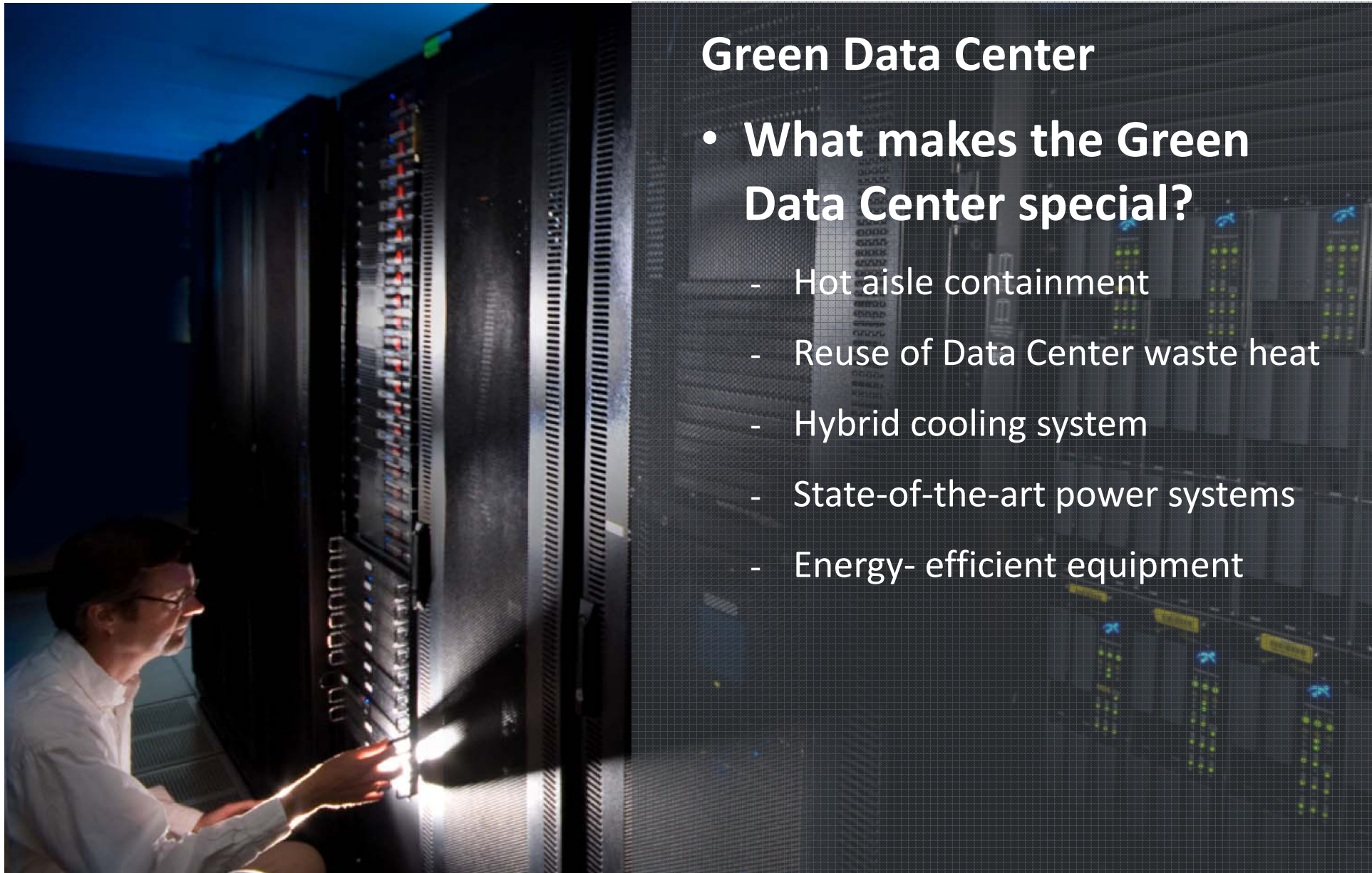
RSF's Energy Efficient Computing

Green Data Center

- Won national award—White House Green Gov FY 2011
- Serves the entire laboratory campus
- Is a model for high energy efficiency computing (1.14 PUE vs. old system 2.5)



RSF's Energy Efficient Computing



Green Data Center

- **What makes the Green Data Center special?**

- Hot aisle containment
- Reuse of Data Center waste heat
- Hybrid cooling system
- State-of-the-art power systems
- Energy- efficient equipment

Staff Involvement

We actively engage staff to change the way we think about our workspaces and our campus sustainability.



Sustainable NREL Commuting Council



- **Traffic/Transportation**
- **Alternative Commuting**
 - Mass transit – Eco Pass – NREL Shuttles
 - Carpooling – Rideshare matching (NREL/DRCOG)
 - Vanpooling – Vanpool vouchers
 - Bicycling and pedestrian – Supportive infrastructure
- **Alternative Working**
 - Telecommuting
 - Alternate Work Schedule
- **Teleconferencing**

Reducing Waste

- White House President's GreenGov award FY11

- Near Zero Waste Committee

- Composting
- Pollution Prevention Initiative
- 4R's – Reduce, Reuse, Recycle, and Rebuy

- Environmentally Preferred Purchasing

- Electronics Recycling

- Federal Electronics Challenge Gold level past 2 years, Platinum award FY11



Social Responsibility

- Support Wind for Schools
- Sustainability Challenge
 - DOE, NREL, GSA, EPA and City of Lakewood
- Earth Week
- Charitable Contributions
- Community Sustainability Outreach
 - Received 2 DOE EStar awards for the - Sustainable Campus of the Future - Waste/Recycling Management
 - Katerva Challenge – NREL completed 3 evaluations



Interagency partnership to promote sustainability



National Media and Recognition

Major National News Stories About the RSF

- Popular Science Online (7/6/11)
- New York Times Online (2/14/11), New York Times Online (2/15/11)
- Associated Press Wire Story (2/23/11)
- Wall Street Journal (2/28/11)

Total Award Count = 30

- Engineering News Record (ENR)
- 2011 Award of Excellence
- 2010 Newsmaker Award
- McGraw-Hill Construction, Outstanding Green Building, 2010
- American Institute of Architects (AIA), Top Ten Green Project



Questions or Thoughts?

Visit us at NREL.gov

