Building Technologies Program
Energy Efficiency Applications in the Home

SOUTH ASIA WOMEN IN ENERGY (SAWIE)
EXECUTIVE EXCHANGE
EFFICIENT ENERGY MANAGEMENT AND RENEWABLE ENERGY

Michael J. McCabe
Washington, DC
May 15, 2009
Importance of Buildings Sector

39% of U.S. Carbon Emissions

Industry & Transportation 992 MMTC (61%)
Buildings 630 MMTC (39%)

72% of U.S. Electricity

40% of U.S. Primary Energy Consumption

Buildings 40%
Transportation 28%
Industry 32%
Commercial 18%
Residential 22%

100% of U.S. Energy Consumption

55% of U.S. Natural Gas

Total U.S. Energy Consumption

Energy Efficiency & Renewable Energy
Buildings Technologies researches and deploys new technologies to make homes more affordable, energy efficient, and better performing.


"Energy Research at DOE: Was it Worth It", NRC 2001, Tables 3.1
Research and Development

- Residential Integration
- Emerging Technology
  - Solid State Lighting
  - Space Conditioning and Refrigeration
  - Thermal Envelope
  - Windows
  - Analysis Tools and Design Strategies

Thermal Envelope
- High R Walls and Roofs (60-70%)
- Smart Insulation and Vapor Barriers (70-80%)

Windows
- R-10 Dynamic Super Window (70-80%)

Space Conditioning and Refrigeration
- Integrated, low capacity heat pump. (60-70%)

Domestic Hot Water
- Engineered Hot Water Distribution (40-50%)
- Integration, low capacity heat pump (60-70%)

Lighting
- Solid State Lighting

Appliances and Other Plug Loads
- Whole House Energy Control Standard
- 10-30% Misc. Electric Savings (40-50%)
Residential Integration: The Building America Program is marching towards Zero Energy Homes (ZEH).

Zero Energy Homes

- **2002 Energy Savings**
  - Energy Star and Building America saves 30-35% on Heating and Cooling

- **2020 Energy Production**
  - ZEH-100 supplies the remaining 30-40% of energy needs from solar electricity and thermal

- **2020 Energy Savings**
  - Building America
    - 60-70% Energy Savings

- **2000**
  - Energy Demand

- **ZEH-50**
  - Purchased Energy

- **ZEH-75**
  - Solar Supply

- **ZEH-100**
  - Zero Net Energy

**ZEH-100 Saves 100% of Traditional Household Energy Use**

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.
Emerging Technology Research Activities

- **Solid State Lighting** - Double the efficiency of lighting technology (relative to fluorescent) by advancing light emitting diodes (LEDs);

- **Advanced envelopes**: Double wall system efficiency by 2010;

- **Advanced windows**: Reduce window energy load by 40-60% by 2020;

- **HVAC and water heating**: Reduce energy use by 50%; and

- **Solar Heating and Cooling**: Cost-competitive solar systems for ZEH.
Solid State Lighting (SSL): research goal of over 200 lumens per Watt for 2020.
Advanced envelopes: research goal to double wall system efficiency by 2010.

- Developing the next generation of Attic/Roof Systems by 2015.
- Producing an advanced wall system that doubles efficiency of 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.
Advanced Windows: research goal to reduce window energy load by 40-60% by 2020.

- Developing fundamental new technology in the laboratory and with private industry.
- Demonstrating highly insulating windows with Building America.
- Researching Dynamic Fully-sputtered windows and manufacturing processes.
- Exploring Daylighting & Advanced Façades.
- Advanced Design & Rating Tools
HVAC and water heating: Research goal to reduce energy use by 50%.

- Developing the **Integrated Heat Pump** for ZEH and involving a major manufacturer in process.
- Furthering the **Heat Pump Water Heater** with a major manufacture committed.
- **Participating in IEA annexes** related to ground source heat pumps, HVAC for ZEH, and compact heat exchangers for heat pumps.
- Working with ASHRAE to develop **test procedures and standards** to provide market signals for industry development and deployment of higher performance products.
Solar Heating and Cooling: research goal to develop cost-competitive solar systems for ZEB.

- 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; and
- Supporting the PV/thermal system development in BA on Solar Electric / Solar Thermal Pathways to ZEH.
Market Introduction: six deployment initiatives built upon base activities.

- **Builders Challenge** will construct over 1.3 million cost-effective high performance homes by 2030.
- **ASHRAE** will develop model codes that are 30% more efficient by 2010.
- **Technology Transfer and Application Centers** create a permanent sustainable presence to transfer regionally-focused energy efficient building technologies, processes and tools.
- **Energy Smart Schools** will build 700 schools at 30-50% better than code by 2012.
- **Commercial Lighting** will improve over 5.5 billion square feet of office space by 30%.
- **Energy Smart Hospitals** will upgrade 200 existing hospitals to 20% better than code and improve 20% of new large hospitals by 30% by 2012.
Market Introduction: Energy Star enables consumers to choose energy-efficient products.

- Promotes energy efficiency through more than 20,000 retail partners, 1,200 product manufacturers, 400 utility partners and others.
  
  - ENERGY STAR labeled product (DOE managed)
    - Existing: Clothes Washers, Dishwashers, Refrigerators, Room A/Cs, CFLs, Windows
    - Emerging: Solid State Lighting, Advanced Technology Water Heaters and Packaged Terminal Air-Conditioners
    - Evaluation of future technologies, e.g. PV, Fuel Cells and Dynamic Windows
  
  - Home Performance with ENERGY STAR
    - A DOE, EPA and HUD program to target energy efficiency in existing homes
  
  - Retail Partnerships
    - Development of efficiency-based whole home services with major retailers
    - Improve the merchandising of ENERGY STAR
    - Development of National Campaigns, e.g. Change-a-Light
**Market Introduction:** Energy Star promotes compact fluorescent lamps

**Energy Star CFL Market Penetration**

**How CFLs Have Changed**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>1992</th>
<th>2002</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price Range ($)</td>
<td>15-25</td>
<td>3-10</td>
<td>0.98-15</td>
</tr>
<tr>
<td>Incandescent sized CFLs</td>
<td>None</td>
<td>Some</td>
<td>Many</td>
</tr>
<tr>
<td># of CFL Manufacturers</td>
<td>Less than 10</td>
<td>Hundreds</td>
<td>Hundreds</td>
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DOE is expanding market penetration by addressing new lighting applications
Market Introduction: Energy Star windows promotes energy efficient windows.

Energy Star windows market share is over 60%
Market Introduction: Building energy codes broaden use of feasible and cost effective technologies, and provides R&D off-ramp.

- Legislatively mandated to support upgrading of building industry Model Energy Codes:
  - Support incrementally upgrading building industry Model Energy Codes
  - Determine whether upgraded model codes would improve energy efficiency in buildings and publish in Federal Register
  - Provide financial and technical assistance to States
  - Develop Federal Building Energy Code (move to FEMP July 2006)
Market Introduction: Builders Challenge provides credit for doing better than code and Energy Star.
Appliance Standards: mandates for energy efficient consumer products and certain commercial and industrial equipment

The Energy Conservation Standards Program (Appliance Standards) was established by the Energy Policy Act of 1975.

<table>
<thead>
<tr>
<th>Appliance Standards Program</th>
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<tbody>
<tr>
<td>➢ Consumer products</td>
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<tr>
<td>➢ Test procedures (DOE)</td>
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<tr>
<td>➢ Energy conservation standards (DOE)</td>
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<tr>
<td>➢ Energy labeling (FTC)</td>
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<tr>
<td>➢ Commercial and Industrial Products</td>
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DOE has established test procedures and standards for consumer products and certain commercial and industrial equipment.

<table>
<thead>
<tr>
<th>Appliance Standards Developed and Issued by DOE (1987 through 2007)</th>
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</thead>
<tbody>
<tr>
<td>➢ Residential Refrigerators (twice)</td>
</tr>
<tr>
<td>➢ Room Air Conditioners (residential)</td>
</tr>
<tr>
<td>➢ Residential Central AC &amp; HP</td>
</tr>
<tr>
<td>➢ Residential Water Heaters</td>
</tr>
<tr>
<td>➢ Residential Furnaces and Boilers</td>
</tr>
<tr>
<td>➢ Small Furnaces, &lt;45 kBtu/hr (residential), (twice)</td>
</tr>
<tr>
<td>➢ Mobile Home Furnaces</td>
</tr>
<tr>
<td>➢ Residential Dishwashers</td>
</tr>
<tr>
<td>➢ Residential Clothes Washers (twice)</td>
</tr>
<tr>
<td>➢ Residential Clothes Dryers</td>
</tr>
<tr>
<td>➢ Electric Ranges and Ovens (residential)</td>
</tr>
<tr>
<td>➢ Fluorescent Lamp Ballasts (commercial)</td>
</tr>
<tr>
<td>➢ Commercial Warm Air Furnaces*</td>
</tr>
<tr>
<td>➢ Commercial Water-Cooled AC/Water-Source HP*</td>
</tr>
<tr>
<td>➢ Commercial Water Heaters*</td>
</tr>
<tr>
<td>➢ Distribution Transformers, Medium Voltage Dry and Liquid-Immersed (commercial)</td>
</tr>
</tbody>
</table>

Congress put into place a schedule for Appliance Standards Rulemakings in 1987 (12 standards in 19 years)

* DOE Adopted ASHRAE 90.1 as revised in Oct. 1999.
**Appliance Standards to be developed by DOE**

- Residential Water Heaters
- Direct Heating Equipment (residential)
- Pool Heaters (residential)
- Small Electric Motors (<1 HP) (commercial)
- Incandescent Reflector Lamps
- Fluorescent Lamps
- Fluorescent Lamp Ballasts (commercial)
- Gas and Electric Ranges and Ovens and Microwave Ovens (residential)
- Residential Clothes Dryers
- Room Air Conditioners (residential)
- Packaged Terminal Air Conditioners and Heat Pumps
- Residential Central Air Conditioners and Heat Pumps
- Commercial Clothes Washers**
- Beverage Vending Machines (commercial)**
- Commercial Refrigeration Products**
- Refrigerators (residential) †
- Battery Chargers and External Power Supplies †
- Clothes Washers (Residential) †
- Furnace Fans
- Incandescent General Service Lamps
- Metal Halide Lamp Fixtures
- Dishwashers
- Refrigerators (Residential)
- Clothes Washers (Residential)
- Walk-In Freezers and Coolers (commercial)

**“The importance of standards pulling technological innovation in buildings...cannot be exaggerated. Often DOE research has been used to provide a proper basis for standards” (NRC, 2001)**


List does not include products with standards prescribed by EPACT 2005 or EISA 2007, if DOE does not have to develop subsequent standards. A determination for HID lamps is scheduled for June 2010. A determination for non-class A external power supplies is scheduled for December 2009.
Building Technologies 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

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