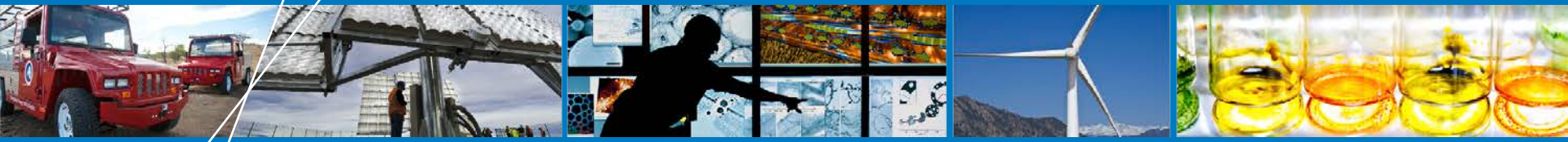
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Energy Efficiency in Buildings

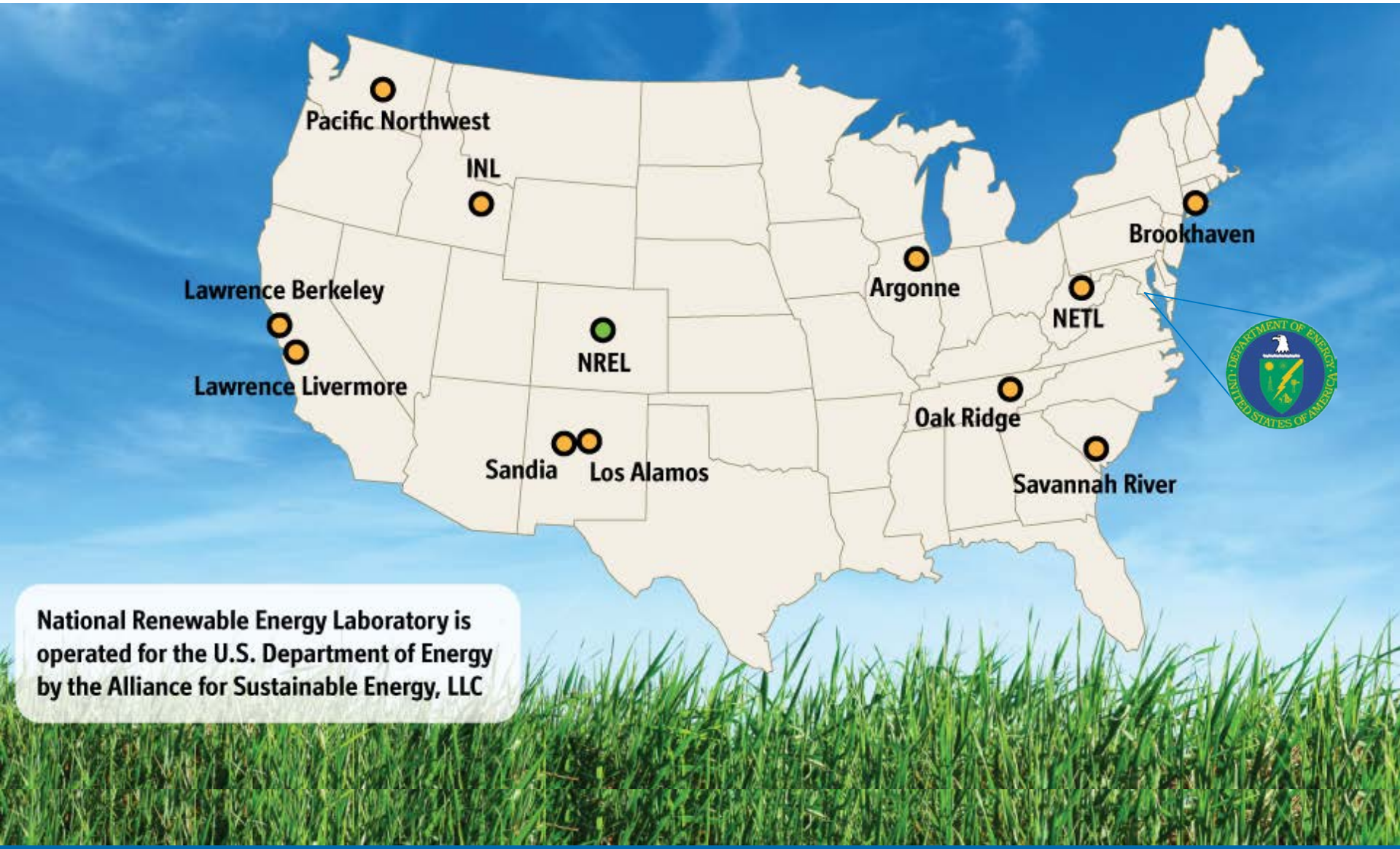


Misty Conrad

Senior Technical Lead

June 20, 2012

DOE Laboratories



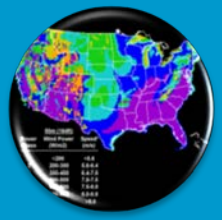
NREL's Mission is Unique

Only national laboratory dedicated to renewable energy (RE) and energy efficiency (EE) R&D

Ability to link scientific discovery, commercialization, and EE/RE program & project development

Integrated Deployment Overview

Build Stakeholder Partnerships



Establish Analytical Framework

Advance Energy Policy

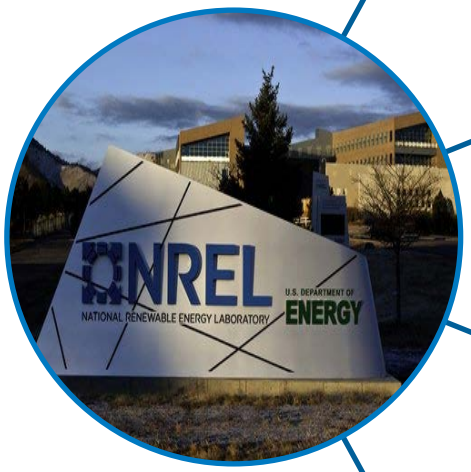
Apply the Business Perspective

Get Early Successes

What do we do?

NREL's Role in Integrated Deployment

- Honest broker of Information
- Unbiased reference point & source of documentation
- Integration of Policy, Technical, Change Management, & *Financial*



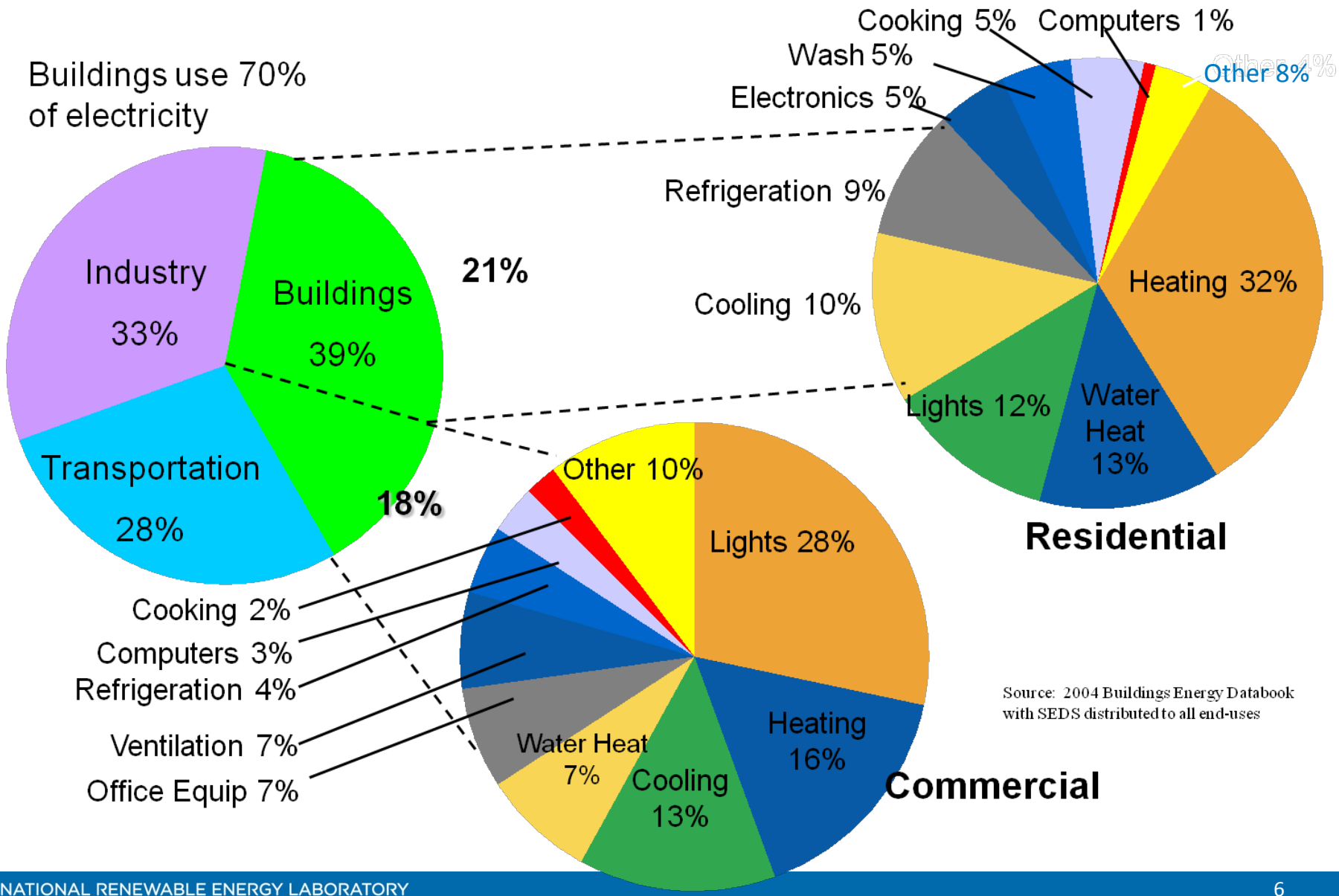
- Tech Systems
- Market Analysis
- Policy Analysis
- Sustainability Analysis
- Models & Tools
- Grid Resiliency

- Advanced Vehicles & Fuels
- Biomass
- Building
- Basic & Computational Science
- Solar & Wind
- Electric Infrastructure Systems
- Geothermal
- Hydrogen
- GIS Mapping

- Commercialization
- Cooperative R&D
- Licensing
- Tech Partnerships
- Entrepreneurship

- Strategic Energy, Climate and Sustainability Planning
- Energy Assessment
- Market Transformation
- Deployment
- Integrated Technology Application
- Training
- Technical Assistance

Building Energy Use



Affecting Building Energy Use

- **New Construction**
  - Building Energy Codes
  - Policies (Lead by Example, solar water heating)
  - Advanced Building Design
    - Leadership in Energy & Environmental Design (LEED) Accreditation
    - Net Zero Energy (NZE) Buildings
- **Retrofits**
  - Policies
    - Energy Efficiency Portfolio Standard (EEPS)
    - Public Benefit Fund (PBF) Program
    - Pay As You Save (PAYS) Program
  - Weatherization
  - Utility Efficiency Programs
- **Behavior**
  - Education & Outreach programs
  - Conservation Programs
  - Demand Response

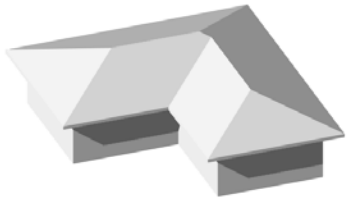
Design Strategies for More Efficient Buildings

Use simulation during the design stage to make better decisions

- Every design decision has an environmental and financial impact

Siting

- Orientation
- Building form/shape/footprint
- Aspect ratio



Shading

- Interior shade: window blinds
- Exterior shade: overhangs, fins
- Building shade: trees and landscape

Building Envelope

- Wall insulation
- Roof/ceiling insulation, radiant barrier, cool roof
- Window type, amount, placement

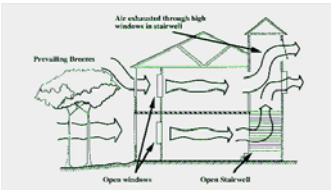
Design Strategies for More Efficient Buildings

Appliance

- Energy Star appliances
- Power save mode
- Vampire power/Phantom load; As high as 5% of residential energy consumption
- Timer / Smart power strips
- Laptop vs. PC (1/4 to 1/3 reduction)

Domestic Hot Water Heater

- Solar hot water system; Flat plate, Evacuate tubes, Thermosiphon
- Hybrid hot water heater
- Heat recovery
- Waste heat



Mechanical System

- Maximize natural ventilation
- Ceiling fan
- High efficiency A/C

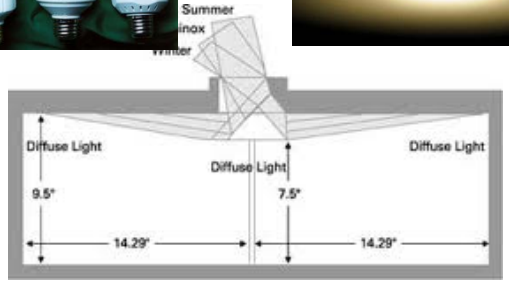
Onsite Renewable Energy

- Solar photovoltaic system

Building Design Strategies: Lighting

Lighting

- Daylighting and dimming controls
  - Daylighting system, light tube
- High efficiency fixtures
  - Indirect/direct
- High efficiency lighting
  - T8/T5 with electronic ballast, CFL, LED lighting
- Motion sensors on interior/exterior lighting
- Timers on interior/exterior lighting
- Task lighting, ambient lighting can be lower



Source: energy.gov

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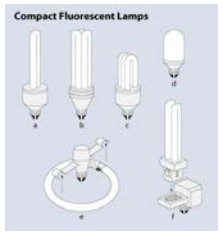

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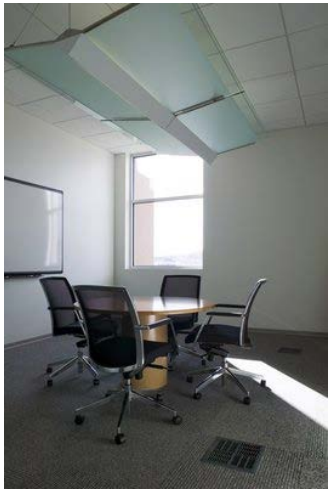


Source: NREL 14972

Retrofits through Utility Offerings

Utilities could offer:

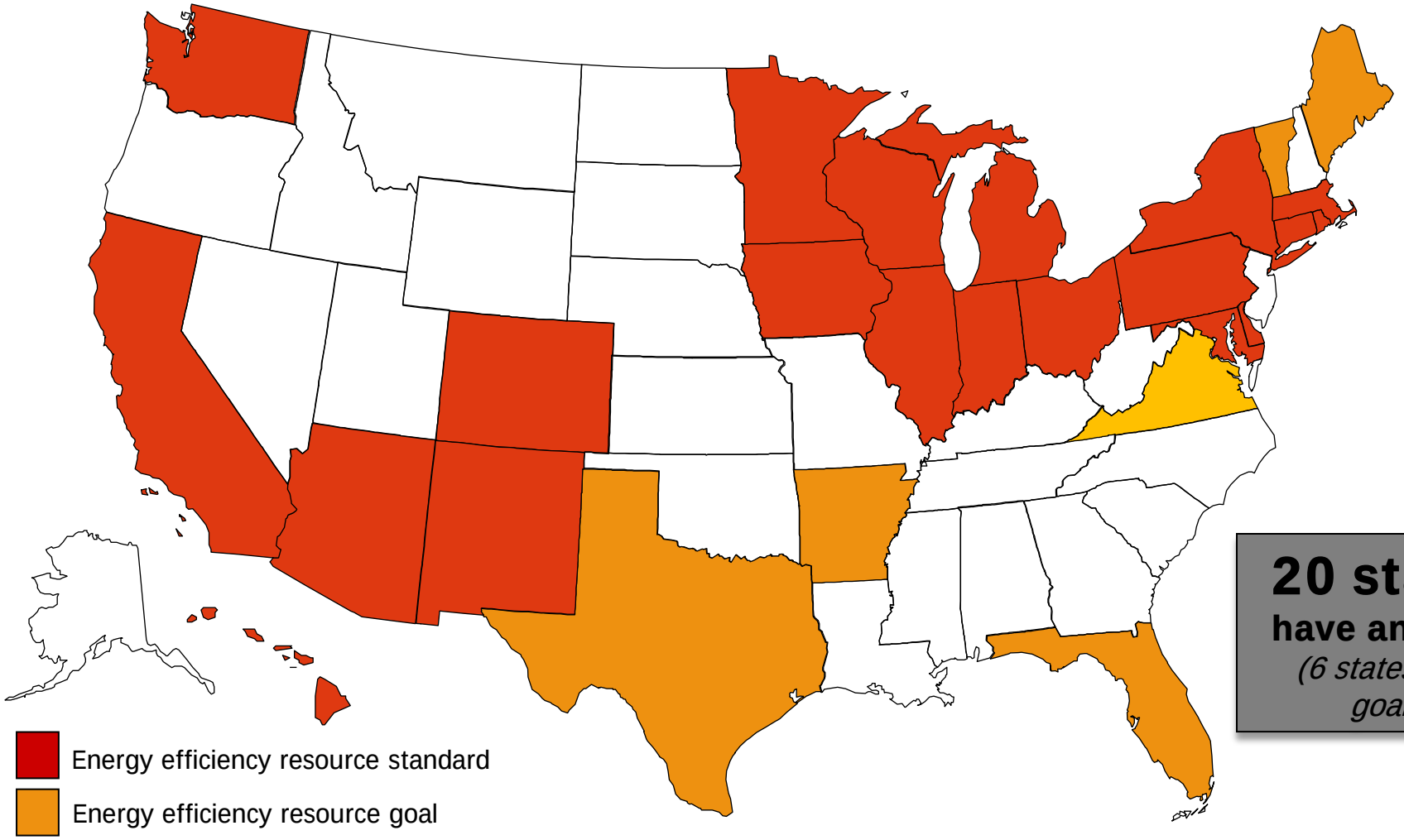
- Rebates
- Incentives
- Audits
- Demand Response Programs
- Training / O&M
- Financing
  - Pay As You Save Programs
  - Energy Services Contracting

Energy Efficiency Resource Standards

- Mandates utilities to reduce a portion of their energy demand through energy efficiency (EE) measures
- Designed to facilitate investment in untapped technically and economically viable EE
- Short term and long term goals, usually defined in terms of a percentage of total sales
- Leading states are achieving 0.75-1.25% savings **annually**

	Benefits
Utility	• Reduced demand, incl. peak demand • Reduced strain on grid
Ratepayer	• Lower electricity bills • Reduced need to fund capacity additions

Energy Efficiency Resource Standards



20 states
have an EERS
(6 states have goals)

www.dsireusa.org

Efficiency through Behavior Change

- **Outreach**
  - Public awareness campaigns
  - Community events
- **Building Controls**
  - Programmable thermostats for homes
  - Automated control systems for commercial bldgs
- **Training**
  - Operation & maintenance
  - Community workshops

Solar Decathlon (www.solardecathlon.org): Case Studies

Universidad de Puerto Rico

CASH - Caribbean Affordable Solar House

Key Features:

- Steel structure with Closed-cell polyurethane spray foam & rigid extruded polystyrene (XPS) foam
- Plumbing – Water supply flows through PEX tubing, copper pipe
- Solar Thermal Water Heating – evacuated tube solar collectors
- Radiant Ceiling – heating and cooling spaces in the house
- Sustainability – rainwater collection for irrigation of plants (not installed for solar decathlon)
- KoolShade screens
- 10 kW Solar PV

Hawaii Example: Kaupuni Net-Zero Energy Village

Objective: Design a net zero energy community of affordable housing

Approach:

- Model individual houses using BEOpt software
- Evaluate renewable options to attain net zero across the entire community
- Design to qualify for LEED Platinum

Results:

- First Net-zero energy affordable housing community
- Designed and built 19 affordable homes + community center for native Hawaiian families
- Integration of local cultural sustainability concepts
- Solar hot water heating and PV electricity
- Dual pane windows, composite roofing, fully insulated walls and ceilings, energy star appliances and lighting package
- Electric vehicle-ready dedicated circuits
- Achieved LEED Platinum certification
- Monitoring indicates net zero energy to date

www.kaupuni.net

Hawaii Example: Kalaeloa Net Zero Mixed Use Community

Objective: Design a Net Zero Energy Mixed Use Community across 20 acres including 300 housing units on Oahu

Approach:

- Net zero energy, water, and waste living community
- Unique prototype for large-scale net zero multi-family housing and commercial development

Features:

- Solar PV
- Solar hot water
- Passive cooling
- Permeable surfaces
- On-site waste treatment

Illustrations/Van Meter Willams Pollack

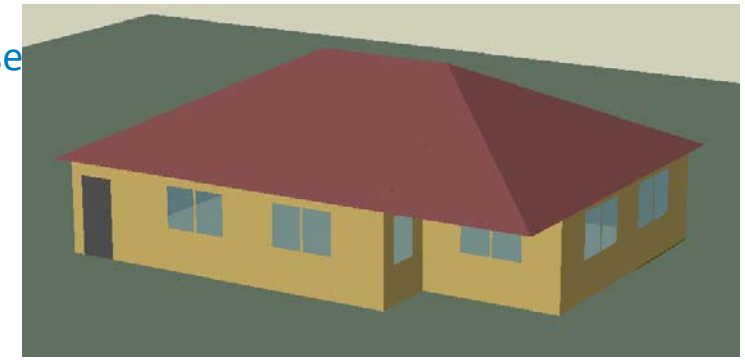
Results:

- Groundbreaking expected in 2014

USVI Example: St Croix Affordable Housing

Model Description

- 1,188 sqft , 3bed/2bath, single family house
- All electric
- $0.27/kWh, 30-year

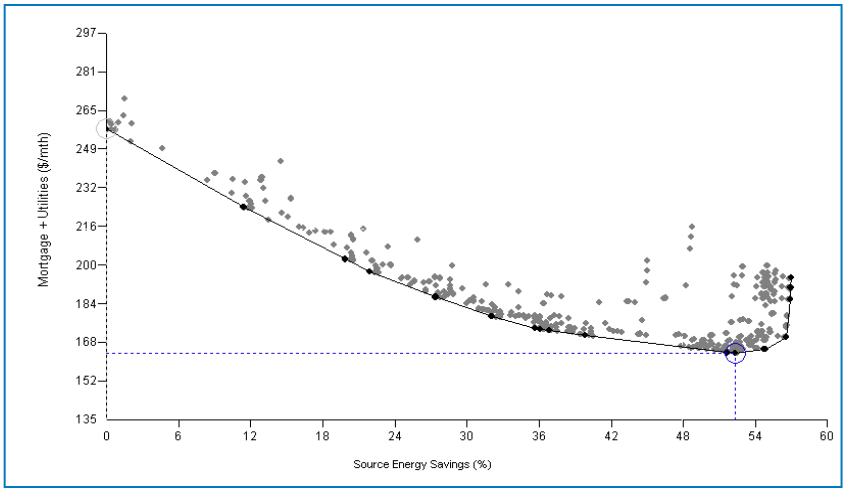


Baseline:

- USVI current practice

Explored Design Options:

- 2009 IECC building envelope (roof/wall insulation, fenestration)
- Cool roof
- 3-ft eaves
- Energy Star appliances
- CFL lighting
- Solar hot water system
- With and Without A/C
  - SEER13-18



USVI Example: St Croix Affordable Housing

Preliminary analysis results – With A/C

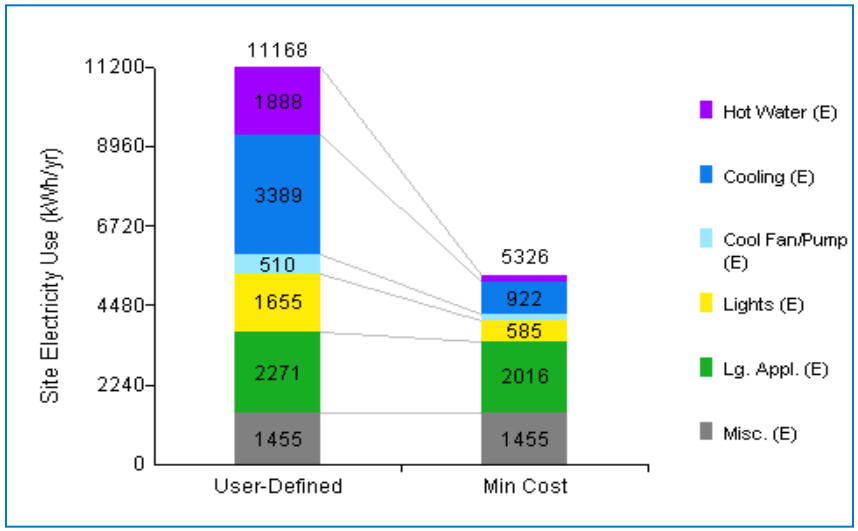
- 52% energy savings relative to USVI current practice
- Reduce utility cost by $94/month

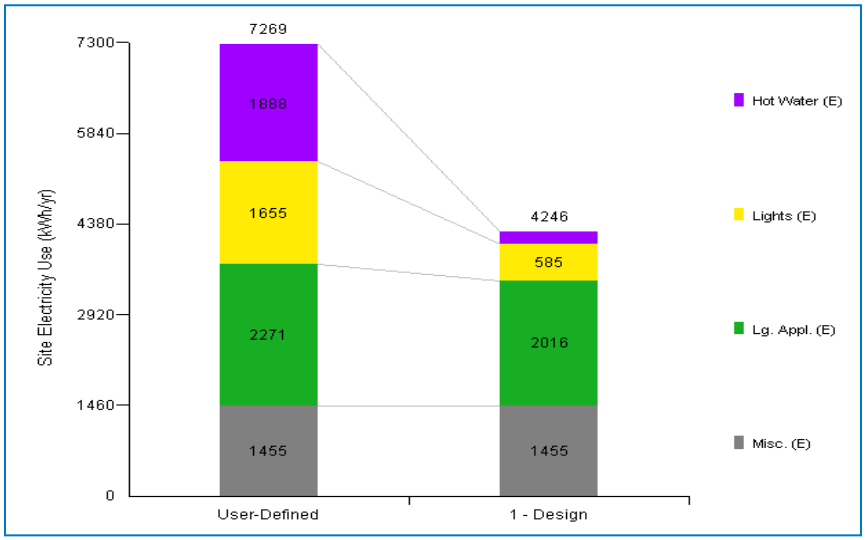
Preliminary analysis results – Without A/C

- 41% energy savings relative to USVI current practice
- Improve comfort – avg. high temperature dropped by 5F

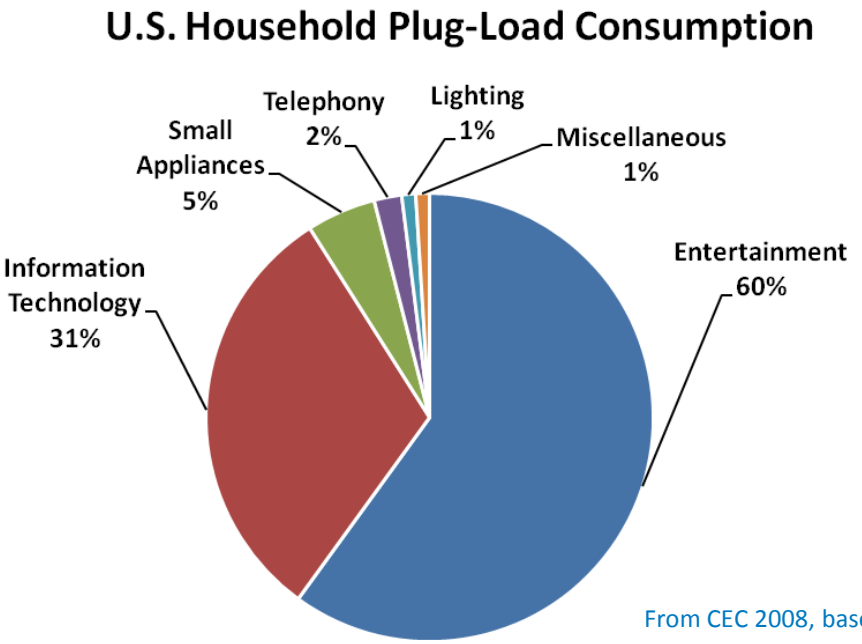
Optimal Design Package:

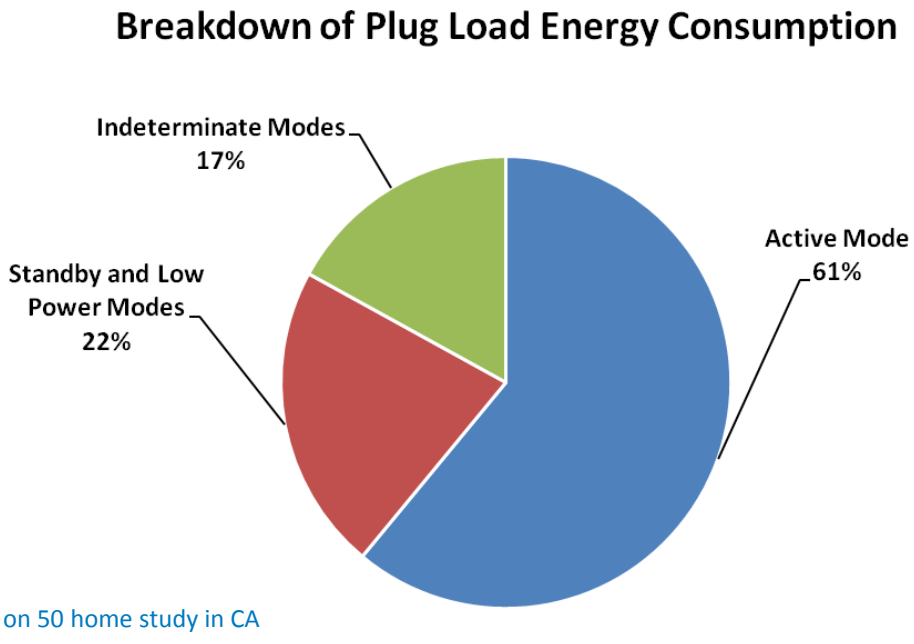
- 2009 IECC building envelope
- Cool roof
- 3-ft eaves shading
- Energy Star appliances
- CFL lighting
- Solar hot water system
- Natural ventilation
- With A/C
  - SEER15 or better





Plug Loads: End Uses to Target





From CEC 2008, based on 50 home study in CA

- The two largest categories for plug load consumption are the home entertainment center and the home office.
- Advanced power strips are target these end uses.

- Standby loads are primary target for most advanced power strips.
- Some active loads can be mitigated too.

Advanced Power Strips (APS)

(Sometimes called "Smart Power Strips")

Advanced Power Strips (APS) are power strips with additional functionality and controls, intended to curb wasted plug load energy consumption.

- look like ordinary power strips
- direct replacement for power strips used with home office and home entertainment center electronics.
- should include surge protection
- variation across products (number of outlets, control strategies, cost, aesthetics)

→ May be good stop gap solution until electronics EE standards are improved

NEEP APS Working Group

June 2010, Albany

Consumer Electronics / Plug Loads Summit

60+ stakeholders:

- efficiency program managers and evaluators
- APS manufacturers
- state and federal policy and regulatory interests

Working Group tasked to formulate a robust assessment methodology for APS devices

Embertec	Belkin	Intertek
EPRI	Sustainable Life Solutions	Tenrehte
Ecos	NYSERDA	PG&E
Tricklestar	Best Buy	Lockheed Martin
NEEP	Efficiency Vermont	Ecotek

Laboratory tests presented in this work are guided by the February 2012 draft of the testing specifications authored by the NEEP working group.

Advanced Power Strips (APS) Research Questions

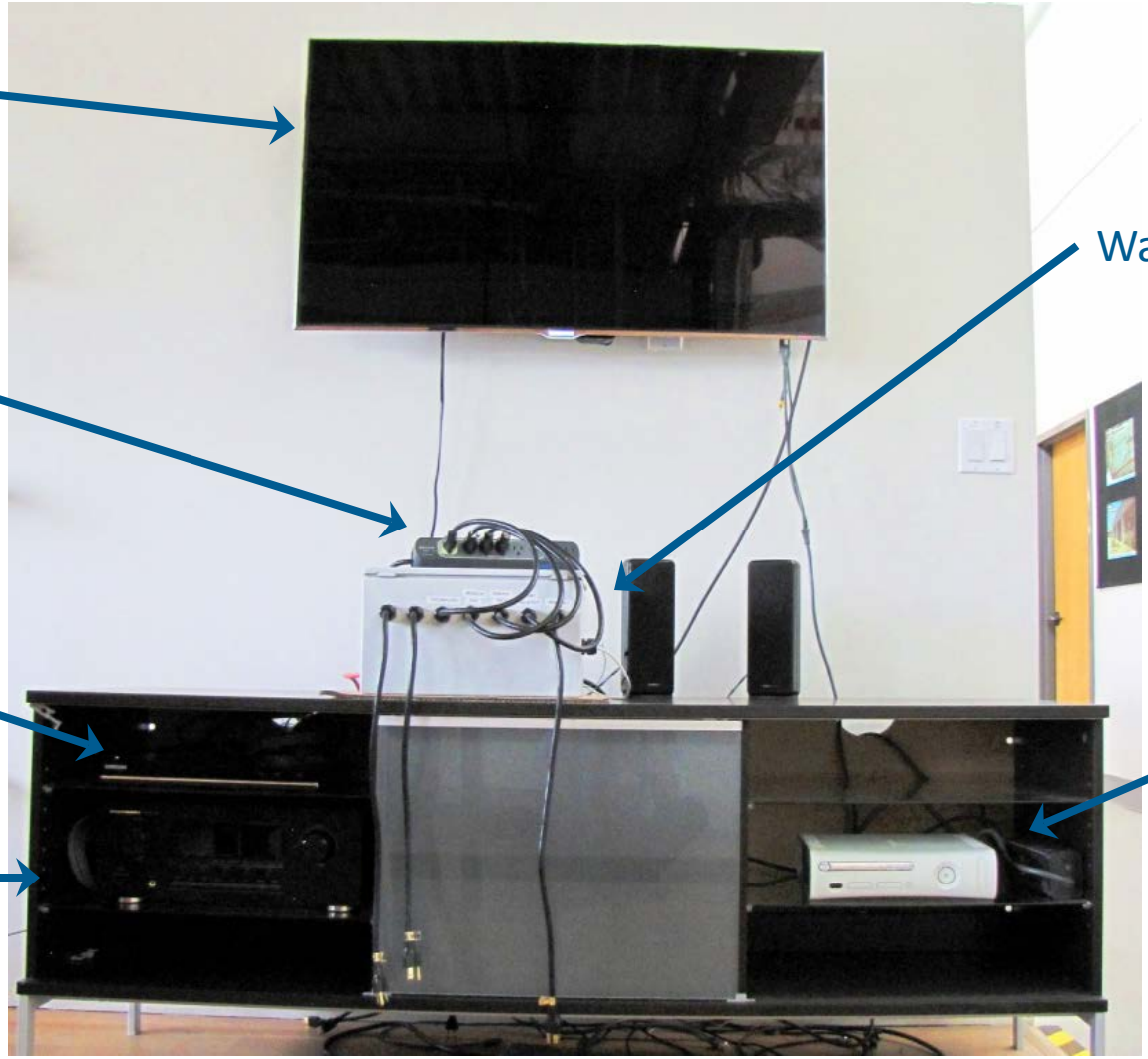
Scope of this study:

- Do they actually work as designed?
- Do they require behavioral changes?
- Do they interfere with normal operation of appliances?
- How much consumer education is required to maximize benefit?
- What are the most effective control strategies?

Follow-up analysis:

- How much energy can be expected to be saved?
- Are they cost effective?

Laboratory Testing: Home Entertainment Center



Laboratory Testing: Home Office

Conclusions

- Most products "work" as designed
  - USB power sensing: does not appear to be robust solution
  - Current-sensing: primarily designed for standby reduction
  - Master-slave: potential to cut active power waste, but does nothing for reducing master energy use
  - IR-sensing: always has extra required user step
- Appropriate choice of APS depends on use case scenario and goal, as well as other factors (price, aesthetics, number of outlets)
- Vintage of computers, TVs matter
  - Energy-savings features of newer appliances can cause problems

→ How much consumer education is required to ensure appropriate and consistent use to maximize energy savings?

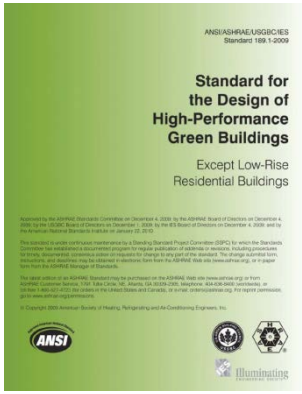
Tools & Resources:
Advanced Energy Design Guides / Standard 189.1

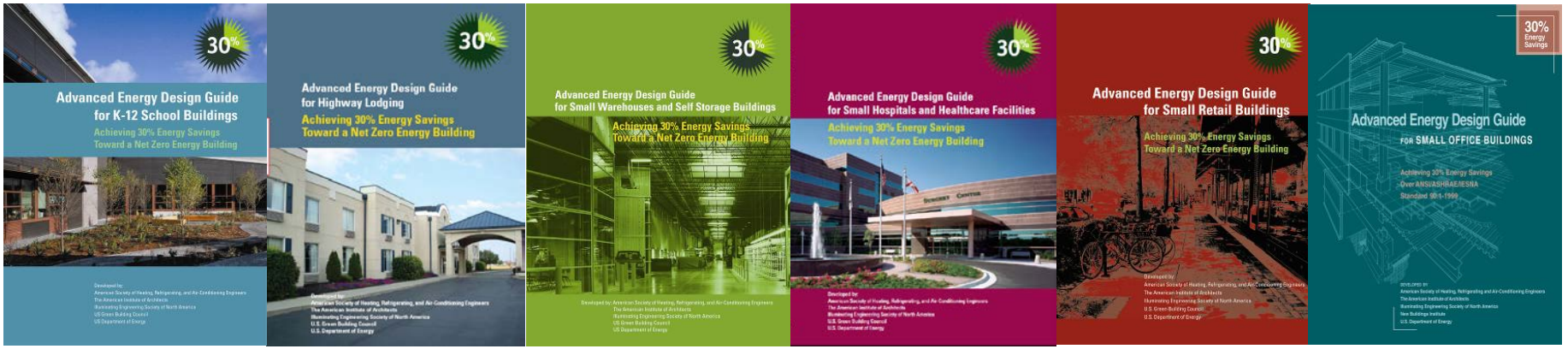
Standard 189.1 developed by ASHRAE, USGBC, and IES

- Code-intended green building standard

AEDGs developed by ASHRAE, AIA, USGBC, IESNA, and DOE

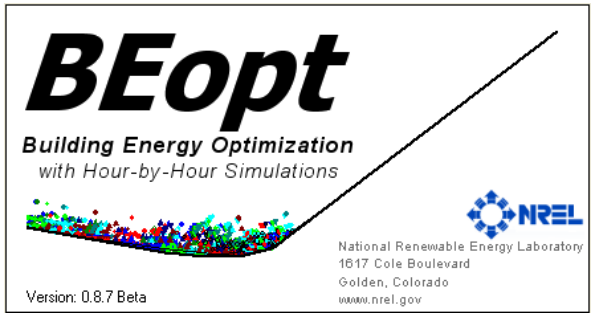
- Easy to use guidance to achieve 30% energy savings
- Recommendations by climate zone
- 4 LEED energy points
- Pre-engineered solutions
- Available at: www.ashrae.org/aedg

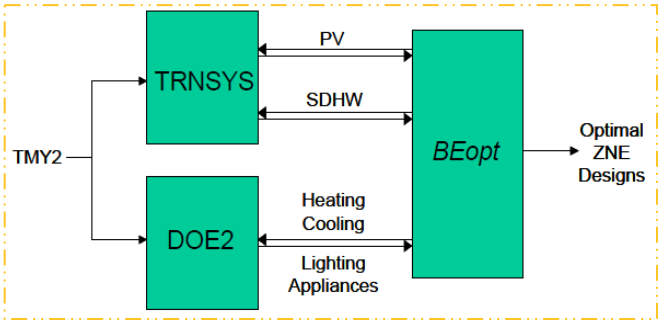


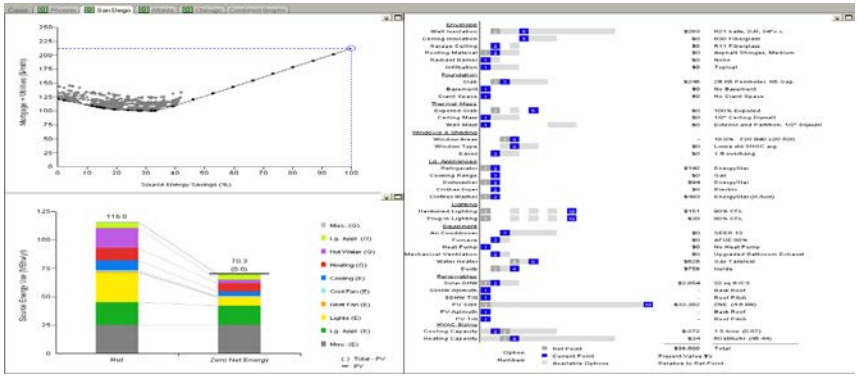


Tools & Resources: Modeling Tools

- BEopt™ Software for Building Energy Optimization
  - designed to identify optimal building designs at various energy-savings levels on the path to zero net energy

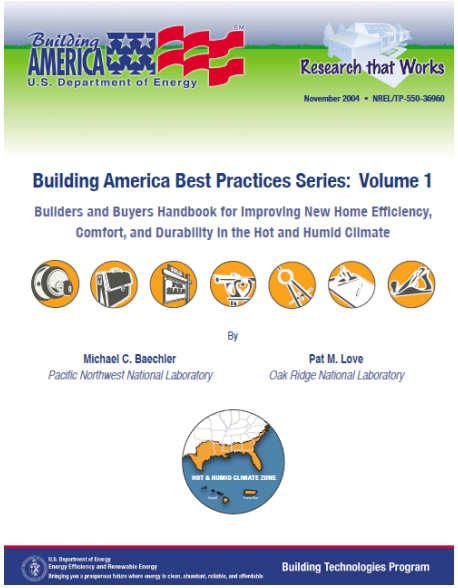


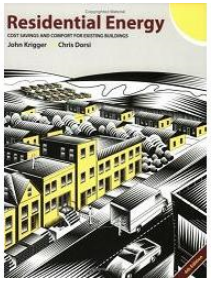


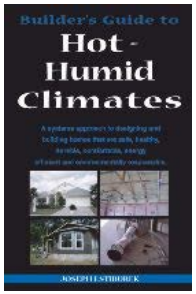


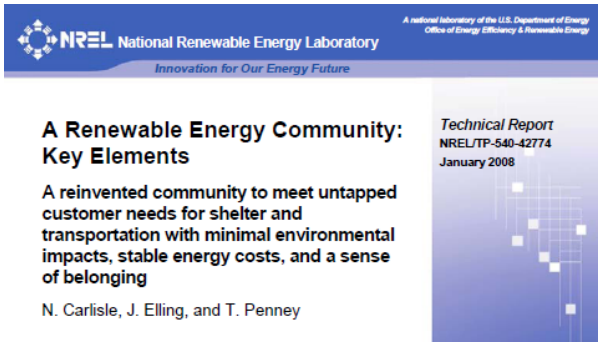
Tools & Resources: Publications

- Building America (www.buildingamerica.gov)
  - Best Practices Handbook - Hot & Humid Climate
  - Hot & Humid Climate Case Studies
  - Affordable Housing Publications
- Solar Ready Buildings Planning Guide
- Renewable Communities
- Builder's Guide to Hot-Humid Climates
- Residential Energy Cost Savings and Comfort









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Thank You!