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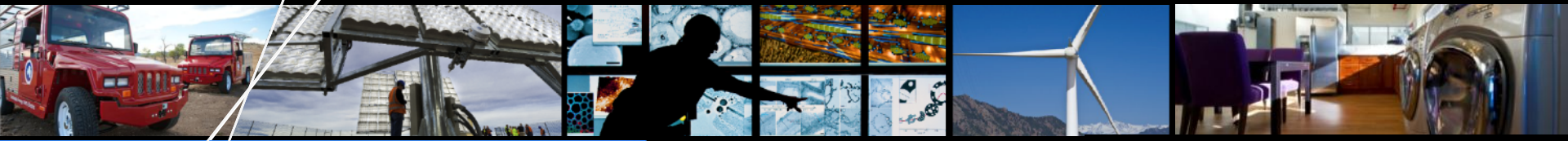
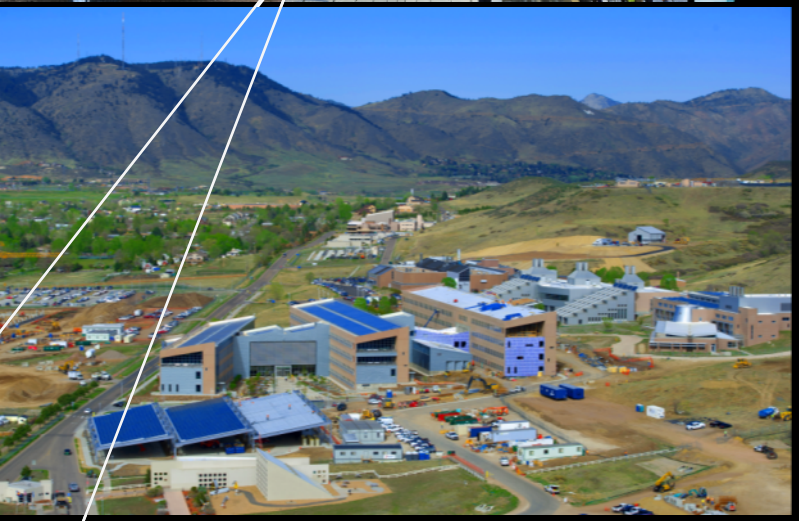
NILM Applications for the Energy-Efficient Home





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National Renewable Energy Laboratory
Golden, Colorado

1st International Workshop on
Non-Intrusive Load Monitoring
7 May 2012

Image credit: Dennis Schroeder, NREL PIX#19029

National Renewable Energy Laboratory

Among the national laboratories, we are unique

- Dedicated solely to energy efficiency & renewable energy technologies
- Highest number of patents, copyrights, and technology transfers *(absolute & per capita)*
- We develop next-generation energy technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation's energy and environmental goals

Image credit: Dennis Schroeder, NREL PIX#17612

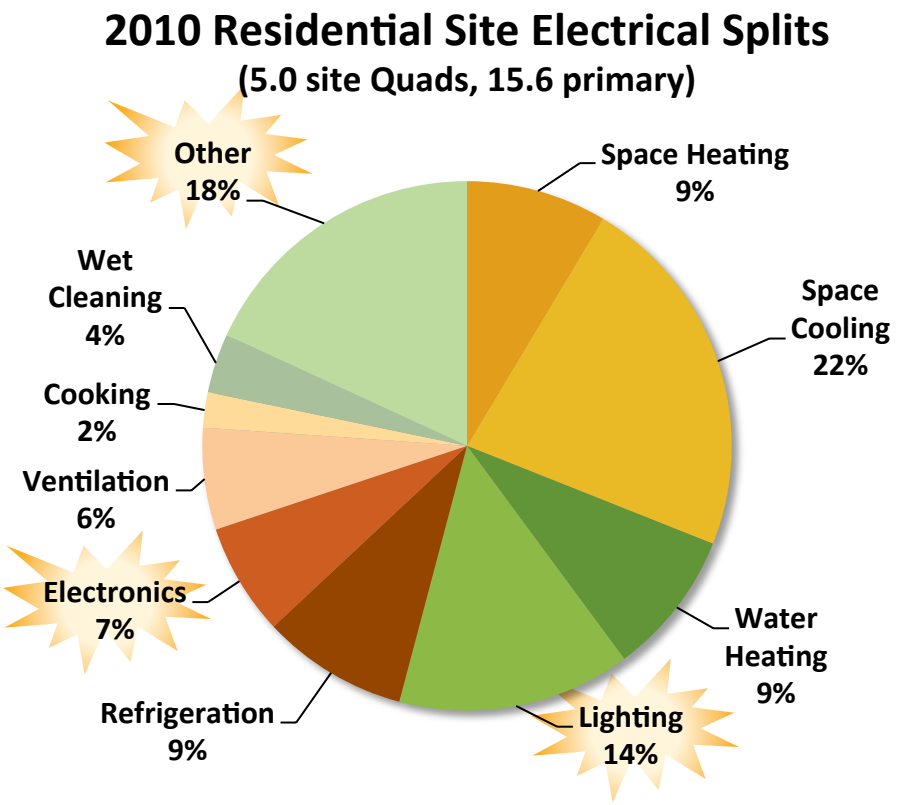
NREL Residential Buildings

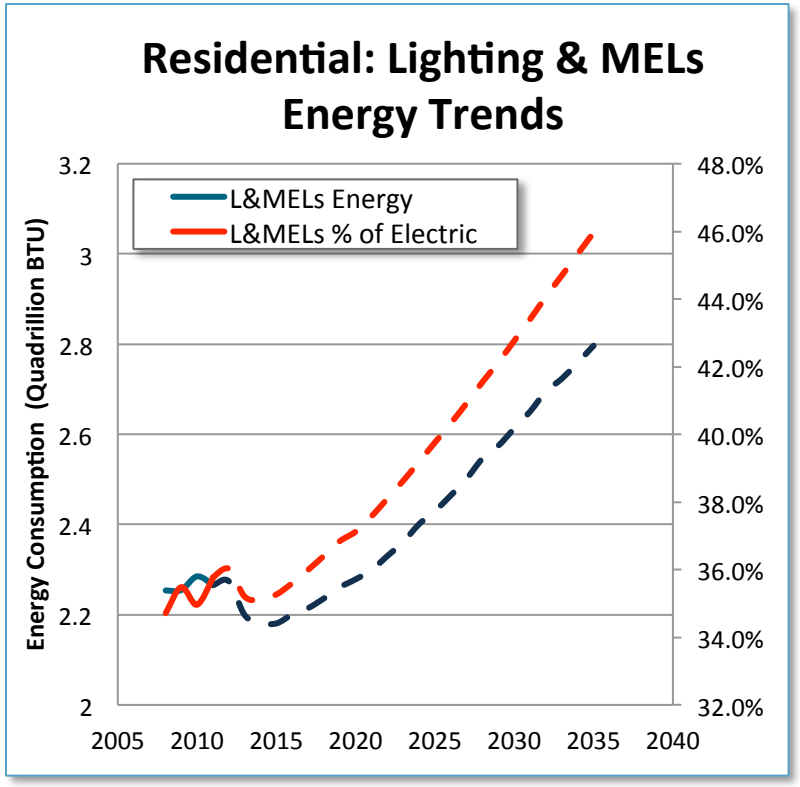
Technical Lead for U.S. Department of Energy's Building America program

- Develop **cost-effective efficiency solutions** for residential retrofit & construction
- Demonstrated in over 45,000 homes over past 20 years, across all US climate regions
- View buildings as a system – components consume energy to serve system functions
- Targets: **50% energy savings** in new construction by 2015 and in retrofit by 2017

Image credit: Dennis Schroeder, NREL PIX#20160

Significance of NILM





Need Technology Enabling Persistent Energy Use Reduction by 20% across Lighting, Appliances & MELs, at Installed Cost of $2000

Sources:

Buildings Energy Data Book 2010, Table 2.1.6

EIA Annual Energy Outlook 2011

"Maximizing Residential Energy Savings: Net Zero Energy House Technology Pathways," NREL TP-550-44547

Customers for NILM Technologies

Homeowner or building manager – responsible for energy use and has various motivations for seeking out NILM applications, products and tools

Technology sector – will incorporate NILM technology into an existing or new product

Service sector – will use NILM tools to deliver home maintenance, retrofits, advertising or security services

Utility – sells the energy and receives regulatory incentives to cost-effectively implement efficiency

Application: **Measurement & Verification**

Near-Term

- Deliver Feedback & Visualization
- Identify High-Consuming End-Uses
- Verification of Savings at Replacement
- Understand Occupancy & Usage Profiles

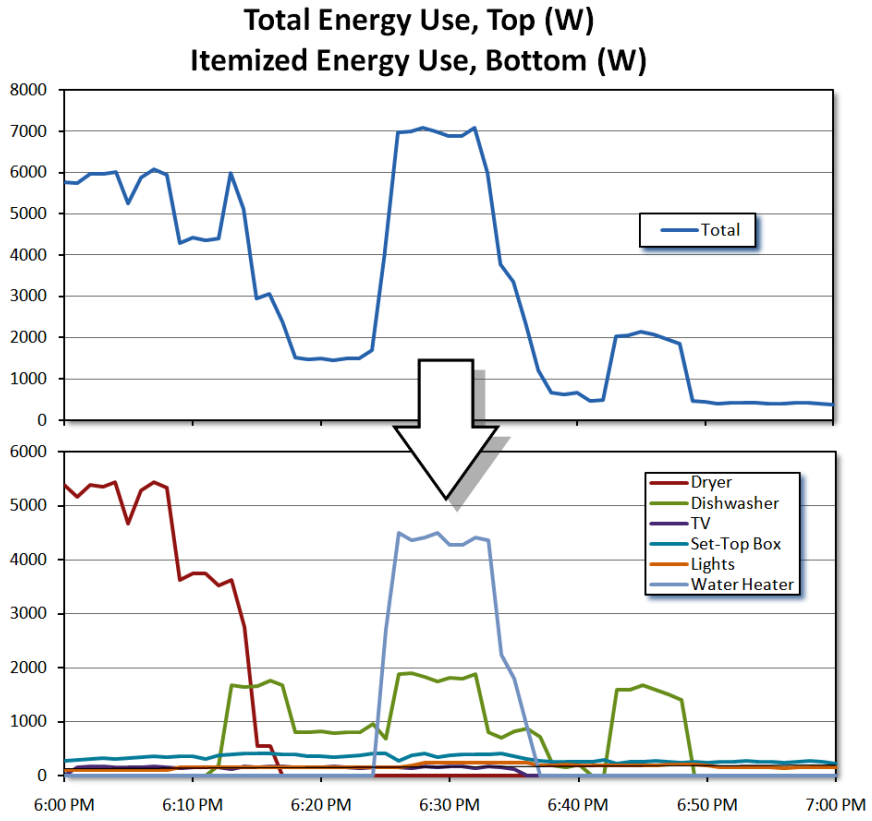
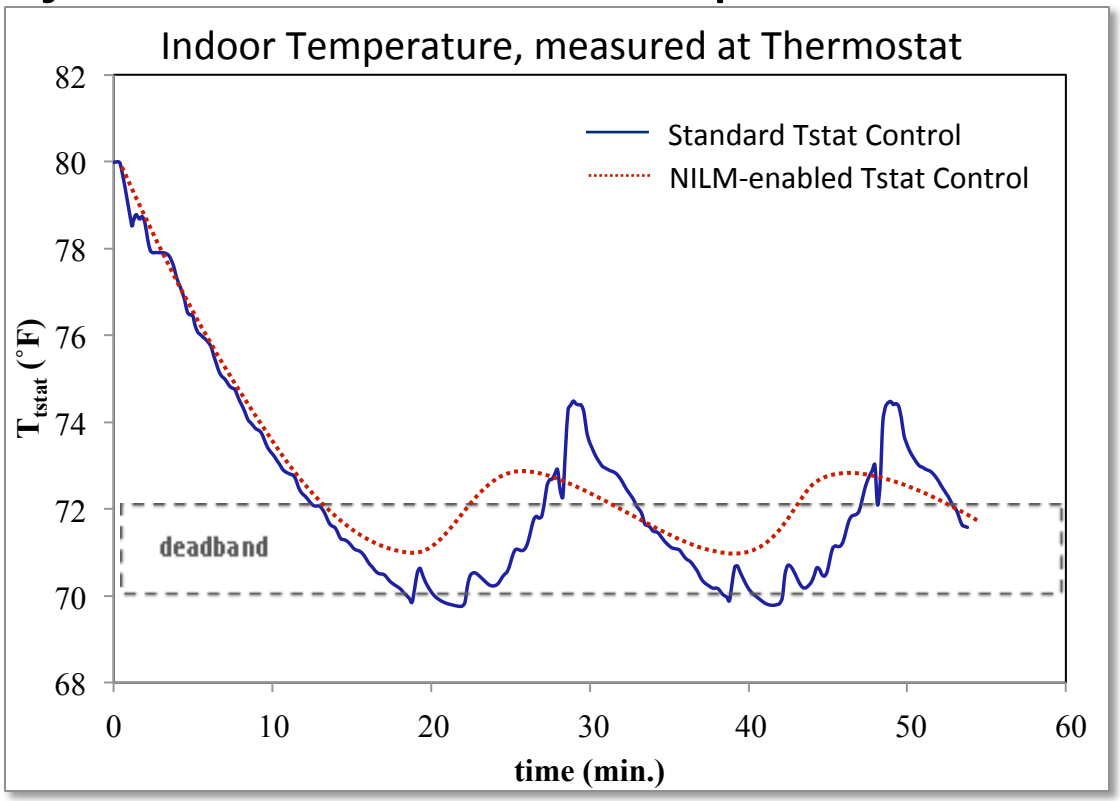


Image credit: Bethany Sparn, NREL PIX#20576

Application: **Climate Controls**

Near-Term

- Smart, Learning Capabilities
- Respond to Occupancy
- Pre-Cool for Greater Efficiency
- React to Loads, not just to Measured Temperature Change
- Deliver Heat & Cooling only to Occupied Zones
- Provide Better Thermal Comfort and Efficiency



Application: **Automated Home Energy Management (AHEM)**

Long-Term

- Automate Energy Savings
  - Turn off devices that are not in use
  - Modulate lighting based on daylight
  - Enable more flexible appliance scheduling
  - Meet utility bill budgets
- Provide Dynamic Demand Response
- Automatic “Vacation Mode”

Application: **End-Use Fault Detection And Diagnostics**

Long-Term

- Recognize Maintenance Needs
- Provide Early Notification of Problems
  - Impending Equipment Failure
  - Envelope Degradation (water, air leaks, etc)
  - Windows, Doors Left Open
- Reduce Service Call Time and Cost
- Verify Quality Installation/Workmanship by Contractor or Technician

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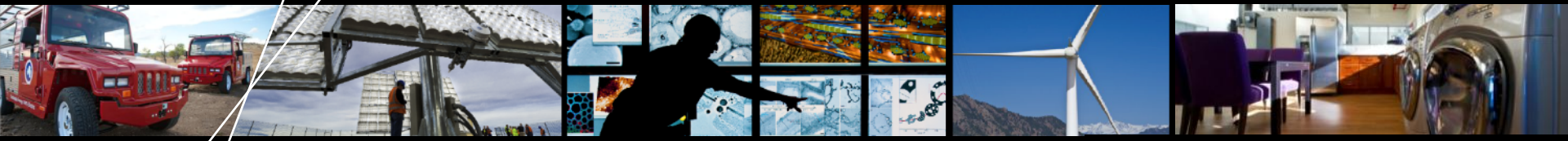


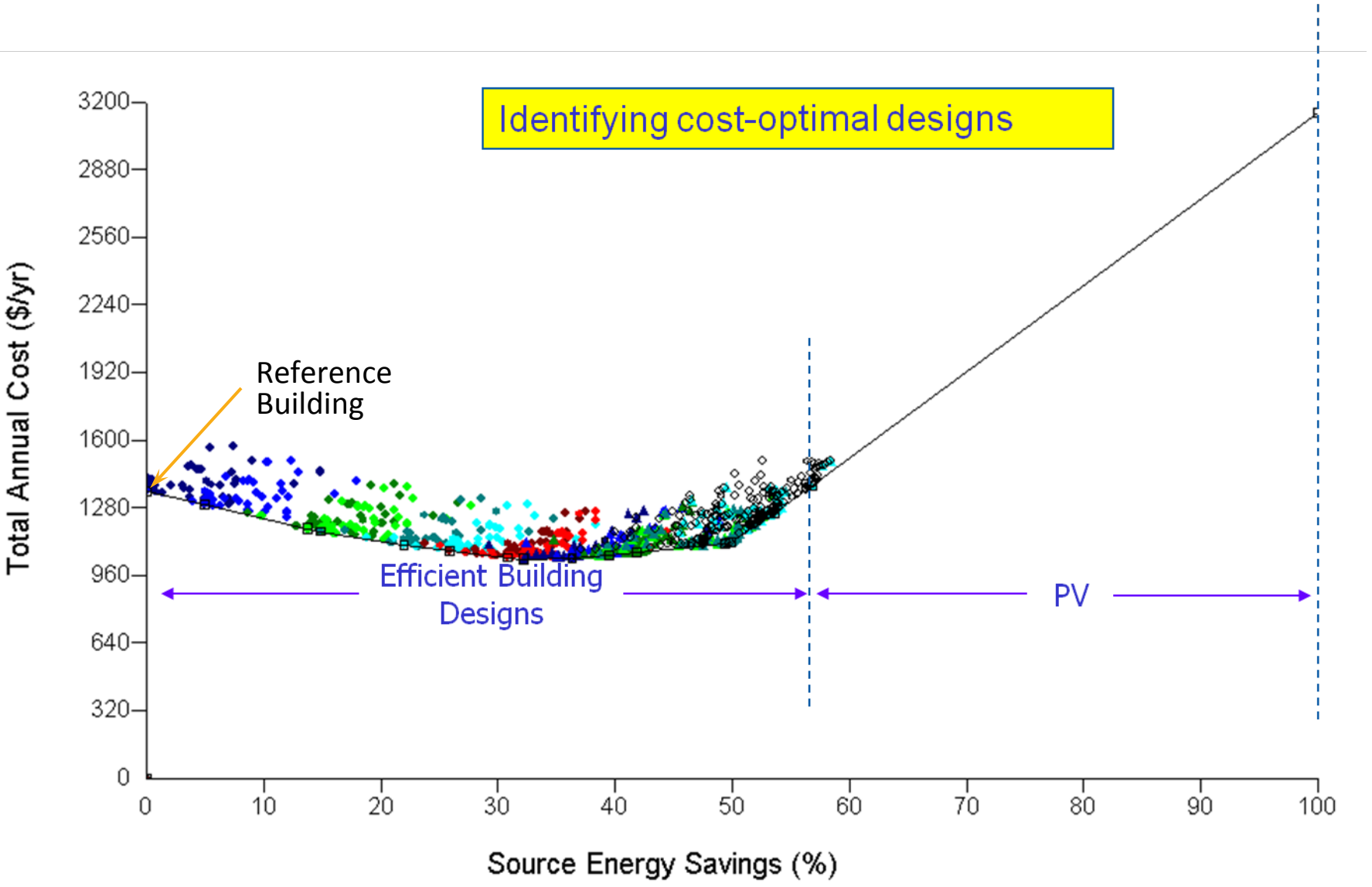
How Can NREL Help?

Investigate Technology/Product Performance

- Neutral, Third-Party Experts
- AHEM Lab: Robust & Accurate Test Bed for Product Evaluation
- Study Interactions with other Home Components & Systems
- Develop Models for Whole-Building Analysis & Optimization

Image credit: Dennis Schroeder, NREL PIX#20007

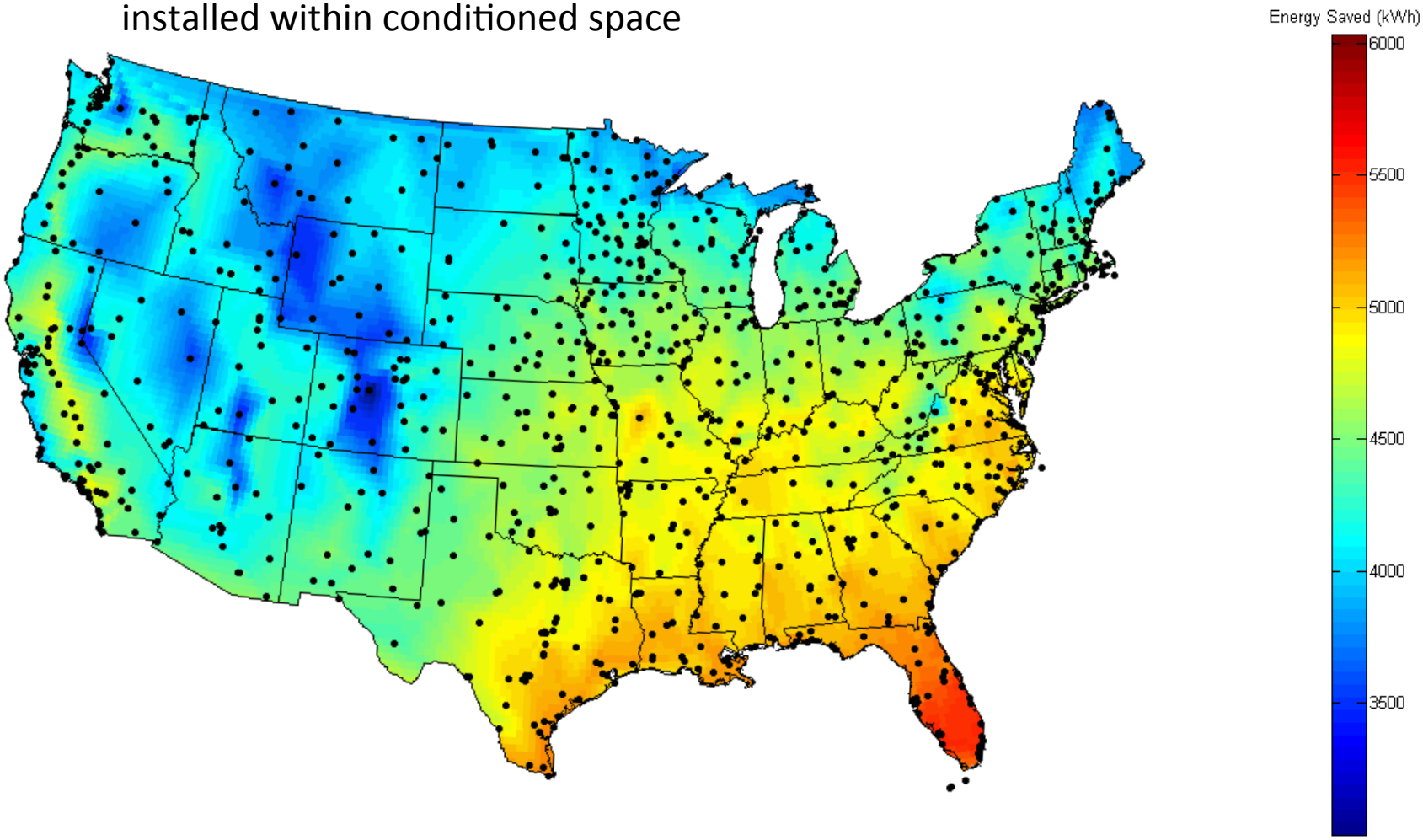
Optimizing System Interactions



Source: BEopt v.1.2

Technology Opportunity Assessment

Example: Energy Savings estimated for HPWH replacing Electric Water Heater installed within conditioned space



Source: "Heat Pump Water Heater Technology Assessment Based on Laboratory Research and Energy Simulation Models." NREL Report No. CP-5500-51433

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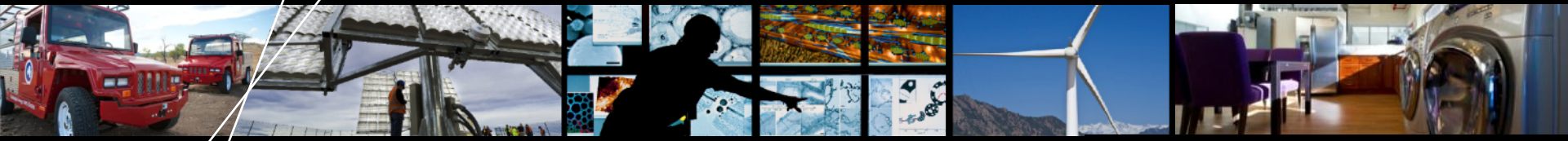
Thank You!



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