

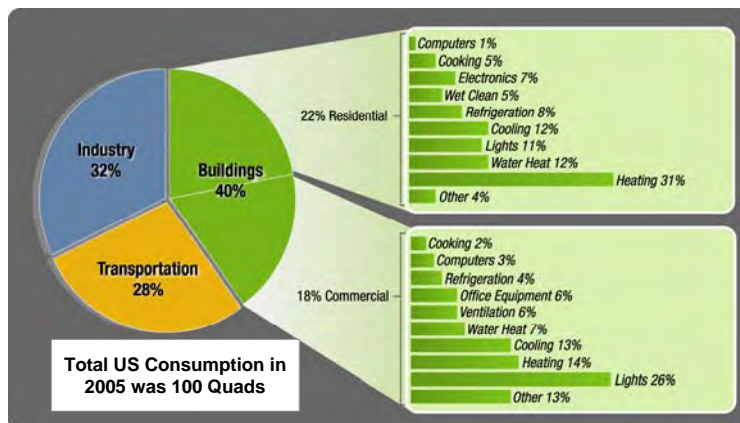


Building Technologies

Jerry Dion
Research Supervisor

ASERTTI 2009 Winter Meeting
February 4, 2009

Buildings Sector Accounts for About 40% of US Energy, 72% of Electricity, 55% of Natural Gas, 39% of Carbon, 19% of NO_x, and 52% of SO₂ Emissions.



Building Sector construction and renovation accounts for 9% of GDP and employs 8 million people. Energy utility bills total \$370B each year.

Market and Policy Signals

Energy Efficiency &
Renewable Energy



- Energy Prices
 - High commodity prices driving energy concerns
- Environmental concern
 - Public and policy makers are ready to act on climate concerns
- Market awareness
 - Manufacturers, designers, owners, and tenants want to be “green”
- Policy
 - EISA 2007 and EPACT 2005 give authority...but resources don’t always follow

3

Program Overview: Mission, Vision and Goals

Energy Efficiency &
Renewable Energy



- Vision
 - Realization of marketable net-zero-energy buildings through the development of conservation technologies and practices.
 - Reduce demand in manner that allows successful integration of renewable energy.
- Mission
 - Develop technologies, techniques, and tools for making residential and commercial buildings more energy efficient, productive, and affordable. Involves
 - Research, Development, Deployment, and Demonstration in partnership with industry, government agencies, universities, and national laboratories
 - Improve components and equipment, and effective integration into “whole-building”
 - Development of energy codes and equipment standards
 - Integration of renewable energy systems into building design and operation
- Goal
 - Create technologies and design approaches that enable net-zero energy buildings at low incremental cost by 2025. A net-zero energy building is:
 - Residential or commercial building with greatly reduced needs for energy through efficiency (60 to 70 percent less energy use)
 - Balance of energy supplied by renewables
 - Efficiency gains will have application to buildings constructed before 2025

4

Budget History

Subprogram	Budget (\$1,000)				
	FY 2007	FY 2008	FY 2009		
	Enacted Budget	Enacted Budget	Presidential Budget Request	House Mark	Senate Mark
Building Technologies Total	102,983	108,999	123,765	168,000	176,481
Residential Buildings Integration	17,270	24,475	26,900	26,900	31,006
R&D: Building America	16,775	23,659	26,900	26,900	31,006
Residential Building Energy Codes	495				
SBIR/STTR		816			894
Commercial Buildings Integration	8,699	11,891	13,000	33,000	40,000
R&D	7,204	11,891	13,000	33,000	40,000
Commercial Building Energy Codes	1,495				
Emerging Technologies	41,840	37,413	39,465	45,352	49,465
Lighting R&D	29,192	23,937	20,108	25,995	29,113
Space Conditioning and Refrigeration R&D	2,845	2,819	3,845	3,845	3,845
Building Envelope R&D	7,119	7,054	8,652	8,652	8,652
Thermal Insulation and Building Materials	2,411	2,389	3,444	3,444	3,444
Windows Technologies	4,708	4,665	5,208	5,208	5,208
Analysis Tools and Design Strategies	2,684	2,660	3,149	3,149	3,149
Solar Heating and Cooling*			3,711	3,711	3,711
SBIR/STTR		943			995
Technology Validation and Market Introduction	18,249	13,239	24,400	37,748	34,116
Rebuild America	7,473	2,808	5,000	5,000	5,000
Energy Star	8,776	6,714	8,000	10,000	9,716
Building Energy Codes	2,000	3,717	8,000	19,348	16,000
Solar Decathlon			3,400	3,400	3,400
Equipment Standards and Analysis	16,925	21,981	20,000	25,000	21,000

Buildings Technologies Program Employs Three Complementary Strategies to Achieve Its Mission.

Energy Efficiency & Renewable Energy



- R&D
 - Whole Building Integration
 - Component, Equipment, and Materials
- Technology Validation and Market Introduction
 - Energy Star
 - Building Energy Codes
 - Marketing Campaigns
- Appliance Standards

A net-zero energy building is a grid-connected residential or commercial building that, over the course of a year, produces with renewable sources as much energy as it consumes

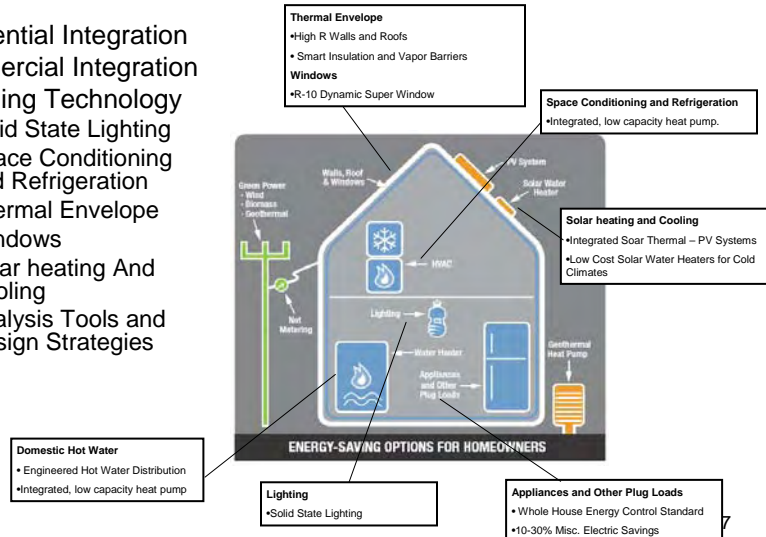
An integrated and aggressive Buildings Program is required to achieve Zero Energy Homes by 2020, and Commercial Buildings by 2025.

Research and Development: Integration of Technologies

Energy Efficiency & Renewable Energy



- Residential Integration
- Commercial Integration
- Emerging Technology
 - Solid State Lighting
 - Space Conditioning and Refrigeration
 - Thermal Envelope
 - Windows
 - Solar heating And Cooling
 - Analysis Tools and Design Strategies



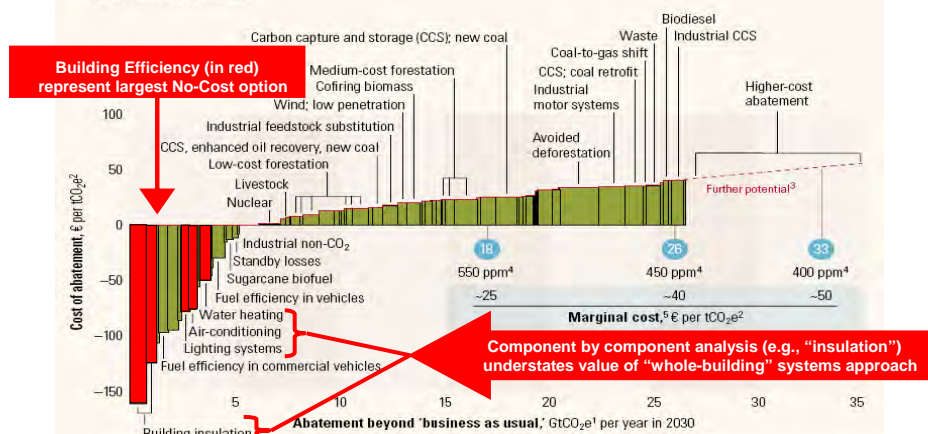
Low/No-Cost Carbon Reduction Options

Energy Efficiency & Renewable Energy



Global cost curve for greenhouse gas abatement measures beyond 'business as usual'; greenhouse gases measured in GtCO₂e¹

• Approximate abatement required beyond 'business as usual,' 2030



¹ GtCO₂e = gigaton of carbon dioxide equivalent; "business as usual" based on emissions growth driven mainly by increasing demand for energy and transport around the world and by tropical deforestation.

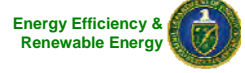
² tCO₂e = ton of carbon dioxide equivalent.

³ Measures costing more than €40 a ton were not the focus of this study.

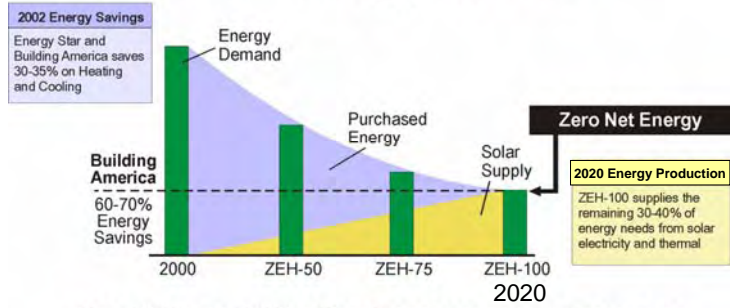
⁴ Atmospheric concentration of all greenhouse gases recalculated into CO₂ equivalents; ppm = parts per million.

⁵ Marginal cost of avoiding emissions of 1 ton of CO₂ equivalents in each abatement demand scenario.

Residential Integration: The Building America Program is marching towards Zero Energy Homes (ZEH) for All Americans.

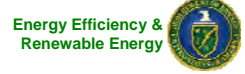


Zero Energy Homes



Ultimate goal is a Zero Energy Home using cost effective tools, techniques and integrated technologies, systems and designs for buildings that generate and use energy so efficiently that buildings are capable of generating as much energy as they consume on an annual basis at neutral cash flow.

Zero-Net-Energy Commercial Buildings Initiative: Implementation and Partners



Guiding market-relevant technology advances from laboratory to marketplace

Net-Zero Energy Commercial Buildings are grid-integrated buildings capable of generating as much energy as they consume through advanced efficiency technologies and on-site generation systems such as solar power and geothermal energy.

Commercial Building Initiative - Next Steps

Energy Efficiency & Renewable Energy



- Commercial Building Energy Alliances
 - Retailer Energy Alliance
 - 29 members, 2 billion sq. ft., \$820 billion in revenue and 104,727 stores
 - Commercial Real Estate Energy Alliance
 - Office, shopping center, hospitality, medical office, GSA
 - Forming this summer
 - Institutional Energy Alliances
 - State and local government
 - Hospitals (Hospital Energy Alliance)
 - Colleges and Universities/K-12 Schools (EnergySmart Schools)
 - Federal government
 - Forming early next year
 - Commercial Building Industry Energy Alliance
 - Manufacturers, suppliers, designer community, utilities, ESCOs, finance
 - Forming early next year
- National Accounts
 - Challenging building owners/developers to build new buildings that use 50% less energy than 90.1-2004 and to retrofit existing buildings for 30% energy savings.

State of Technology: Key Component Technologies (Residential)

Energy Efficiency & Renewable Energy



Component	Current Technology Status	Program Target	Technical Issues to Higher Performance
Lighting	Primarily Incandescent to Compact Fluorescent (CFL) and some dedicated fluorescent	Solid State Lighting with performance equal to 122 lm/W in 2012 and 160 lm/W in 2020	<ul style="list-style-type: none"> •CFLs accounted for ~20% of sales in 2007 up from 5% in 2005. •Prototype LEDs could offer potential savings beyond CFLs.
Walls	R-value: 13 to 19	Dynamic R-20 – R-30 within tradition 3.5" wall, approximately 50% more efficient.	<ul style="list-style-type: none"> •Cost and design issues. •Incremental gains in insulating materials necessary to make more feasible option. •Potential smoke and fire hazards with advanced materials.
Ceiling	R-value: 30 to 60	Dynamic roof/attic with a 50% reduction in roof/attic losses	<ul style="list-style-type: none"> •Cost and design issues. •Additional ways to provide savings from ceilings / roofs in reflective roofs and radiant barriers that enhance or supplement insulation.
Windows	R-value range (R2 – 5), fixed SHGC in southern U.S. down to 0.30	40-60% reduction in energy consumption (2003 Energy Star low E baseline)	<ul style="list-style-type: none"> •High end current products expensive and difficult to install. •U-value (R-value) approaching 0.1 (R-10) with current technologies. •R&D focused on achieving U-0.1 with gas-filled / vacuum panes, aerogels.
HVAC	AFUE 80% to 97% for gas heating, 7.7 to 10.6 HSPF for electric heating, SEER 13 to SEER 21 for air conditioning	50% reduction in energy consumption (2004 baseline)	<ul style="list-style-type: none"> •Very high first cost. •Highest SEER products not very prevalent.

Technology Validation and Market Introduction

Energy Efficiency & Renewable Energy



- **ENERGY STAR**
 - Labeling (e.g., Refrigerators, Solid State Lighting, future products)
 - Existing homes (Home Performance with ENERGY STAR)
 - A DOE, EPA and HUD program to target energy efficiency in existing homes
 - Retail Partnerships (National Campaigns, whole home services, merchandising)
- **Building Codes**
 - Commercial: ASHRAE 90.1-2010 30% improvement goal
 - Residential: IECC Model Code push towards 30% improvement, 2009 IECC 12-17% increase in stringency
- **Targeted Markets**
 - Energy Smart Schools
 - Energy Smart Hospitals
 - Builders Challenge (200 builders have accepted)
- **Solar Decathlon Fall 2009**
 - MOU with Spain for Europe 2010

13

Market Transformation: ENERGY STAR®

Energy Efficiency & Renewable Energy

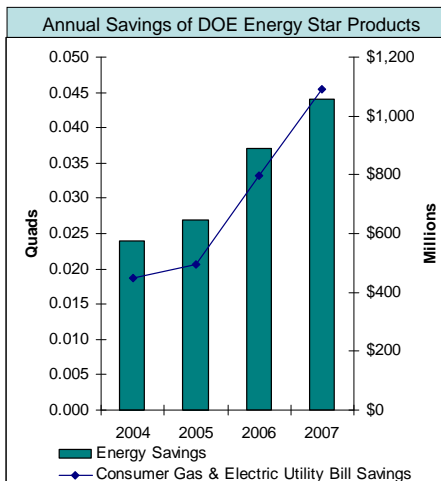


DOE Products

- Dishwashers
- Clothes Washers
- Refrigerators/Freezers
- Room Air Conditioners
- CFLs
- Windows

Emerging Products

- SSL (NEW!)
- Adv Tech Water Heaters (NEW!)
- Packaged Terminal A/C
- Photovoltaics
- Small Wind Turbines

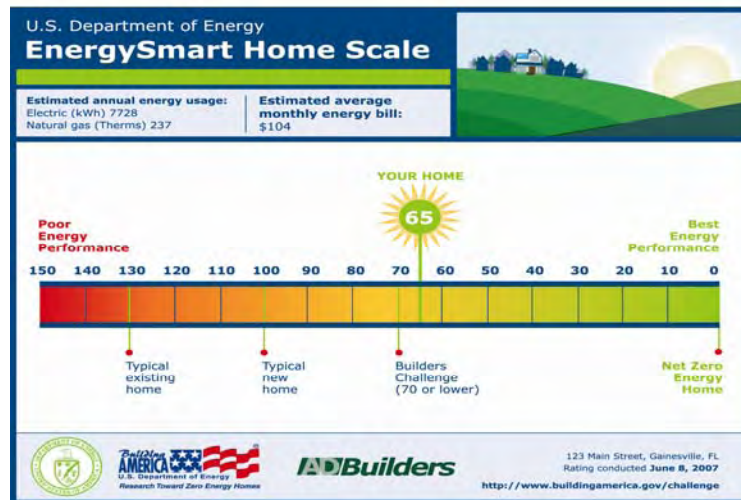


DOE Energy Star beginning to encompass advanced technology... Issued a Solid State Lighting specification for minimum efficiency

14

Builders Challenge: Recognizing Energy Leadership in Homebuilding

Energy Efficiency &
Renewable Energy



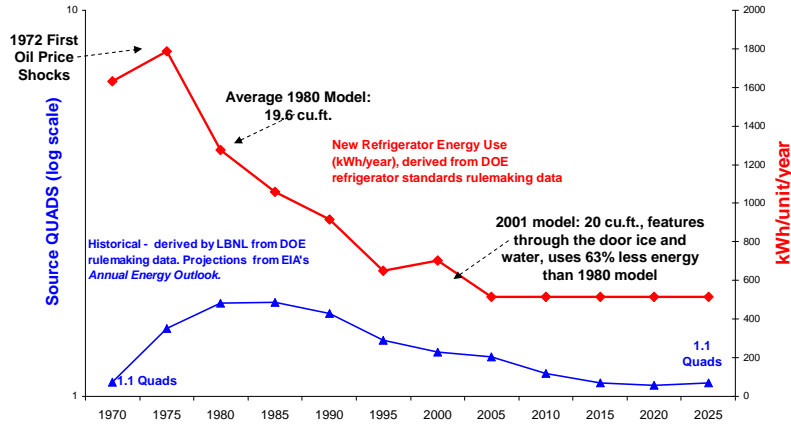
Appliance Standards

Energy Efficiency &
Renewable Energy



- Energy efficiency standards and test procedures issued for 16 products from 1987 through 2007
 - Standards for some products raised more than once
- DOE Must Issue another 18 standards between January 2008 and June 2011
 - Covers some of the same products again
 - http://www1.eere.energy.gov/buildings/appliance_standards/index.html
- EISA 2007 amends and extends EPACT 2005 to revisit or issue standards for another 9 products
 - Most notable is Incandescent General Service Lamps

Past successes have resulted in large and sustained savings.



Advanced Refrigeration "...one of the last half-century's more remarkable technological achievements in the energy field: a reduction of more than two-thirds in the average electricity consumption over 25 years, even as average unit sizes increased, performance improved,...DOE was an early and effective leader, ..." ("Energy Research at DOE: Was it Worth It", NRC 2001, page 96)

Contacts

Jerry Dion, Research Supervisor

jerry.dion@ee.doe.gov

<http://www.eere.energy.gov/buildings/>

Backup Slides

Energy Efficiency &
Renewable Energy



State of Technology: Zero Energy Homes

Energy Efficiency &
Renewable Energy



The goal of Building America is to integrate energy efficiency and onsite/renewable power solutions, demonstrated on a production basis by building community subdivisions, which will reduce whole-house energy use in new homes by an average of 50 percent by 2015 and 70 percent by 2020 compared to the Building America Benchmark at net zero financial cost to the home owner.

Target (Energy Savings)	Marine	Hot Humid	Hot/Mixed Dry	Mixed Humid	Cold
30%	2006	2007	2005	2006	2005
40%	2008	2010	2007	2009	2009
50%	2012	2012	2011	2013	2014
70%	2017	2016	2015	2017	2018

Key
Completed
Current

Commercial Integration is Working to Achieve ZEB in 2025.

Energy Efficiency & Renewable Energy

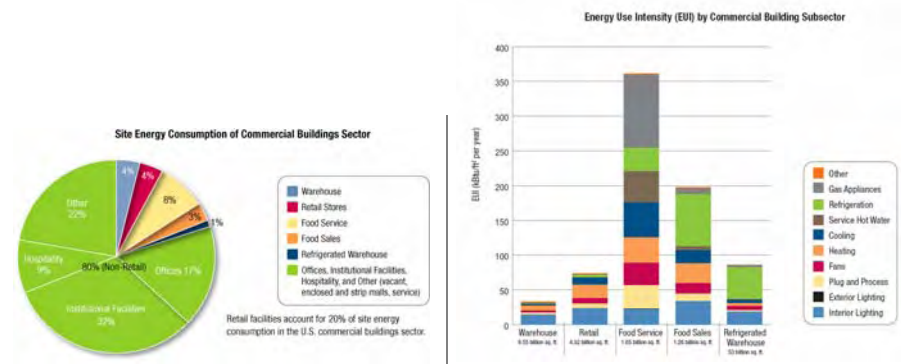


- Establishing National Alliances which are groupings of similar building types/sectors and National Accounts to implement energy savings measures.
- Developing Advanced Design Guides which contain design technology packages for new commercial buildings (that achieve 30 to 50 percent increase in energy efficiency relative to the ASHRAE 90.1-2004 benchmark).
- Developing Building Decision Tools and Technology Option Sets to enable high efficiency building designs.
- The Net-Zero Energy Commercial Building Initiative (CBI)
 - Public-private partnership led by DOE
 - Achieve continuous technology improvement and commercialization of advanced building technologies
 - Enable net-ZEB no later than 2025 in all climate zones

21

Retailer Energy Alliance

Energy Efficiency & Renewable Energy



25 Alliance Members: 2 Billion Square Feet in 69,377 Stores; \$820 Billion Annual Revenue

State of Technology: Zero Energy Buildings

Energy Efficiency & Renewable Energy



The Commercial Integration goal is to achieve the development of net-zero energy commercial buildings (NZEBS) in the United States, including:

1. Improve the whole-building energy performance in new construction by 50% by 2015; and by 70% by 2025, relative to ASHRAE/IESNA/ANSI Standard 90.1-2004. A 70% reduction in whole building energy use, combined with renewables, provides net-zero energy buildings.
2. Improve existing building stock energy performance by 50% by 2030 over the Commercial Buildings Energy Consumption Survey (CBECS) 2003 baseline.

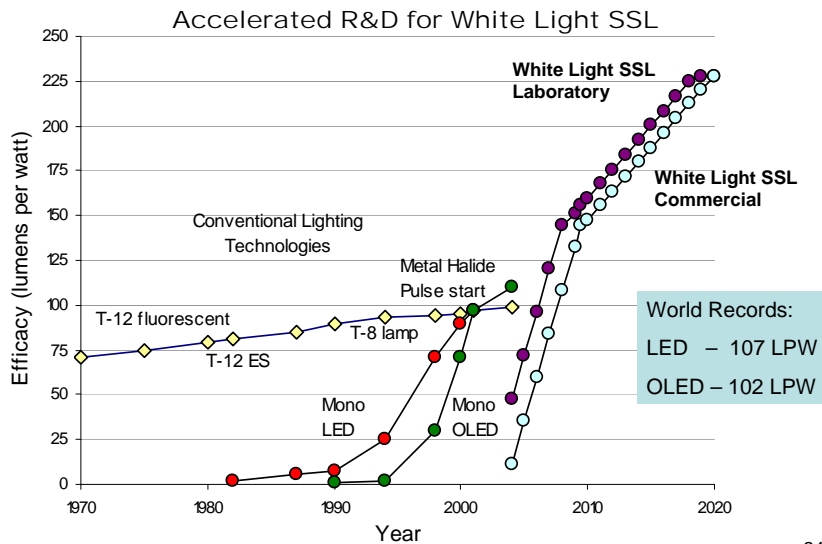
Technology Status: Building Design Technology Packages Performance Targets

Characteristics	Energy Savings	2005	2006	2007	2008	2009	2010	2011	2012
Small and Medium Sized Commercial Building Design Technology Packages	30%	1	1	2	4	4	2	-	-
Technology Option Sets	50%	-	-	-	-	-	2	4	4

Key
Completed
Current

Solid State Lighting (SSL) R&D working toward over 200 lumens per Watt for 2020.

Energy Efficiency & Renewable Energy



Building Technologies Research on Advanced Envelopes and Windows:

Energy Efficiency & Renewable Energy



- Developing the next generation of Attic/Roof Systems by 2015.
- Producing an advanced wall system that doubles efficiency of current wall systems by 2010.
- Exploring materials that control thermal flows to building envelope; use dynamic energy storage to reduce net energy transport through wall or roof system; control moisture through passive dynamic systems.



25

R&D To Reduce Windows Energy Load by 40-60% by 2020

Energy Efficiency & Renewable Energy



- Demonstrating highly insulating windows with Building America.
- Researching Dynamic Fully-sputtered windows and manufacturing processes.
- Exploring Daylighting & Advanced Façades.
- Participating in Asia Pacific Partnership Activities to encourage product labeling and durability testing



Prototype – Concept Window
(Highly Insulating and Dynamic
R 5.6, SHGC 0.04 – 0.34)
Low cost unsealed center lite

26

R&D To Reduce HVAC and Water Heating Energy Use by 50%

Energy Efficiency &
Renewable Energy



- Developing the Integrated Heat Pump for ZEH and involving a major manufacturers in process.
- Advanced Heat Pump Water Heater resulted in General Electric Hybrid Water Heater (market introduction late 2009)
- Participating in IEA annexes related to ground source heat pumps, HVAC for ZEH, and compact heat exchangers for heat pumps.

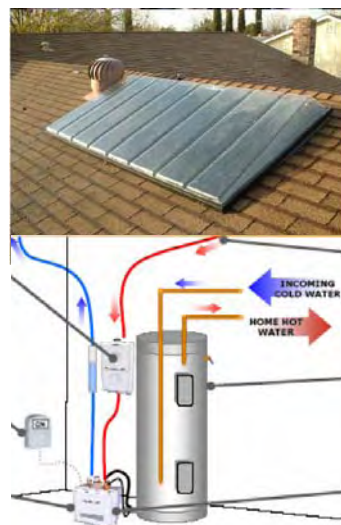
27

R&D To Develop Cost-Competitive Solar Heating and Cooling Systems

Energy Efficiency &
Renewable Energy



- Leveraging the polymer systems work done for warm climates to develop Low-cost Solar Water Heaters for ZEH
- Conducting fundamental systems analysis on seasonal storage concept for SH&C Systems
- Supporting the PV/thermal system development in Building America on Solar Electric/Solar Thermal Pathways to ZEH
- Participating in IEA Solar Heating and Cooling Implementing Agreement



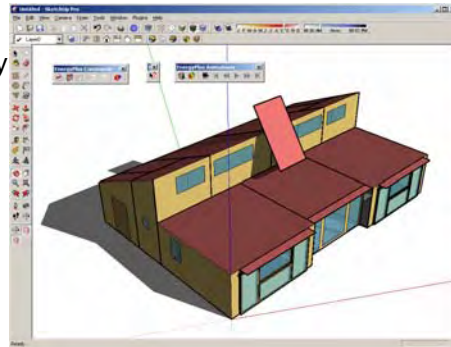
28

Develop Analysis Tools To Facilitate the Design and Analysis of ZEB

Energy Efficiency & Renewable Energy



- Extending the capabilities of **EnergyPlus** through code compliance and inclusion of key technologies.
- Validating **EnergyPlus** with widely accepted test methods for building simulation.
- Deploying through increasing interoperability with currently used tools, training firms, running workshops, and licensing with industry.
- Participating in Asia Pacific Partnership to disseminate **EnergyPlus** and train practitioners.



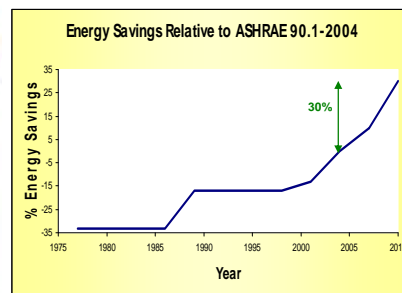
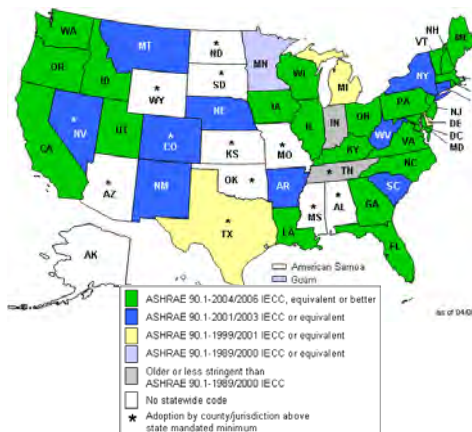
29

Commercial Building Codes:

Energy Efficiency & Renewable Energy



DOE and ASHRAE teamed, building the foundation to achieve 30% savings in new commercial buildings by 2010.



DOE is working with ASHRAE to achieve 30% more energy efficiency relative to Standard 90.1-2004 by 2010.

Ongoing Energy Conservation Standards Activities

Energy Efficiency & Renewable Energy



Product	Driver	Scheduled Completion
1. Package Terminal Air Conditioners and Heat Pumps	Backlog	COMPLETED
2. Distribution Transformers	Backlog	COMPLETED
3. Furnaces and Boilers, Residential	Backlog	COMPLETED
4. Small Furnace	Backlog	COMPLETED
5. Mobile Home Furnaces	Backlog	COMPLETED
6. Small Electric Motors (Determination)	Backlog	COMPLETED
7. 15 Product EPACT 2005 En Masse Standard	EPACT 2005	COMPLETED
8. Ceiling Light Fan Kits	EPACT 2005	COMPLETED
9. Commercial Refrigeration Equipment	EPACT 2005	January 2009
10. EISA 2007 En Masse Standard	EISA 2007	January 2009
11. Clothes Washers, Commercial	EPACT 2005	March 2009
12. Ranges and Ovens (Electric and Gas) and Microwave Ovens	Backlog	March 2009
13. Refrigerated Bottle or Canned Beverage Vending Machines	EPACT 2005	August 2009
14. Incandescent Reflector Lamps	Backlog	June 2009

Ongoing Energy Conservation Standards Activities (cont.)

Energy Efficiency & Renewable Energy



Product	Driver	Scheduled Completion
15. General Service Fluorescent Lamps	Backlog	June 2009
16. External Power Supplies, non-Class A (Determination)	EISA 2007	December 2009
17. Small Electric Motors	Backlog	February 2010
18. Water Heaters, Residential	Backlog	March 2010
19. Direct Heating Equipment	Backlog	March 2010
20. Pool Heaters	Backlog	March 2010
21. High-Intensity Discharge Lamps (Determination)	Backlog	June 2010
22. Refrigerators, Residential	EISA 2007	December 2010
23. Fluorescent Lamp Ballasts	Backlog	June 2011
24. Room Air Conditioners	Backlog	June 2011
25. Clothes Dryers	Backlog	June 2011
26. Central Air Conditioners and Heat Pumps	Backlog	June 2011
27. Battery Chargers	EISA 2007	July 2011
28. External Power Supplies, Class A	EISA 2007	July 2011
29. ASHRAE 90.1 Products	EISA 2007	July 2009 / July 2011*

*DOE will adopt as uniform national energy standards the amendments in ASHRAE 90.1 within 18 months of the date of publication of ASHRAE Standard 90.1 or set more stringent standards not later than 30 months after the date of publication of the amendment to the ASHRAE/IES Standard 90.1 for the product.

Ongoing Test Procedure Activities

Energy Efficiency &
Renewable Energy



Product	Driver	Scheduled Completion
1. Battery Chargers (standby)	EISA	December 2008
2. External Power Supplies (standby)	EISA	December 2008
3. Fluorescent Lamp Ballasts (standby)	EISA	March 2009
4. Clothes Dryers (standby)	EISA	March 2009
5. Room Air-Conditioners (standby)	EISA	March 2009
6. Microwave Ovens (standby)	EISA	April 2009
7. Metal Halide Lamp Fixtures (Ballasts, active and standby)	EISA	June 2009
8. Residential Clothes Washers (standby)	EISA	June 2009
9. Incandescent Reflector Lamps	Std. Rulemaking	June 2009
10. General Service Incandescent Lamps	Std. Rulemaking	June 2009
11. General Service Fluorescent Lamps	Std. Rulemaking	June 2009
12. Small Electric Motors	EPCA	June 2009

Ongoing Test Procedure Activities (cont.)

Energy Efficiency &
Renewable Energy



Product	Driver	Scheduled Completion
13. Furnaces and Boilers (standby)	EISA	September 2009
14. Walk-In Coolers and Walk-In Freezers	EISA	December 2009
15. Residential Refrigerators	Std. Rulemaking	December 2010
16. Fluorescent Lamp Ballasts (active mode)	Std. Rulemaking	June 2011
17. Battery Chargers (active mode)	Std. Rulemaking	June 2011
18. Televisions	Petition for Rulemaking	TBD