

Building Technologies
Funding Profile by Subprogram

	FY 2008 Current Appropriation ^a	FY 2009 Original Appropriation	FY 2010 Request
Building Technologies			
Residential Buildings Integration	23,725	21,900	40,000
Commercial Buildings Integration	11,891	33,000	40,000
Emerging Technologies	36,546	43,840	92,698
Technology Validation and Market Introduction	13,239	21,260	30,000
Equipment Standards and Analysis	21,981	20,000	35,000
Total, Building Technologies	107,382	140,000	237,698

Public Law Authorizations:

P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-385, "Energy Conservation and Production Act" (ECPA) (1976)
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 95-618, "Energy Tax Act" (1978)
P.L. 95-619, "National Energy Supply Policy Act" (NECPA) (1978)
P.L. 95-620, "Power Plant and Industrial Fuel Use Act" (1978)
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Supply Act" (1987)
P.L. 100-357, "National Appliance Energy Supply Amendments" (1988)
P.L. 100-615, "Federal Energy Management Improvement Act" (1988)
P.L. 102-486, "Energy Policy Act" (1992)
P.L. 109-58, "Energy Policy Act of 2005" (2005)
P.L. 110-140, "Energy Independence and Security Act of 2007" (2007)

Mission

The mission of the Building Technologies Program (BT) is to provide clean, secure energy by changing the landscape of energy demand and driving energy efficiency to decrease energy use in homes and buildings, which will also lower greenhouse gas (GHG) emissions, foster economic prosperity and increase National energy security. BT brings together science, discovery and innovation to develop the technologies, techniques, and tools for making residential and commercial buildings more energy efficient, productive, and affordable.

Benefits

Buildings account for more than 70 percent of the electric energy consumed in the U.S.^b BT is aligned with DOE's goal to provide clean, secure energy by developing reliable, affordable, and environmentally sound energy efficiency and renewable energy technologies that significantly reduce the energy consumption of residential and commercial buildings. BT strives to make net zero energy buildings (ZEB) a reality by taking a whole buildings approach through the systems integration of state-

^a SBIR/STTR funding was transferred to the Science Appropriation in FY 2008, which includes a reduction of \$1,443,000 that was transferred to the SBIR program, and \$174,000 that was transferred to the STTR program

^b U.S. DOE Energy Efficiency and Renewable Energy, *2008 Buildings Energy Databook*, September 2008.

of-the art energy efficient construction and appliances with commercially available renewable energy systems.

The program pursues its mission through complementary activities designed to improve the energy efficiency of buildings. These activities include Research and Development (R&D), Equipment Standards and Analysis, and Technology Validation and Market Introduction (TVMI). R&D activities research the most advanced energy efficiency technologies. Equipment Standards and Analysis activities eliminate the most inefficient existing technologies in the market by establishing new – and improving – existing energy efficiency standards. TVMI activities catalyze the introduction of new advanced technologies and the widespread use of highly efficient technologies already in the market.

In addition, BT's progress depends upon the coordination of other EERE program efforts. To achieve ZEB, the Solar Buildings Initiative will have to accelerate the R&D and large scale commercialization of distributed photovoltaic (PV) technology for buildings. The Weatherization and Intergovernmental Program (WIP) will provide consumers and decision makers with information on cost, performance, and financing of energy efficiency projects. The Federal Energy Management Program (FEMP) will promote energy efficiency at Federal facilities.

Climate Change

The U.S. building sector is responsible for 38 percent of total U.S. carbon dioxide emission.^a BT contributes to the reduction of GHG by providing technologies that, when commercialized, will make the Nation's buildings more energy efficient. The efficiency gains from these advanced technologies will be integrated with renewable energy technologies to not only reduce buildings' overall energy demand but also reduce their consumption of electricity generated from fossil fuels. The use of energy efficient components and whole-building (systems integrated) design strategies will eventually permit carbon neutral buildings to become an everyday reality while keeping net costs of new components at the same level as existing technology. Achievement of program goals could result in the cumulative reduction of CO₂ emissions by 5 gigatons of CO₂ by 2030 and more than 18 gigatons of CO₂ by 2050.

Energy Security

By utilizing advanced efficiency technologies, oil use can be reduced, making the Nation less vulnerable to oil supply disruptions or price spikes. R&D activities in advanced envelope and windows technologies subprograms reduce heating loads in buildings, and space heating accounts for the primary end use of energy in homes. In certain regions of the U.S., homes are heated exclusively by petroleum derivatives.^b By reducing their heating load, reducing demand through efficiency, and replacing petroleum with renewables as the source of space heat, BT reduces domestic dependence on petroleum. Achievement of the program's goals is expected to displace 0.4 million barrels of imported oil in 2030 and 1.5 million barrels in 2050, based on energy-economy models. This displacement will yield energy security benefits by diversifying the energy base, making the economy and the American consumer more resilient to price and supply shocks by decentralizing a part of energy supply as consumers begin generating a greater percentage of electricity and heat on site via renewables. This will in turn, lower GHG, provide clean, secure energy, and stimulate economic prosperity.

^a U.S. DOE Energy Efficiency and Renewable Energy, *2008 Buildings Energy Databook*, September 2008.

^b Ibid.

Economic Impacts

Reduced energy use in buildings can be expected to lead to reduced energy bills for American families and businesses. New technologies developed with the help of BT and manufactured by domestic industry will create jobs, spur economic growth, and restore America's role as a global innovator and exporter of high-tech products. Efficient buildings have the added benefit of mitigating the need for the electric power industry to construct expensive new power plants. 'Nega-watts' will save power companies money, and these savings will flow through directly to electricity consumers. Savings experienced by power companies might also be spent modernizing the electric grid and on other needed energy infrastructure investments.

Achieving BT's goals of reducing the cost of advanced building technologies and homeowner energy bills will permit consumers to spend these saved dollars elsewhere, stimulating other parts of the economy and could result in cumulative net consumer savings of nearly \$450 billion by 2030 and nearly \$3.4 trillion by 2050. In addition, cumulative savings to the electric power industry are expected to be over \$300 billion by 2030 and over \$1 trillion by 2050.

The proposed FY 2010 Budget investments complement funds provided by the Recovery Act which support the development of advanced building technologies and deployment mechanisms to accelerate progress on achieving zero energy homes (ZEH) and ZEB construction goals, as well as initiate an aggressive effort to address the substantial energy savings in new and existing buildings. To enable decision makers and the public to follow performance and plans, the program will post its progress in these planned activities at: <http://www.energy.gov/recovery/index.htm>.

The primary benefits table below shows the primary estimated strategic security, economic and environmental benefits and supporting metrics from 2015 through 2050 that would result from realization of the program's goals. These benefits are achieved by targeted Federal investments in technology research and development in partnership with equipment manufacturers and equipment suppliers, energy companies, other Federal agencies, State government agencies, universities, National Laboratories, and other stakeholders. These partnerships facilitate the technical coordination of activities and attract cost sharing to provide leveraged benefits.

The benefits table also reflects the increasing penetration of the program's technologies over time, as BT's goals are met. Not included are any policies, regulatory mechanisms, or other incentives not already in existence that might be expected to support or accelerate the achievement of the program goals. The expected benefits reflect solely the achievement of the BT's goals. A more detailed summary of the quantified primary benefits appears below.

**Primary Metrics for FY 2010 Budget Request
(Incorporates Approximate Impacts of EISA 2007)**

	Metric ¹	Model	Year			
			2015	2020	2030	2050
Energy Security	Oil Imports Reduction, cumulative ² (Bil bbl)	NEMS	ns	0.1	0.4	N/A
		MARKAL	0.1	0.2	0.4	1.5
	Natural Gas Imports Reduction, cumulative (Tcf)	NEMS	0.8	2.4	7.3	N/A
		MARKAL	2.7	8.0	22.5	65.6
	Reduction in Share of Highway Fuel Demand Derived from Crude Oil ³ (%)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	ns
Environmental Impacts	CO ₂ Emissions Reduction, cumulative (Mil mtCO ₂)	NEMS	326	1258	5193	N/A
		MARKAL	292	999	4787	18919
	SO ₂ Allowance Price Reduction ⁴ (\$/ton)	NEMS	ns	ns	ns	N/A
		MARKAL	N/A	N/A	N/A	N/A
	NO _x Allowance Price Reduction (\$/ton)	NEMS	ns	1420	1827	N/A
		MARKAL	N/A	N/A	N/A	N/A
	Hg Allowance Price Reduction (thousand \$/lb)	NEMS	ns	ns	ns	N/A
		MARKAL	N/A	N/A	N/A	N/A
Economic Impacts	Consumer Savings, cumulative ⁵ (Bil \$)	NEMS	53	148	439	N/A
		MARKAL	140	404	1250	3417
	Electric Power Industry Savings, cumulative (Bil \$)	NEMS	42	118	338	N/A
		MARKAL	32	113	392	1050
	Household Energy Expenditures Reduction (\$/household/yr)	NEMS	70	120	240	N/A
		MARKAL	143	254	447	577
<p>1. "Reductions" and "savings" are calculated as the difference between results from the baseline case (i.e. no DOE technology) and the technology case (i.e. all DOE technology R&D programs are successful).</p> <p>2. All cumulative metrics are based on results beginning in 2010.</p> <p>3. Metric includes oil-derived fuel use by light-duty vehicles, commercial light trucks and freight trucks; the metric excludes buses. Reported oil use is adjusted to exclude ethanol, biodiesel and CTL.</p> <p>4. All monetary metrics are in 2006\$.</p> <p>5. Cumulative monetary metrics are in 2006\$ that are discounted to 2010 using a 3% discount rate.</p> <p>ns - Not significant NA - Not yet available N/A - Not applicable</p>						

Secondary Metrics for FY 2010 Budget Request

(Incorporates Approximate Impacts of EISA 2007)

	Metric ¹	Model	Year			
			2015	2020	2030	2050
Energy Security	Oil Imports Reduction, annual (Mbpd)	NEMS	ns	0.1	0.1	N/A
		MARKAL	ns	0.1	0.1	0.2
	Natural Gas Imports Reduction, annual (Tcf)	NEMS	0.2	0.4	0.6	N/A
		MARKAL	0.8	1.2	1.6	2.6
	MPG Improvement ² (%)	NEMS	ns	ns	ns	N/A
MARKAL		ns	ns	ns	ns	
Environmental Impacts	CO ₂ Intensity Reduction of US Economy (Kg CO ₂ /\$GDP)	NEMS	ns	0.02	0.02	N/A
		MARKAL	ns	0.01	0.03	0.02
	CO ₂ Intensity Reduction of US Power Sector ³ (Kg CO ₂ /kWh)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	ns
	CO ₂ Intensity Reduction of US Transportation Sector ⁴ (Kg CO ₂ /mile)	NEMS	ns	ns	ns	N/A
MARKAL		ns	ns	ns	ns	
Economic Impacts	Consumer Savings, annual ⁵ (Bil \$)	NEMS	17	32	69	N/A
		MARKAL	40	89	180	322
	Electric Power Industry Savings, annual (Bil \$)	NEMS	14	25	47	N/A
		MARKAL	10	29	59	100
	Energy Intensity of US Economy (energy/\$GDP)	NEMS	0.10	0.20	0.30	N/A
		MARKAL	0.11	0.20	0.35	0.30
Net Energy System Cost Reduction, cumulative (Bil \$)	NEMS	N/A	N/A	N/A	N/A	
	MARKAL	585	1419	3479	7514	
<p>1. "Reductions" and "savings" are calculated as the difference between results from the baseline case (i.e. no DOE technology) and the technology case (i.e. all DOE technology R&D programs are successful).</p> <p>2. Change in light duty vehicles miles traveled per gallon of oil, where oil is only that derived from petroleum.</p> <p>3. Emissions include all power sector emissions. Generation calculated as total net generation adjusted for estimated T&D losses.</p> <p>4. Emissions calculated using highway fuel use and related carbon emission factor. Miles calculated as highway miles traveled, excluding buses.</p> <p>5. All monetary metrics are in 2006\$.</p> <p>ns - Not significant NA - Not yet available N/A - Not applicable</p>						

The following external factors could affect Building Technologies' ability to achieve its strategic goal:

- **Fragmented construction market.** There are several factors that can hinder the private sector making R&D investments in energy efficient building technologies. These include a highly diversified industry comprised of thousands of builders and manufacturers, none of which has the capacity to sustain research and development activities over multi-year periods.

- Communication between professional groups. The compartmentalization of the building professions, in which architects and designers, developers, construction companies, engineering firms, and energy services providers do not typically apply integrated strategies for siting, construction, operations and maintenance.^a
- Upfront costs. The high initial cost of energy efficient building appliances can keep consumers from purchasing them even if they are cost effective in the long run.
- Housing market. Conditions in the housing market that would affect the number of new subdivisions being built would slow down research on ZEB. The last phase of research is having a builder construct a subdivision using technologies developed by BT in order to prove them in a real world setting. If fewer subdivisions are being constructed by more risk-adverse contractors, it could slow BT's research considerably.
- Unit price of renewable energy. ZEB goals are contingent upon the development of cost effective small scale renewable energy systems.

Contribution to the Secretary's Priorities

The BT Program contributes to the Secretary's priorities focusing on clean, secure energy by changing the landscape of energy demand and driving energy efficiency to decrease energy use in homes and buildings. By bringing together science, discovery, and innovation the gains achieved by BT, U.S. buildings will be significantly more efficient, productive, and affordable.

Priority 1: Science and Discovery – Invest in science to achieve transformational discoveries

The BT program connects basic and applied sciences by developing the next generation of highly efficient technologies and practices for both residential and commercial buildings through Emerging Technologies R&D activities. In addition, BT aims to create an effective mechanism to integrate National Laboratory, university, and industry activities through public/private alliances, cost share, and technical advisory efforts through BT R&D activities.

BT partners globally by providing technical R&D support to the International Energy Agency (IEA) and coordinating U.S. industry support, while also building research networks across departments, government, Nations and the globe, such as the ENERGY STAR[®] activity in partnership with the U.S. Environmental Protection Agency (EPA).

Priority 2: Clean, Secure Energy – Change the landscape of energy demand and supply

BT encourages technology and business model innovation by creating incentives for industry through the Builders' Challenge and motivating builders to build high performance homes. In addition, BT creates vehicles for novel government/university and industrial collaborations and intellectual property models for development, commercialization and deployment of efficient energy-using technologies and systems through zero energy buildings R&D. BT works to change behavior to "waste not, want not" via outreach efforts, marketing campaigns, green branding via the ENERGY STAR campaigns such as the Change a Light, Change the World or BT's work mobilizing a greening effort in the U.S. military through Operation Change Out.

Priority 3: Economic Prosperity – Create millions of green jobs and increase competitiveness

BT utilizes research on ventilation, controls, and lighting to reduce energy consumption in homes and commercial building to reduce energy demand. In addition, BT improves existing buildings through energy efficiency upgrades by investing in building component R&D to address the unrealized

^a Scott Hassell, Anny Wong, Ari Houser, Debra Knopman, Mark Bernstein, RAND Corporation: *Building Better Homes: Government Strategies for Promoting Innovation in Housing*, 2003.

efficiency gains in America's stock of existing homes and buildings. BT will contribute to the development of America's new green workforce by training builders, home auditors, architects, engineers and others around the country to help the American middle class retrofit their homes through the Home Performance with ENERGY STAR activities.

Priority 5: Lower GHG Emissions – Position U.S. to lead on climate change policy, technology and science

BT is working to produce development and deployment pathways that will provide technologies that will reduce energy consumption in the U.S., permitting America to set a high standard on global environmental issues and lead by example. In addition, BT supports developing world clean energy by reducing energy consumption in the U.S. through R&D and deployment of energy efficient technologies in buildings, providing a source of clean, secure energy.

Contribution to GPRA Unit Program Goal 1.4.20.00

BT contributes to the following GPRA goal:

GPRA Unit Program Goal 1.4.20.00: Building Technologies - The BT program goal is to develop 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.

Key technology pathways that contribute to achievement of the goal include:

- Residential Buildings Integration R&D Activities: Provide the energy technologies and solutions that will catalyze a 70 percent reduction in energy use of new prototype residential buildings that when combined with onsite energy technologies result in Zero Energy Homes by 2020, and when adapted to existing homes results in a significant reduction in their energy use. By 2010, develop, document and disseminate five cost effective technology packages that achieve an average of 40 percent reduction in whole house energy use.
- Commercial Buildings Integration R&D Activities: By 2010, collaborate with industry to develop, document and disseminate a complete set of 16 technology packages that provide builders energy efficient options to meet their complex performance demands. These packages will enable the achievement of a 30 percent (12 packages) or 50 percent (4 packages) reduction in purchased energy use in new, small to medium-sized commercial buildings relative to the American Society of Heating, Refrigerating, and Air-Conditioning Engineer (ASHRAE) 90.1-2004 standards.
- Emerging Technologies Activities: Develop the next generation of highly efficient technologies and practices for both residential and commercial buildings. The emerging technologies activities support BT goals through R&D of advanced lighting, building envelope, windows, space conditioning, water heating and appliance technologies and analysis tools. In the area of Solid State Lighting (SSL), the goal is to achieve lighting technologies with double the efficiency of today's most efficient lighting sources. The goal of ZEB will not be met without advanced components and subsystems developed in the Emerging Technologies activities.
- Technology Validation and Market Introduction: Accelerate the adoption of clean and efficient domestic energy technologies through activities such as Rebuild America, ENERGY STAR and Building Energy Codes. By 2010, achieve market penetration target for ENERGY STAR-labeled windows of 20 percent (40 percent, 2003 baseline), 13 percent for CFLs (2 percent, 2003 baseline) and 33 percent (30 percent, 2003 baseline) for ENERGY STAR appliances. Rebuild America activities will work to remove technical, financial and institutional barriers to the widespread awareness, availability, and application of highly efficient building techniques including building design, construction, retrofit and operations practices. Building Energy Code activities will support

the development and adaptation of improved building energy codes that are 30 percent more efficient than the 2004 codes, which increases the energy efficiency of new and renovated buildings.

- Equipment Standards and Analysis: Increase minimum efficiency levels of buildings and equipment through standards that are technologically feasible, economically justified, and save significant energy. By 2010, issue 14 to 17 formal proposals, in accordance with legal mandates, for enhanced product standards and test procedures. By 2011, complete one rulemaking for every product in the backlog. Performance indicators include product standards and test procedures proposed/issued that will result in more efficient buildings energy use.

Means and Strategies

The BT program will use various means and strategies, as described below, to achieve its GPRA Unit Program goal. “Means” include operational processes, resources, information, and the development of technologies, and “strategies” include program, policy, management and legislative initiatives and approaches. Collaborations are integral to the planned investments, means and strategies, and to addressing external factors.

The Building Technologies Program will implement the following means:

The Residential Buildings Integration activity focuses on improving the efficiency of the approximately 1.5 to 2.0 million new homes built each year and 100+ million existing homes. These improvements are accomplished via RD&D and technology transfer activities. Overall, the program seeks to make improvements through the application of a systems engineering approach to optimize the technologies in whole buildings and concurrently ensure the health and safety of the buildings in addition to integrating renewable technologies into buildings;

The Commercial Buildings Integration activity addresses energy savings opportunities in new and existing commercial buildings (\$307.1 billion spent annually for new building construction and over \$190.5 billion for renovation in 2006^a). This includes RD&D of whole building technologies, such as sensors and controls, design methods and operational practices. These efforts support the ZEB goal not only by reducing building energy needs, but also by developing design methods and operating strategies which seamlessly incorporate solar and other renewable technologies into commercial buildings;

The Emerging Technologies activity conducts R&D and technology transfer associated with energy-efficient products and technologies for both residential and commercial buildings. These efforts address high-impact opportunities within building components, such as lighting, building envelope technologies (including advanced windows), solar heating and cooling (SH&C), and analysis tools;

The Equipment Standards and Analysis activity leads to improved efficiency of appliances and equipment by conducting analyses and developing standards that are technologically feasible and economically justified by the Energy Policy and Conservation Act (EPCA), as amended. Analysis performed under this program will also support related program activities such as ENERGY STAR to ensure a consistent methodology is used in setting efficiency levels for related programs; and

The TVMI activity accelerates the adoption of clean, efficient, and domestic energy technologies. The three major initiatives within are ENERGY STAR, Rebuild America, and Building Energy Codes. ENERGY STAR is a joint DOE/EPA activity designed to identify and promote energy efficient products. Rebuild America is aligned with the Commercial Building Integration R&D activity to accelerate the adoption of advances in integrated commercial building design, software tools, practices and advanced controls, equipment and lighting. The activity will target decision-makers with national

^a 2008 Buildings Energy Data Book.

and regional market scope such as multi-brand corporations in the retail, lodging, restaurant sectors, commercial property developers, owners, and operators as well as in the school and hospital sector. Building Energy Codes submits code proposals and supports the upgrades of the model building energy codes. The activity also provides technical and financial assistance to States to update, implement, and enforce their energy codes to meet or exceed the model codes, in support of Section 304 of Energy Conservation and Production Act (ECPA). It also promulgates standards for manufactured housing as required by Section 413 of the Energy Independence and Security Act of 2007 (EISA 2007).

BT's challenge is to address the opportunities with apt strategies and design programs that give appropriate consideration to the marketplace and barriers to energy efficiency. To accomplish this, the BT will implement the following strategies:

- Focus the R&D portfolios to ensure that the most promising and revolutionary technologies and techniques are being explored, align the Residential and Commercial Integration activities to a vision of ZEBs, appropriately exit those areas of technology research that are sufficiently mature or proven to the marketplace, and close efforts where investigations prove to be technically or economically infeasible (“off ramps”);
- Use a “whole buildings” approach to energy efficiency that takes into account the complex and dynamic interactions between a building and its environment, among a building’s energy systems, and between a building and its occupants. BT analysis suggests that this approach has achieved energy savings of 30 percent beyond those obtainable by focusing solely on individual building components, such as energy-efficient windows, lighting, and water heaters;
- Invest in collaborative research with the Solar Energy Program to reduce barriers to the installation and operation of photovoltaic technology on zero energy homes and buildings;
- Develop technologies and strategies to enable effective integration of energy efficiency and renewable energy technologies and practices;
- Increase minimum efficiency levels of buildings and equipment through codes, standards, and guidelines that are technologically feasible and economically justified. BT develops standards through a public process and submits code proposals to International Energy Conservation Code (IECC) and ASHRAE;
- Coordinate with other programs in EERE in support of a management strategy that achieves ZEB. The Solar Energy, Biomass and Biorefinery Systems R&D, Wind Energy, Water Power, Fuel Cell Technologies, FEMP, and WIP programs may have important technologies to contribute. BT also invests in technical program review, market analysis, and performance assessment in order to direct effective strategic planning; and
- Provide technical information to customers through deployment of cost-effective energy technologies, forming partnerships with private and public sector organizations.

These strategies can result in significant cost savings and a dramatic reduction in the consumption of energy, an increase in the substitution of clean and renewable fuels, and can cost effectively reduce demand for energy, thus lowering carbon emissions and decreasing energy expenditures.

In carrying out the program’s mission, BT performs the following collaborative activities:

- Partnerships and cost share arrangements with industry and other Federal agencies which act as critical management tools that can build a critical mass to address these barriers. ENERGY STAR is a joint DOE/EPA program (EPA Act 2005) with more than 4,000 retailers to label ENERGY STAR qualified appliances and energy efficient products. Rebuild America will partner with decision-makers with national and regional market scope such as multi-brand corporations in the retail, lodging, restaurant sectors, the schools and hospital sector, as well as commercial property

developers, owners and operators. DOE coordinates its R&D, regulatory activities, and technology demonstrations with EPA's marketplace activities (<http://www.energystar.gov/>). Through these activities with EPA, BT contributes to the Administration's objective of reducing GHG emissions;

- In support of EISA 2007, BT is implementing a Commercial Buildings Initiative (CBI) which collaborates with National Laboratories, the private sector, other Federal agencies, and non-governmental organizations to advance high-performance commercial green buildings and produce market-ready commercial ZEB 2025. ZEBs are grid-integrated buildings capable of generating as much energy as they consume by using cutting-edge technologies and on-site generation systems, such as solar power and geothermal energy. In support of CBI, BT has launched programs and initiatives that will produce quick-hitting, practical results, including:
 - Commercial Building Energy Alliances (including retailers, commercial real estate owners, and institutions);
 - National Laboratory Collaborative on Building Technologies; and
 - National Account teams.
- The Building Energy Code activity works with National, regional, and State building code officials and stakeholders to help building owners, builders and the design community understand the science, benefits, and techniques for going significantly beyond code with added value strategies. BT also trains over 10,000 code officials, designers, and builders to implement these codes and updates and improves the core materials and code compliance software to reflect recent changes in the model energy codes and emerging energy efficiency technologies;
- Partners with EERE's Solar Energy Technologies Program to work toward the goal of ZEHs;
- Coordinates with the Office of Science in basic research on SSL technology;
- BT's management strategy involves four key elements: a customer-focused, team-based organization for greater accountability and improved results; systematic multi-year planning including collaboratively developed technology roadmaps to provide for a more integrated, customer driven R&D portfolio; utilization of stage-gate management processes to ensure progress and market relevance; greater competition in project solicitations to increase innovation and broaden research participation; and increased peer review to assure scientifically sound approaches; and
- BT interacts regularly with industry to ensure relevance of research, including R&D workshops (e.g., biennial reviews in solid state lighting and windows research) and peer reviews.

Validation and Verification

To validate and verify program performance, BT will conduct various internal and external reviews and audits. These programmatic activities are subject to continuing review by Congress, the General Accountability Office, the Department's Inspector General, the U.S. EPA, and State environmental agencies. The table below summarizes validation and verification activities.

Data Sources: Energy Information Agency (EIA) Annual Energy Review (AER); Commercial Building Energy Consumption Survey (CBECS); Residential Energy Consumption Survey (RECS); and Annual Energy Outlook (AEO) ISTAR (ENERGY STAR database). U.S. Department of Commerce (DOC) Current Industrial Reports (CIR). Various trade publications. Information collected directly from BT performers or partners.

Baselines: The following are key baselines used in the BT program:

- New Residential Buildings: Energy use varies by climate region, based on the

Building America Benchmark. The program will focus on creating design technology packages to reduce energy consumption from the Building America Benchmark. In 2003, 0 technology package research reports at 30/50/70 percent energy savings.

- New Commercial Buildings Energy Use Intensity: Varies by climate region and building type (ASHRAE 90.1-2004). The program will focus on creating design technology packages to reduce energy consumption by 30 and 50 percent for small commercial buildings (baseline 1 technology package for 30 percent and 0 technology option sets for 50 percent in 2005).
- Solid State Lighting (2002): 25 lumens/Watt efficacy (solid state lighting white light).
- Windows (2003): 0.33 to 0.75 U-values (varies by region).
- Residential Heating and Cooling (2003): Average total heating and cooling system energy use, defined by reported consumption in EIA for residential buildings and all existing buildings, and the Building America benchmark for new residential buildings, by climate region.
- New Residential Building Codes: 2003 International Energy Conservation Code (IECC), International Code Council.
- New Commercial Building Codes: ASHRAE 90.1-2004.
- ENERGY STAR: Federal appliance minimum standards and applicable national building codes (windows).

Frequency: Complete revalidation of assumptions and results can only take place every three to four years, due to the reporting cycle of two crucial publications: CBECS and RECS. However, updates of most of the baseline forecast and BT outputs will be undertaken annually.

Evaluation: In carrying out its mission, BT uses several forms of evaluation to assess progress and to promote program improvement:

- Technology validation and operational field measurement, as appropriate;
- Peer review by independent outside experts of both the program and subprogram portfolios;
- Annual internal technical and management reviews of program and subprogram portfolios;
- Specialized program evaluation studies to examine process, impacts, or market baseline and effects, as appropriate;
- Quarterly and annual assessment of program and management results based performance through Joule;
- Peer reviews as needed when evaluating go/no go decision points in each research area;
- Annual review of methods, and recomputation of potential benefits for the GPRA; and
- Continue to conduct and build upon the transparent oversight and performance management initiated by Congress and the Administration

- Data Storage: EIA and DOC data sources are publicly available. Trade publications are available on a subscription basis. BT output information is contained in various reports and memoranda.
- Verification: Calculations are based on assumptions of future market status, equipment or technology performance, and market penetration rates. These assumptions can be verified against actual performance through technical reports, market survey and product shipments.

Annual Performance Results and Targets

FY 2005 Results	FY 2006 Results	FY 2007 Results	FY 2008 Targets	FY 2009 Targets	FY 2010 Targets
<p>GPRA Unit Program Goal 1.4.20.00 (Building Technologies)</p> <p>Residential Buildings Integration</p>					
<p>Complete the research for production-ready new residential buildings that are 30 percent more efficient than the whole-house Building America benchmark in 2 climate zones and document the results in Technology Package Research Reports. [MET]</p>	<p>Complete system research with lead builders in two climate zones demonstrating production-ready new residential buildings that are 30 percent more efficient than the whole-house Building America benchmark and document the results in Technology Package Research Reports. [MET]</p>	<p>Document in Technology Package Research Reports research results for production ready new residential buildings that are 30 percent more efficient in 1 climate zone and 40 percent more efficient in 1 climate zone than the whole-house Building America benchmark. [MET]</p>	<p>Complete one design technology package for new residential buildings (that is 40 percent more energy efficient relative to the 2004 Building America benchmark) at net zero financed cost to the homeowner for one climate zone. [MET]</p>	<p>Complete one design technology packages for new residential buildings (that are 40 percent more energy efficient relative to the 2004 Building America benchmark) at net zero financed cost to the homeowner for one climate zones.</p>	<p>Complete two design technology packages for new residential buildings (that are 40 percent more energy efficient relative to the 2004 Building America benchmark) at net zero financed cost to the homeowner for two climate zones.</p>
<p>Analyze and develop code change proposals that are expected to result in a cost-effective improvement in energy efficiency in residential buildings of approximately 1-2 percent. [MET]</p>					
<p>Commercial Buildings Integration</p>					
<p>Complete assessments of controls technology, optimization methods and market opportunities, with substantial input from designers and building owners, to establish a framework for development of programmatic pathways to achieve 50 percent or better energy performance in significant numbers of buildings enabling development of design and/or technology packages for new commercial buildings. [MET]</p>	<p>Complete the development of one design technology package to achieve 30 percent or better energy savings, focusing on a single, high priority building type, such as small commercial retail or office buildings, based on the technical and market assessments completed in 2005. [MET]</p>	<p>Complete the development of two new design technology packages for a second small to medium sized commercial building type to achieve 30 percent energy savings over ASHRAE 90.1-2004. . [MET]</p>	<p>Complete four additional design technology packages for new commercial buildings (that achieve 30 percent increase in energy efficiency relative to the ASHRAE 90.1-2004 benchmark) with five year or less payback. These design technology packages will be for small to medium-sized commercial buildings. [MET]</p>	<p>Complete four additional design technology packages for new commercial buildings (that achieve 30 percent increase in energy efficiency relative to the ASHRAE 90.1-2004 benchmark) with five year or less payback.</p>	<p>Complete four design technology packages for new commercial buildings (that achieve at least 50 percent increase in energy efficiency relative to the ASHRAE 90.1-2004 benchmark) with five year or less payback.</p>
<p>Analyze and develop code change proposals that are expected to result in a cost-effective improvement in energy efficiency in commercial buildings of approximately 1-2 percent. [MET]</p>					

FY 2005 Results	FY 2006 Results	FY 2007 Results	FY 2008 Targets	FY 2009 Targets	FY 2010 Targets
Emerging Technologies					
<p>Select five new competitively based research awards for cost-shared research on technology (such as optical materials and device structures) to achieve ≥ 65 lm/W white light from solid state devices with industry, National Laboratories, and universities. [MET]</p>	<p>Conduct cost-shared, competitively selected research on technology to achieve = 65 lm/W (in a laboratory device) of white light from solid state devices with industry, National Laboratories, and universities. [MET]</p>	<p>Achieve at least 86 lumens per Watt (in a laboratory device) of white light from solid state devices based on cost-shared research which is competitively selected. [MET]</p>	<p>Achieve efficiency of “white light” solid state lighting in a lab device, of at least 101 lumens per Watt. [MET]</p>	<p>Achieve efficiency of “white light” solid state lighting in a lab device, of at least 110 lumens per Watt.</p>	<p>Achieve efficiency of “white light” solid state lighting in a lab device, of at least 113 lumens per Watt.</p>
<p>Complete a prototype dynamic window that will have a Solar Heat Gain Coefficient (SHGC) in the range of 0.05 to 0.60 , while meeting American Society for Testing and Materials (ASTM) durability standards for cycling in a high temperature, high ultraviolet light environment. [MET]</p>					
<p>Complete a thermodynamic study of emerging refrigerants. Based on study results, make go/no-go decision on initiation of first stage development of a laboratory prototype, high efficiency residential 1-ton air-conditioning and heat pump unit that uses a novel approach to the vapor compression refrigeration cycle and has the potential for a Seasonal Energy Efficiency Ratio (SEER) of over 20. [MET]</p>					

FY 2005 Results	FY 2006 Results	FY 2007 Results	FY 2008 Targets	FY 2009 Targets	FY 2010 Targets
Equipment Standards and Analysis					
<p>Complete analytical and regulatory steps necessary for DOE issuance of 3-4 rules, consistent with the law, to amend appliance standards and test procedures that are economically justified and will result in significant energy savings. [MET]</p>	<p>Complete analytical and regulatory steps necessary for DOE issuance of 4 rules, consistent with the law, to amend appliance standards and test procedures that are economically justified and will result in significant energy savings. Develop for DOE issuance notices of proposed rulemaking (NOPRs) regarding energy conservation standards for electric distribution transformers, commercial unitary air conditioners and heat pumps, and residential furnaces and boilers. [MET]</p>	<p>Final rules will be issued for 3-5 product categories, consistent with the law, to amend appliance standards and test procedures that are economically justified and will result in significant energy savings. This includes final rules for distribution transformers and residential furnaces and boilers. [MET]</p>	<p>Complete 11-13 proposals to update appliance standards and test procedures publish in the Federal Register. Final rules will be issued for 1-2 of these product categories, consistent with the law, to amend appliance standards and test procedures that are economically justified and will result in significant energy savings</p> <p>For this measure “proposal” includes unique product inclusions in Advance Notice of Proposed Rulemakings ANOPRS, NOPRS, and Final Rules. Multiple proposals (covering a number of product categories) could be bundled in Federal Register Notices. [MET]</p>	<p>Complete 14-16 proposals to update appliance standards and test procedures publish in the Federal Register. Final rules will be issued for 4-6 of these product categories, consistent with the law, to amend appliance standards and test procedures that are economically justified and will result in significant energy savings.</p> <p>For this measure “proposal” includes unique product inclusions in ANOPRS, NOPRS, and Final Rules.</p> <p>Multiple proposals (covering a number of product categories) could be bundled in Federal Register Notices.</p>	<p>Complete 14-17 proposals to update appliance standards and test procedures publish in the Federal Register. Final rules will be issued for 10 of these product categories, consistent with the law, to amend appliance standards and test procedures that are economically justified and will result in significant energy savings.</p> <p>For this measure “proposal” includes unique product inclusions in ANOPRS, NOPRS, and Final Rules.</p> <p>Multiple proposals (covering a number of product categories) could be bundled in Federal Register Notices.</p>
Technology Validation and Market Introduction/Rebuild America					
<p>Help Rebuild America community partnerships to upgrade 60 million square feet of floor space in K-12 schools, colleges, public housing, and State/local governments, reducing the average energy used in these buildings by 18 percent. [MET]</p>					

FY 2005 Results	FY 2006 Results	FY 2007 Results	FY 2008 Targets	FY 2009 Targets	FY 2010 Targets
Technology Validation and Market Introduction/ENERGY STAR					
Recruit 500 additional retail stores, 5 additional utilities and 10 additional manufacturers. Complete draft Commercial Window specification. Begin update of Residential Window specification. Expand coordination with all gateway activities. [MET]	Increase market penetration of appliances (clothes washers, dishwashers, room air conditioners and refrigerators) to 38 to 42 percent (baseline 30 percent calendar year 2003), to 2 to 3 percent for Compact Fluorescent Lamps (baseline 2 percent calendar year 2003) and 40 to 45 percent for windows (baseline 40 percent calendar year 2004). Estimated energy savings will be 0.030 Quads and \$657 million in consumer utility bill savings. [MET]	Increase market penetration of appliances to 30 to 32 percent (baseline 30 percent calendar year 2003), to 2.5 to 4 percent for CFL's (baseline 2 percent calendar year 2003) and 45 to 50 percent for windows (baseline 40 percent for calendar year 2003). Estimated energy savings will be 0.032 Quads and \$671 million in consumer utility bill savings. [MET]	Achieve market penetration target for ENERGY STAR appliances of 33 percent (baseline 30 percent in 2003), 6 percent for CFLs (baseline 2 percent in 2003), and 48 percent for windows (baseline 40 percent in 2003). [MET]	Achieve market penetration target for ENERGY STAR appliances of 39 percent (baseline 30 percent in 2003), 12 percent for CFLs (baseline 2 percent in 2003), and 56 percent for windows (baseline 40 percent in 2003). Revised criteria for clothes washers, refrigerators and windows Release criteria for photovoltaic systems. Complete evaluation for developing ENERGY STAR criteria for small wind turbines.	Achieve market penetration target for ENERGY STAR appliances of 33 percent, 13 percent for CFLs, and 20 percent for windows. ^a
<u>Contribute proportionately to EERE's corporate goal of reducing corporate and program uncosteds to a range of 20-25 percent by reducing program annual uncosteds by 10 percent in 2005 relative to the program uncosted baseline in 2004 (\$33,417k) until the target range is met. [NOT MET]</u>	<u>Maintain total administrative overhead costs (defined as Program Direction and Program Support excluding earmarks) in relation to total program costs of less than 12 percent. [MET]</u>	<u>Maintain total administrative overhead costs (defined as Program Direction and Program Support excluding earmarks) in relation to total program costs of less than 12 percent. [MET]</u>	<u>Maintain administrative costs as a percent of total program costs less than 12 percent. [MET]</u>	<u>Maintain administrative costs as a percent of total program costs less than 12 percent.</u>	<u>Maintain administrative costs as a percent of total program costs less than 12 percent^b.</u>

^a Revised criteria will take effect for Clothes Washers, Dishwashers, and Windows in 2010, with revised criteria for CFLs in 2009. Because of the increased stringency in the revised criteria, market share levels, particularly in the case of windows, will decrease.

^b Administrative costs are comprised of Program Direction and elements of Program Support (Technology Advancement and Outreach; and Planning, Analysis and Evaluation), baseline and targets under development.

Residential Buildings Integration

Funding Schedule by Activity

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Residential Buildings Integration			
Research and Development Building America	23,725	21,900	40,000
Total, Residential Buildings Integration	23,725	21,900	40,000

Description

The long-term goal of the Residential Buildings Integration (RBI) subprogram is to develop cost effective, production ready systems in five major climate zones that result in houses that produce as much energy as they use on an annual basis. This Zero Energy Building (ZEB) initiative, referred to as Zero Energy Home (ZEH) initiative in residential sector research, is bringing a new concept to homebuilders across the U.S. A ZEH combines state-of-the-art, energy efficient construction and appliances with commercially available renewable energy systems such as solar water heating and solar electricity. This combination can result in a net zero energy consumption. A ZEH, like most houses, is connected to the utility grid, but can be designed and constructed to produce as much energy as it consumes on an annual basis. With its reduced energy needs and renewable energy systems a ZEH can, over the course of a year, give back as much energy to the utility as it takes. This ZEH also has a cost component goal of net zero financial cost to the home owner. The annual energy savings in utility bills will offset the annual financing cost of ZEH energy efficiency upgrades. In addition, as funding levels have increased, BT has begun to research multi-family housing, the Builders Challenge deployment activities, and research on energy efficient improvements in existing homes.

In order to achieve the technical capability for ZEH by 2020, BT will develop integrated cost-effective whole-building strategies to reduce the energy consumption of residential buildings by 70 percent (compared to the Building America Benchmark) and provide energy for the remaining 30 percent through the use of integrated onsite power systems.^a Building America is a private/public partnership that conducts research on energy solutions for new and existing homes on a cost shared basis with major stakeholders in the homebuilding industry. Building America combines the knowledge and resources of industry leaders with DOE's technical capabilities. Together, they act as a catalyst for energy efficient change in the home-building industry. Industry partners provide all costs for equipment, construction materials and construction labor used in research projects.

Building America also integrates 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 2014, 70 percent by 2018, and ZEB by 2020 (compared to

^a Whole house energy savings for all residential end uses are measured relative to the BA Research Benchmark Definition (Building America, Building America Research Benchmark Definition, Version 3.1, November 11, 2003, National Renewable Energy Laboratory). (www.buildingamerica.gov)

the Building America Benchmark^a). ZEBs integrate energy efficiency gains with onsite renewable power solutions at net zero financial cost to the home owner to achieve the final goal of an annual net zero energy home.

To ensure meeting the performance goals, Building America specified the following interim performance targets for completion of technology package research reports for each climate region, shown below. The annual performance goals will be evaluated and adjusted due to market conditions and the degree of technical complexity involved in developing solutions for each climate.

Residential Integration Performance Targets by Climate Zone

Target (Energy Savings)	Marine	Hot-humid	Hot/Mixed Dry	Mixed Humid	Cold
30%	2006	2007	2005	2006	2005
40%	2008	2010	2007	2009	2010
50%	2012	2013	2011	2013	2014
70%	2017	2016	2015	2017	2018
ZEH ^b	2020	2020	2020	2020	2020

The Residential Buildings Integration subprogram is an integral part of the BT Program which evaluates research in the context of the market.

Benefits

Residential Buildings Integration R&D activities will provide the energy technologies and solutions that will catalyze a 70 percent reduction in energy use of new prototype residential buildings that, when combined with onsite energy technologies result in ZEH by 2020, and when adapted to existing homes results in a significant reduction in their energy use. By 2010, RBI will develop, document and disseminate five cost effective technology packages that achieve an average of 40 percent reduction in whole house energy use. These activities and outputs lead directly to decreased energy use in homes and reduced homeowner energy bills. BT activities also lead to investment in National Laboratories and R&D projects contributing to the deployment of science and basic research to create the energy technologies of the future.

^a Whole house energy savings are measured relative to the BA Research Benchmark Definition (Building America, Building America Research Benchmark Definition, December 29, 2004, NREL) which consists of the 2000 IECC requirements plus lighting, appliances and plug load energy levels (www.buildingamerica.gov).

^b This table reflects the energy efficient component of the ZEH goal and renewable energy systems integration. While 70 percent efficiency targets are expected by 2015 to 2018, additional research and time (with 2020 as a target) is needed to provide the remaining 30 percent through the integration of onsite renewable energy systems.

Detailed Justification

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

Research and Development: Building America	23,725	21,900	40,000
---	---------------	---------------	---------------

The residential systems research, driven by the performance targets by climate zone and the financial constraint of zero or less net cash flow, is conducted in three stages for each climate zone.^a During the three stages, Building America acts as a national residential energy systems test bed where homes with different system options are designed, built and tested at three levels of system integration, including technology pathways and research houses (Stage 1), production prototype houses (Stage 2), and community scale housing (Stage 3).

From technology package research reports developed in Stage 3, “Best Practices” manuals are designed for builders, manufacturers, homeowners, real estate agents, educators, insurance companies, and mortgage providers. The manuals present research results in illustrated text targeted to a specific audience to make it easily assimilated. Manuals also synthesize research findings into energy-efficient processes for the building industry.

The three research stages currently take approximately four years. For more advanced energy efficiency levels at and above 50 percent whole house savings, the system research process is expected to take additional iterations of whole house testing before implementation in production ready homes.

In FY 2010, BT will continue research at the 40 percent efficiency level for the hot-humid and cold climates. Research at the 40 percent efficiency level for the mixed humid was completed in FY 2009. The specific climate zone targets may be adjusted due to market conditions and the degree of technical complexity involved in developing solutions for each climate.

During 2010, BT will begin testing strategies to achieve a 50 percent reduction in the energy used in a home. The 50 percent systems research will continue work to reduce the energy used to heat and distribute hot water, field test lower cost efficient windows, and methods of space heating and cooling in a very efficient home. Electric energy used by miscellaneous small appliances in the home will become a higher priority research area with a focus on home automation.

Additionally, BT will invest in collaborative research with the Solar Energy Program to reduce barriers to the installation and operation of solar systems on homes and buildings. The focus of BT efforts will be on the building/solar energy system interface and maximizing the amount of energy from the solar energy system that is actually delivered to meet electricity needs in the home.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, pilot deployment studies and other analyses.

Total, Residential Buildings Integration	23,725	21,900	40,000
---	---------------	---------------	---------------

^a Building America deals with five climate zones in the U.S.: Marine, Hot-humid, Hot/Mixed Dry, Mixed Humid, and Cold. These climate zones require unique approaches to reach the 30-40-50 percent energy target savings.

Explanation of Funding Changes

FY 2010 vs. FY 2009 (\$000)

Research and Development: Building America

The increase in funding will be used to continue research at the 40 percent efficiency level for the hot-humid climate, begin testing strategies to reduce energy use in multifamily buildings, and begin testing strategies to achieve a 50 percent reduction in energy use in single family homes. These strategies include research on high R wall systems, reduction of miscellaneous electric loads and home energy storage. Additionally, the increased funding will be used to support the Builders Challenge at 30 percent energy savings in thousands of new single family homes and to research strategies to support home performance contracting to achieve 30 percent reductions in energy use in existing homes. The increased funding will also allow evaluations of energy efficient retrofitted homes against control groups of unchanged homes.

With the increased budget in FY 2010, BT will continue research and market transformation activities to improve the energy efficiency of existing homes by 25-30 percent. These research activities seek to improve the energy retrofit capabilities of contractors and explore cost effective ways to reach energy reductions greater than 50 percent in existing homes. The market transformation activities will spur innovation in information and service delivery approaches to reach an increasing number of existing middle class homeowners. In addition to supporting the Home Performance activity within the ENERGY STAR program, BT will also undertake to bring energy efficient retrofits to large numbers of homeowners via subdivision, city wide and utility wide efforts. Increased funding will also allow evaluations of energy efficient retrofitted homes against control groups of unchanged homes. In addition, BT will improve coordination with the Weatherization Assistance Program to disseminate R&D results to that user community and to learn best practices from them.

+18,100

Total Funding Change, Residential Buildings Integration

+18,100

**Commercial Buildings Integration
Funding Schedule by Activity**

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Commercial Buildings Integration			
Research and Development	11,891	32,454	38,502
SBIR/STTR	— ^{aa}	546	1,498
Total, Commercial Buildings Integration	11,891	33,000	40,000

Description

Sections 421 and 422 of EISA 2007 reauthorized the activities of the Commercial Buildings Integration subprogram, and specifically directed the establishment of a Net-Zero Energy Commercial Building Initiative (CBI). DOE launched the CBI on August 5, 2008, and is implementing a comprehensive program to achieve the CBI goals to develop and disseminate technologies, practices, and policies for the development and establishment of zero net energy commercial buildings for: (1) any commercial building newly constructed in the U.S. by 2030; (2) 50 percent of the commercial building stock of the U.S. by 2040; and (3) all commercial buildings in the U.S. by 2050.^b The comprehensive program may include:

- R&D on building science, design, materials, components, equipment and controls, operation and other practices, integration, energy use measurement, and benchmarking;
- Pilot programs and demonstration projects to evaluate replicable approaches to achieving energy efficient commercial buildings for a variety of building types in a variety of climate zones;
- Deployment, dissemination, and technical assistance activities to encourage widespread adoption of technologies, practices, and policies to achieve energy efficient commercial buildings;
- Other RD&D, and deployment activities necessary to achieve each goal of the initiative;
- Development of training materials and courses for building professionals on achieving cost-effective high performance energy efficient buildings;
- Development and dissemination of public education materials to share information on the benefits and cost-effectiveness of high performance energy efficient buildings;
- Support of code-setting organizations and State and local governments in developing minimum performance standards in building codes that recognize the ready availability of many technologies utilized in high-performance, energy efficient buildings;
- Development of strategies for overcoming the split incentives between builders and purchasers, and landlords and tenants, to ensure that energy efficiency and high-performance investments are made that are cost-effective on a lifecycle basis; and
- Development of improved means of measurement and verification of energy savings and performance for public dissemination.^c

^a SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

^b EISA 2007, Section 422(c)

^c EISA 2007, Section 422(d)

The organization of the CBI involves significant engagement of private sector companies, public, non-government and trade organizations through Commercial Building Energy Alliances, formally recognized green building partnership consortia, and a competitively selected CBI supporting consortium. As directed by EISA 2007, BT consults with the supporting partnership consortium and others to establish priorities and plans for the CBI. Based on those plans, BT is executing a program of high-value RD&D and technology deployment, as well as engaging the commercial buildings industry, manufacturer and supplier base, financial institutions, and stakeholder organizations in overcoming regulatory and market barriers to the adoption and use of the technologies, practices, tools, and techniques being developed. Commercial Building Energy Alliances for Retailers, Commercial Real Estate (owned and leased, lodging), and Institutions (higher education, hospitals, State and local government) are vehicles for peer assistance, technology procurements, and sharing of technology assessments and best practices.

BT is also providing cost-shared research and technical assistance on a competitive basis to National Accounts (business entities with building portfolios of significant square-footage who regularly engage in new construction, and who also implement retrofit of existing buildings on a regular basis). National Accounts have committed to a building retrofit that reduces energy use by 30 percent and the design of a prototype new building at 50 percent reduced energy use, relative to ASHRAE 90.1-2004. National Account activities are enabling the development of an in-depth understanding of the technical challenges and gaps, market factors and barriers, and business cases and obstacles associated with achieving CBI goals. As the CBI progresses, retrofit and prototype savings targets will be increased to reflect research successes and availability of new and advanced technologies, tools and practices. In addition to National Account activities, BT is engaging the full spectrum of research performers (i.e. National Laboratories, universities, and private sector companies) in cost-shared research needed to develop technologies, tools and practices required to meet the long-term CBI goals.

Commercial Building Design Technology Packages Performance Targets

Characteristics	Units	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Small and Medium Sized Commercial Building Design Technology Packages	30% Energy Savings	0	1	1	2	4	4	-	-	-	-	-
Commercial Building Design Technology Packages	50% Energy Savings	0	0	0	0	0	0	4	-	-	-	-
Case Studies (Retrofit)	30% Energy Savings	0	0	0	0	-	-	-	5	10	10	10
Case Studies (New Buildings)	50% Energy Savings	0	0	0	0	0	0	0	5	10	10	10

The Commercial Buildings Integration subprogram is an integral part of the BT program which evaluates research in the context of the buildings market.

Benefits

By 2010, Commercial Buildings Integration R&D activities, in collaboration with industry, will develop, document, and disseminate a complete set of 16 technology packages that provide builders energy efficient options to meet their complex performance demands. These packages will enable the achievement of a 30 percent (12 packages) or 50 percent (4 packages) reduction in the purchased energy use in new, small to medium-sized commercial buildings relative to ASHRAE 90.1-2004. These activities and outputs lead directly to decreased energy use in commercial buildings and reduced energy bills for American businesses, with direct benefits to U.S. economy.

Detailed Justification

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

Research and Development

11,891 32,454 38,502

In 2010, Building Technologies will continue R&D on new design guides that will help drive a net cost-effective increase (50 to 70 percent) in commercial building energy efficiency over ASHRAE 90.1-2004. Based on a series of design guides completed through 2009, BT began establishing public-private alliances with three major building segments of the commercial building market: retailers, commercial real estate, and hospitals. BT works with these alliances to develop highly efficient prototype designs, and challenges alliance members to build and demonstrate their version of these designs that are at least 50 percent more efficient than current designs.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

SBIR/STTR

— 546 1,498

In FY 2008, \$669,408 and \$80,719 were transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements of the continuation of the SBIR and STTR program.

Total, Commercial Buildings Integration

11,891 33,000 40,000

Explanation of Funding Changes

FY 2010 vs. FY 2009 (\$000)

Research and Development

Increases in FY 2010 funding will accelerate the RD&D of 50 to 70 percent reduced energy consumption through Commercial Building National Accounts and Energy Alliances in three commercial building segments: Retail, Commercial Real Estate, and Hospitals. Two additional Energy Alliances will be launched in FY 2010: colleges and universities, and State and local government. BT will work with these groups to

FY 2010 vs. FY 2009 (\$000)

identify new or underused energy efficiency technologies and for advancement in the marketplace. In addition, more technical assistance will be provided to the partnerships. Additional National Account teams will be selected to construct or retrofit buildings that achieve savings of 50 percent and 30 percent respectively above ASHRAE/IESNA Standard 90.1-2004. These cost-shared public-private partnerships have the potential to move several commercial building sectors rapidly forward towards the net zero energy goal.

Additional Commercial Lighting Solutions will be developed by DOE in partnership with top lighting designers, architects, and commercial end users. These solutions will be delivered through an interactive web tool that will estimate energy savings based on project-specific inputs. Commercial Lighting Solutions have been developed and analyzed for five types of retail stores (big box, small box, grocery, specialty market, and pharmacy), and solutions for other sectors will be developed. The solutions are designed to meet or exceed the savings levels to qualify for EAct 2005 tax incentives. New Technologies Solutions similar to the Commercial Lighting Solutions will also be initiated by DOE in partnership with the Commercial Building Energy Alliances on HVAC and refrigeration systems and equipment.

+6,048

SBIR/STTR

Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.

+952

Total Funding Change, Commercial Buildings Integration

+7,000

Emerging Technologies
Funding Schedule by Activity

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Emerging Technologies			
Lighting R&D	24,013	24,454	19,200
Space Conditioning and Refrigeration R&D	2,819	3,329	9,000
Building Envelope R&D	7054	8,652	16,000
Analysis Tools	2,660	3,149	5,500
Solar Heating and Cooling ^a	–	3,711	6,500
Energy Innovation Hub: Energy Efficient Building Systems Design	–	–	35,000
SBIR/STTR	– ^b	546	1,498
Total, Emerging Technologies	36,546	43,841	92,698

Description

The long-term goal of the Emerging Technologies subprogram is to develop cost effective advanced technologies (e.g., lighting, windows, and space heating and cooling) for residential and commercial buildings. Research will focus on developing technologies to support the residential and commercial building goal reducing the total energy use in buildings by up to 70 percent. BT is actively analyzing technology advancement in areas that will be required to reach the ZEB goals and using this analysis to inform the continued direction of the program and corresponding funding needs. The improvement in component and system energy efficiency, when coupled with research to integrate onsite renewable energy supply systems into the commercial and residential buildings, will establish the technologies from which to package marketable net zero energy designs.

Specifically, the Emerging Technologies subprogram will focus on:

- Solid State Lighting (SSL), which has long term efficiencies with the technical potential to approach 200 lumens per watt (lm/W), compared to most conventional technologies with maximum efficiencies in the 85 to 115 lm/W range;
- Heating and cooling systems with the technical potential to reduce annual heating, ventilation, and cooling (HVAC), dehumidification and water heating energy consumption by 50 percent aligned with advanced technology performance requirements of the Residential Integration activities;
- Advanced windows that incorporate advanced insulation materials and dynamic solar control, which have the potential to become net energy producers in many climates by harvesting passive heating, while dramatically reducing peak cooling loads; and
- EnergyPlus simulation tool with full capabilities to model whole-building integration of emerging energy-efficiency technologies and renewable energy systems into building design and operation.
- Technologies to support the thermal energy needs of a ZEB such as building end uses that can be met by solar thermal technologies, including domestic water heating, space heating, and space cooling.

^a Transferred from the EERE Solar Energy Program in FY 2009.

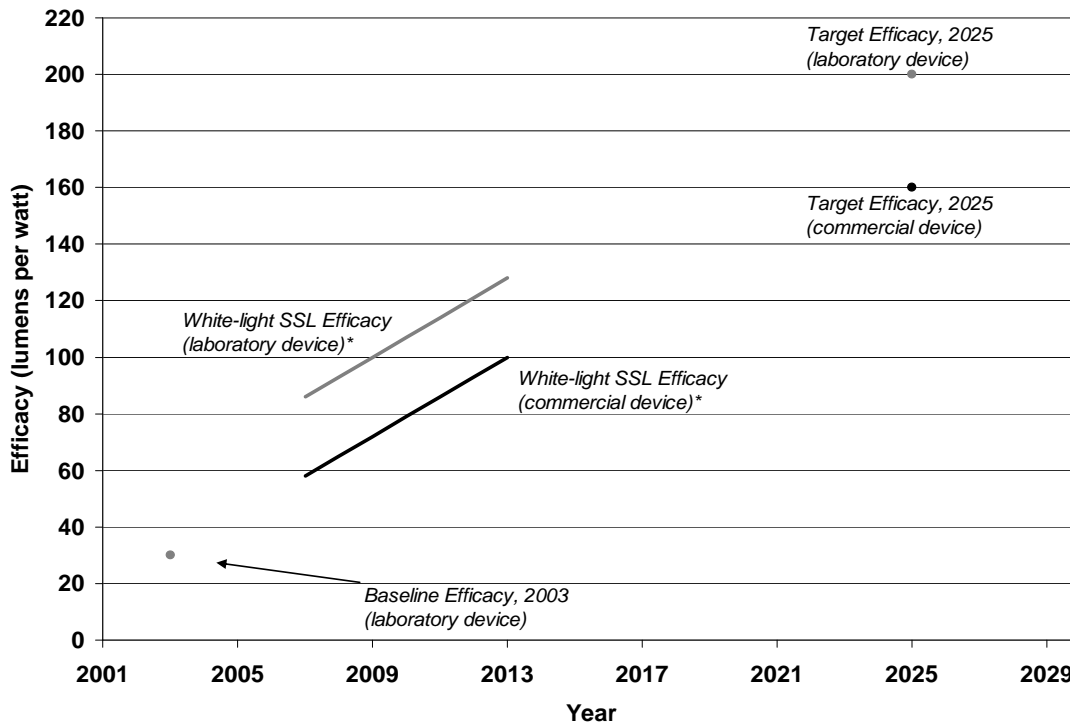
^b SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

- Integrating smart materials, designs, and systems to tune building functionality for increased conservation of energy and well managed usage of lighting, heating, air conditioning, and electricity.

Lighting Research and Development

The goal of the Lighting Research and Development activity is to achieve lighting technologies with double the efficacy of today’s most efficient lighting sources, linear and compact fluorescents.^a The primary target is solid state lighting devices and technologies, both inorganic light emitting diodes (LEDs) and organic light emitting diodes (OLEDs), that can produce white light with efficacies in excess of 160 lm/W in commercial products, with an interim target of 119 lm/W projected for laboratory devices by 2012.^b The anticipated rate of performance for LEDs is shown in the following diagram.

Efficacy Projection for White-Light SSL Laboratory Devices (Projections 2005 to 2012)



This projection is translated into point values in the following table, with the five-year target milestones.

^a Linear fluorescent lamps offer efficacies as high as 80 lm/W. Compact fluorescent lamps, a derivative of this technology, are less efficient (approximately 60 lm/W); however they still offer a four-fold improvement over traditional incandescent bulbs.

^b For solid-state lighting technologies, the performance target is focused on the energy efficiency rating "efficacy," of the device measured in lumens of light produced per Watt of energy consumed. Several lighting products, including fluorescent lamps and incandescent reflector lamps, are regulated using an efficacy target. The efficacy projections for solid-state lighting are generated for laboratory devices because the Lighting R&D portfolio does not have direct influence over commercially offered products.

Point Values of Efficacy Projections for White-Light SSL Laboratory Devices

Characteristics	Units	2003 (baseline)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Solid State Lighting Performance Targets	Lumens/Watt	30	65	79	95	101	110	113	116	119	122	125
Actual		48	65	79	95	107	-	-	-	-	-	-

Space Conditioning and Refrigeration Research and Development

Space conditioning systems, which have transformed the 20th Century by enabling building users to become more productive and comfortable, will play a critical role in achieving BT’s goal of ZEB. Space conditioning equipment for residential and commercial buildings consumes approximately 32.5 percent of the total energy used in buildings and is the most important contributor to summer peak electricity demand.^a

Although the energy efficiency of HVAC equipment has increased substantially in recent years, new approaches and technologies are needed to continue this trend. The dramatic reductions in HVAC energy consumption necessary to support the ZEB goals require a systems-oriented approach. This approach characterizes each element of energy consumption, identifies alternatives, and determines the most cost-effective combination of options. Therefore, the first task in this effort will involve system characterizations, identification of necessary upgrades to analysis tools, and an assessment of cost and performance of alternative solutions.

To achieve ZEHs, the Space Conditioning R&D activity will reduce the energy consumption of HVAC, dehumidification and water heating equipment by 50 percent over baseline levels at net zero financed cost.

Space Conditioning System Performance Goals

Characteristics	2004 Status	2007 Target	2010 Target
Annual HVAC, Water Heating and Dehumidification Energy Consumption Reduction vs. Building America benchmark (demonstrated product)	Baseline	25%	50%

Building Envelope Research and Development

Thermal Insulation and Building Materials

The Building Envelope element will contribute to ZEB goals by advancing a portfolio of new insulation and membrane materials, including improved exterior insulation finishes, with both residential and commercial wall applications. The next generation of attic/roof systems integrating thermal mass, ventilation and advanced insulated roof structures will be applied to the residential new construction market.

The table below lists the performance goals for the Thermal Insulation activities. All performance measurements are relative to historical baselines that have been set as the Building America regional

^a 2008 Buildings Energy Data Book, US Department of Energy, September 2008.

baseline new construction. Achieving cost-effectiveness and durability are critical aspects of these targets.

Thermal Insulation and Materials Performance Goals

Characteristics	2004 Status (units: R-Value*)	2007 Target (units: R-Value*)	2010 Target (units: R-Value*)
Advanced attic/roof system	30	35	Dynamic annual performance equal to conventional R-45
Wall insulation	10	Dynamic annual performance equal to conventional R-20 ^a	Dynamic annual performance equal to conventional R-20 ^b

* R-value measures the resistance to heat flow for a material. The higher the R-value, the better walls and roof will resist the transfer of heat

Windows Technologies

Window performance will also be vital to reaching residential and commercial buildings goals. Development of cost effective, highly efficient glazing and fenestration systems for all building types in all parts of the country will require a portfolio of technologies matched to those types and climatic conditions. The table below lists the performance measurement targets for the windows element. All performance measurements are relative to historical baselines that were set as the baseline for new construction in 2003.

Windows Performance Goals Percent Reduction in Energy Use*

Characteristics	2003 Status	2007 Target	2010 Target	2015 Target	2020 Target
Energy Consumption Improvement	Base ENERGY STAR (Low E)	20-30%	30-40%	40-50%	40-60%

* These percentage reductions will only be considered complete after meeting technical performance requirements such as incremental price/sq. ft., size (sq. ft.), visual transmittance, solar heat gain coefficient, durability (American Society for Testing and Materials Tests), U-value, and incremental cost \$/sq. ft.

Analysis Tools

BT established aggressive goals to create a new generation of residential and commercial building technologies by 2025 that will enable ZEB. Similar technologies and design approaches will also be applied to improve the performance of existing buildings. These ZEB goals cannot be met alone through research to significantly improve the performance of components (e.g., windows, appliances, heating and cooling equipment, and lighting). It also requires a revolutionary approach to building design and operation that can achieve up to 70 percent reductions in load, coupled with careful

^a Interim target NOT subject to cost constraints and may not be in commercial production.

^b Subject to no additional operating cost, within the traditional 3.5-in. wall dimension, with acceptable durability characteristics.

integration with onsite renewable energy supplies as well as thermal and electrical storage.^a This in turn requires powerful simulation tools that support evaluation of new ZEB demand-reduction and energy-supply technologies throughout building design, operation, and retrofit.

Solar Heating and Cooling (SH&C)

The mission of SH&C is to provide the thermal energy needs of a ZEB. Building end uses that can be met by solar thermal technologies include domestic water heating, space heating, and space cooling. The overall goal is a 40 to 50 percent cost reduction of installed SH&C systems with a levelized cost of energy of \$0.06 to 0.08/kWh over the life of the system by FY 2015.^b This is considered essential to attain the Building America Program's goal of ZEB by FY 2020 at neutral cost - whereby the added amortized cost of new home construction for energy efficiency and renewable energy measures are absorbed by the increased energy savings.

Energy Innovation Hub: Energy Efficient Building Systems Design

DOE proposes to establish multi-disciplinary Energy Innovation Hubs (Hubs) to address the basic science, technology, economic, and policy issues hindering the ability to become energy secure and economically strong while being good stewards of the planet by reducing GHG emissions. The main focus of the hub is to push the current state-of-the-art energy science and technology toward fundamental limits and support high-risk, high-reward research projects that produce revolutionary changes in how the U.S. produces and uses energy.

The hubs are inspired by the Bell Labs research model, which produced the transistor, the building block of modern computers. Their objective is to focus a high-quality team of researchers on a specific question and to encourage risk taking that can produce real breakthroughs, as opposed to the typical, more cautious approach that can result in meaningful, but often only incremental, improvements to existing technology. DOE will encourage risk-taking by making the initial grant period five years, renewed thereafter for up to 10 years. Any funding after 10 years would be predicated on "raising the bar" above that needed for simple renewal. The grants will not provide "bricks and mortar," but up to \$10 million of the \$35 million award may be used for capital equipment.

In FY 2010, BT will establish an R&D Hub that focuses on energy efficient building systems design. This hub will work on integrating smart materials, designs, and systems to tune building usage to better conserve energy, as well as maximizing the functioning of lighting, heating, air conditioning, and electricity to reduce energy demand. Areas of interest include improved exterior shell materials, membranes of energy efficient windows, insulation, improved approaches to building design, systems control, and energy distribution networks.

Benefits

Emerging Technologies activities will accelerate the introduction of highly efficient technologies and practices for both new and existing residential and commercial buildings. The emerging technologies

^a Building energy performance, particularly in ZEB, is the result of interactions among many elements including climate (outdoor temperature, humidity, solar radiation and illumination), envelope heat and moisture transfer, internal heat gains, lighting power, HVAC equipment, controls, thermal and visual comfort, and energy cost. These complex interactions cannot be understood and quantified without simulation tools. For example, the effect of daylighting dimming controls on the electric lights with daylighting has several effects: lighting electricity use goes down as does the heat gain from lights. Lower heat from lights reduces cooling use (amount depends on cooling equipment efficiency) but in the winter it can significantly increase the heating energy. Thus, the annual impact of daylighting on energy use requires detailed calculations that consider these interactions. In a series of field evaluation case study reports, NREL found that simulation tools were one of the essential elements for tuning the building design as well as the operating building performance [Paul A. Torcellini, Ron Judkoff, and Drury B. Crawley, "Lessons Learned: High-Performance Buildings," ASHRAE Journal, September, 2004].

^b Warm climates had a baseline of \$0.12 to 0.14/kWh in 1999 and cold climates, on which research has just begun, have a baseline of \$0.18 to 0.20/kWh with a base year of 2009.

activities support the BT goal through R&D of advanced lighting, building envelope, windows, space conditioning, water heating and appliance technologies and analysis tools. Without advanced components and subsystems developed in the Emerging Technologies activities, the goal of ZEB will not be met.

Detailed Justification

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

Lighting R&D	24,013	24,454	19,200
-------------------------	---------------	---------------	---------------

The R&D agenda of the SSL activities is established through an annual consultative process with general lighting industry, compound semi-conductor industry, universities, research institutions, National Laboratories, trade organizations, other industry consortia, and the Next Generation Lighting Industry Alliance (DOE’s competitively selected SSL Partnership). A majority of the tasks are competitively bid and awarded to entities with proposals that meet these priorities and the SSL portfolio’s stated objectives. The SSL activity classifies projects into four R&D classes: LED Core Technology, LED Product Development, OLED Core Technology, and OLED Product Development.

Product Development tasks are the systematic use of knowledge gained from basic and applied research to develop or improve commercially viable materials, devices, or systems. Technical activities focus on a targeted market application with fully defined price, efficacy, product concept modeling through to the development of test models and field ready prototypes, and other performance parameters necessary for success of the proposed product. Within each R&D class, there are active, detailed R&D pathways which contribute to the larger programmatic objective.

The SSL portfolio currently funds nine Core priority R&D topics and eleven Product Development priority R&D topics^a. Each year, the R&D topics are reviewed for progress, completion of topical areas, new topics to start, and advice from the Alliance and the research community. The R&D topics are reprioritized for each annual solicitation.

^a For further information on the SSL R&D Pathways, as discussed at the SSL Workshop by the research community and documented in the Multi-Year Program Plan FY 2009 – FY 2014, see the SSL website for these two documents (<http://www.eere.energy.gov/buildings/about/mypp.html> and www.netl.doe.gov/ssl)

In FY 2010, the program will continue the SSL R&D projects that have demonstrated progress and completed a peer review. These projects resulted from the competitive solicitations in 2007 and 2008 to develop and deploy SSL products for general illumination. These project topical areas are identified in the table on the following page.

Solid State Lighting R&D Topics

Topic	LEDs		OLEDs	
	Current R&D	Future R&D	Current R&D	Future R&D
Core:	<ul style="list-style-type: none"> • Phosphors • Semiconductor materials • Defect Physics • Light extraction 	<ul style="list-style-type: none"> • Substrates, buffers and wafers • Alternative Structures • Encapsulating and packaging • Fabrication of component prototypes 	<ul style="list-style-type: none"> • Novel Materials • New architectures • Light extraction • Improved charge injection • Transparent electrodes 	<ul style="list-style-type: none"> • Encapsulating materials • Material/structures evaluation • Substrate materials • Down conversion materials • Modeling of material principles • Electrodes and interconnects • Fabrication and patterning techniques
Product Development:	<ul style="list-style-type: none"> • Luminaire life and performance • Optical coupling and modeling • Packaging • Manufactured materials • Thermal design • Materials in devices • Light extraction from devices 	<ul style="list-style-type: none"> • Electronic development • Fabrication and manufacturing challenges • Device architectures • Mechanical design 	<ul style="list-style-type: none"> • Application of materials in fabrication • Applied light extraction • Manufacturing process optimization • Device encapsulation and packaging 	<ul style="list-style-type: none"> • Surface modification techniques • Demonstration architectures • Simulation tools for devices • Power spreading and driver electronics • Luminaire design • Synthesis manufacturing scale-up • Tools for manufacturing

Activities will continue to analyze and address barriers to enable market introduction and commercialization of technologies resulting from these research projects.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Space Conditioning and Refrigeration R&D	2,819	3,329	9,000
---	--------------	--------------	--------------

In FY 2010, BT will continue the development of an air-to-air integrated heat pump (IHP) system that can meet the air heating, cooling, dehumidifying, ventilating, and water heating requirements of a tight-envelope mechanically ventilated near-ZEH, and the development of a ground-source integrated heat pump (GS-IHP). In FY 2010, field experiments with prototype advanced HVAC/Water Heating (WH) systems will take place in research houses. This will demonstrate the performance of advanced prototype HVAC/WH systems including GS-IHPs and potentially high efficiency electric water heaters (HEWH) achieving 50 percent energy savings compared to the 2004 Building America baseline. It is further anticipated that air-source integrated heat pump (AS-IHP) systems will be demonstrated in FY 2011.

In FY 2009, BT completed an assessment of advanced heat pump technologies for ZEH applications. In FY 2010, research will start for technologies that have demonstrated through laboratory or field testing the long term potential (relative to Building America Benchmarks) to reduce annual HVAC, dehumidification and water heating energy consumption. This includes several different heat-pump based technology development options for ZEH applications, including but not limited to evaporative precooling and/or split-condensers into integrated heat pumps or integrated air-conditioners, and exploring the use of different working fluids in an integrated heat pump.

New strategies for achieving ZEH/ZEB will also be assessed, looking at the contribution to ZEH/ZEB, as well as overall market potential. These strategies will include novel ways of integrating highly efficient space conditioning and water heating, while also insuring comfort through proper ventilation and humidity control. Strategies which are essential to achieving ZEH, but which also have widespread application potential to existing buildings, will be a particular focus of the research.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Building Envelope R&D

Thermal Insulation and Building Materials	2,389	3,444	5,500
--	--------------	--------------	--------------

Reducing energy losses through the building enclosure will contribute significantly to DOE's attainment of a practical ZEB. In pursuit of the next generation of attic/roof systems that will save 50 percent energy over the Building America baseline, BT will continue the integration and optimization of key technologies including cool roofs, thermal mass, radiant barriers, and above deck ventilation. From FY 2007 through FY 2009, peak heat flux through the roof was reduced by 90 percent in a test facility. Completion of the validation of optimized technologies for energy and cost performance in a whole house side-by-side demonstration with detailed monitoring in a hot climate zone will be a significant effort in FY 2010. Developmental systems will further be refined for mixed and cold climates, and evaluation in multiple, more challenging climate zones will be initiated.

BT is developing advanced envelope materials in response to needs identified in the Residential and Commercial Integration activities. In FY 2010, dynamic membranes will be further analyzed and evaluated in cooperation with private industry as a result of prior fundamental material science research and partnerships formed in FY 2009. The membranes will allow for greater performance of insulation while eliminating moisture issues. Whole house, full scale applications for insulation with phase change materials that offer thermal mass effects to dramatically reduce peak loading were evaluated in a mixed climate zone in FY 2009. The new experimental insulation passed critical fire code rating tests in FY 2008. In FY 2009, the first commercialized products entered the marketplace. In FY 2010, large scale whole house side by side evaluations will be conducted, continuing work from FY 2009. In FY 2010, the thermal material subprogram will initiate fundamental new research on basements for both existing and

new construction.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Windows Technologies	4,665	5,208	10,500
Total, Building Envelope R&D	7,054	8,652	16,000

In FY 2010, BT will continue competitive fundamental science research to develop the second generation of materials, chemical engineering applications, and advanced manufacturing processes that can offer “leap frog” reductions in cost for dynamic windows while maintaining a high level of reliability and durability with a broad range of optical properties. The second generation of dynamic windows is targeted to enter the market in the 2011 to 2015 timeframe with substantially lower consumer prices. However, these initial second generation product offerings will not meet DOE long term price goals for ZEBs by 2020 and 2025.

Analysis Tools	2,660	3,149	5,500
-----------------------	--------------	--------------	--------------

In 2010, BT will continue to develop, improve, verify, and maintain software packages for researchers, engineers, architects, and builders who design or retrofit buildings to be energy efficient and comfortable. BT will also conduct research on, and incorporate additions to, EnergyPlus whole-building energy simulation software to allow building designers, operators, owners, and researchers to evaluate technologies for substantially improving the energy efficiency of buildings and reducing energy costs while maintaining comfort. BT will continue to focus on technologies, systems, and controls which are needed in low- and zero-energy buildings, incorporating new modules in EnergyPlus versions which specifically support BT residential and commercial building research, design, analysis and retrofit of low- and ZEBs. EnergyPlus module development research will focus on the top 30 to 40 features, completing new capabilities for recent state-of-the-art fenestration and envelope, daylighting, building controls and management systems, innovative low-energy HVAC equipment and systems, fuel cell systems, and renewable energy technologies such as solar and wind, as well as assistance with building code development.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Solar Heating and Cooling (SH&C)	0^a	3,711	6,500
---	----------------------	--------------	--------------

Activities for SH&C in FY 2010 will include research on exemplary low-cost solar water heating systems for ZEH in cold climates and the development of prototype systems; R&D of combined solar heating, cooling, and water heating systems that utilize seasonal storage to achieve high solar fractions; continued development of dehumidification applications for combined photovoltaic/thermal systems for ZEH; and support of a solar rating and certification system. In addition, coordination with the Solar America Showcases project of the Solar Energy Program and with the prototype house evaluation process of the Building America program will accelerate deployment of solar thermal technologies into the marketplace.

In FY 2010, SH&C will also leverage research activities with similar R&D conducted through the International Energy Agency SH&C Program, including the development of advanced solar thermal testing and characterization procedures for certification of collectors and systems.

In addition, these funds may be used to support efforts such as peer reviews; data collection and

^a The Solar Energy program was appropriated \$1.954 million appropriated for Solar Heating and Cooling in FY 2008.

dissemination; and technical, market, economic, and other analyses.

Energy Innovation Hub: Energy Efficient Building Systems Design

0 0 35,000

In FY 2010, BT will establish an R&D Hub that focuses on integrating smart materials, designs, and systems to tune buildings to conserve energy and control the allocation of lighting, heating, air conditioning, and electricity. A solicitation will be made to establish this hub on Energy Efficient Building Systems Design. A standard, peer-reviewed process will be held and a Board of Advisors will be established to review the progress of the hub. The grants will not provide “bricks and mortar,” but up to \$10 million of the \$35 million award may be used for capital equipment.

SBIR/STTR

— 546 1,498

In FY 2008, \$773,592 and \$93,281 were transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements of the continuation of the SBIR and STTR program.

Total, Emerging Technologies

36,546 43,841 92,698

Explanation of Funding Changes

FY 2010 vs. FY 2009 (\$000)

Lighting R&D

Decreases in funding in FY 2010 are due to increased focus on the most promising topics areas in progress and a down-selected portfolio of R&D projects; and reductions to joint projects such as the Bright Tomorrow Lighting Prize. Existing projects will continue advancements in device efficacy, durability, manufacturing, and cost needed to reach a commercially viable white light with efficacies meeting the 160 lm/W goal. Efforts to analyze and address barriers to enable market introduction and commercialization of technologies resulting from these research projects will continue. -5,254

Space Conditioning and Refrigeration R&D

Additional funds will focus on affordable advanced materials, components, refrigeration cycles and systems that improve system energy consumption (including CO₂ systems) and non-vapor compression technologies with humidity control to reduce the energy consumption of HVAC, dehumidification and water heating equipment by 50 percent over baseline levels.

Additional R&D will include: retrofit technologies, application of nanotechnology to AC component design, development of zero-global warming potential refrigerants, development of next-generation residential water heaters at a cost effective price premium with multi-functional capabilities, development of integrated end-use appliances, and identification of the most promising target technologies and components in miscellaneous electric loads to reduce energy consumption by 30 percent. +5,671

Building Envelope R&D

Thermal Insulation and Building Materials

Research will focus on high performance, low cost foundation systems and on roof systems that reduce heating and cooling loads — including a full demonstration, evaluation, and side by side whole house comparisons of the next generation attic/roof systems in a hot climate. The new fully code compliant systems will outperform the Building America team’s best available technology. In addition, research will focus on higher performance envelope materials, and high performance retrofit-specific designed systems with reduced cost and easier installation.

+2,056

Windows Technologies

Increased funding will support a multiyear investment to achieve a fundamental technology and cost reduction for highly insulating windows with R7 to R10 performance. Research will continue on coating technologies and reduced cost for dynamic windows with solar heat gain coefficient range of 0.1 – 0.5, and easy to install daylighting systems and controls (research will investigate daylighting systems that are fully integrated with glazing façade systems and also integrated into the whole building design). Additionally, FY 2010 funding will be used to commercialize cost effective windows within the 2014 to 2017 timeframe. Funding will also be used to evaluate system performance of currently available R10 windows (non-cost effective) in a whole house cold climate research study.

+5,292

Total, Building Envelope R&D

+7,348

Analysis Tools

Additional funds will accelerate incorporation of building controls capabilities and refrigeration systems plug-ins into existing building simulation software, increasing the number of new components and features added by 25 percent. Efforts will be accelerated to develop and incorporate analysis and design tools that allow for simulation and modeling of emerging technologies. In addition, technical tools and other enabling technologies will be developed that establish accurate test procedures and verification tools to aid commercialization of technologies.

+2,351

Solar Heating and Cooling Systems

Additional funding will focus on combined solar heating, cooling, and water heating systems for ZEH, solar electric/solar thermal pathways to ZEH and development of the next generation of solar water heaters. Increased funding will also accelerate the development of manufacturing processes that lead to enhanced, building-integrated SHC products that are cost-effective and easy to install. Commercialization activities will be implemented, including: the establishment of initiatives, activities and studies that promote expanded utilization of SHC such as purchase agreements through utilities; the creation of one or more University Centers to support innovation and development of SHC products; and the formation of technical support teams that promote development, technical and market transformation assistance for SHC through collaboration with SHC RD&D and existing market transformation initiatives. BT will also be able to provide financial and technical support for establishing a National Administrator of Expertise in Solar Workforce Development. This effort is needed to manage operations of a National Consortium of 7-10 newly created Solar Resource Centers that will produce technical instruction materials and curricula to train a growing solar technology workforce. In turn, BT will establish up to 25 community-based solar installation workforce training programs across the U.S. to broaden the Nation's ability to provide quality solar installations, to create new jobs and to promote the expanded use of solar energy for a clean and reliable energy future.

+2,789

Energy Innovation Hub: Energy Efficient Building Systems Design

This funding will establish a hub focusing on integrating smart materials, designs, and systems to tune buildings to conserve energy and control the allocation of lighting, heating, air conditioning, and electricity.

+35,000

SBIR/STTR

Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.

+952

Total Funding Change, Emerging Technologies

+48,857

**Technology Validation and Market Introduction
Funding Schedule by Activity**

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Technology Validation and Market Introduction			
Rebuild America	2,808	5,000	5,000
ENERGY STAR	6,714	7,484	10,000
Building Energy Codes	3,717	5,376	10,000
Solar Decathlon	— ^a	3,400	5,000
Total, Technology Validation and Market Introduction	13,239	21,260	30,000

Description

Technology Validation and Market Introduction (TVMI) accelerates the adoption of clean and efficient domestic energy technologies, including ENERGY STAR, Rebuild America, and Building Energy Codes. ENERGY STAR is a joint DOE/EPA activity designed to identify and promote energy efficient products. Through its partnership with more than 7,000 private and public sector organizations, ENERGY STAR delivers the technical information and tools that organizations and consumers need to choose energy efficient solutions and best management practices.

The Rebuild America Program activity is aligned with BT R&D activities to accelerate the adoption of advances in building integrated design, software tools, practices and advanced controls, equipment, and lighting. BT will continue implementation of the Commercial Lighting initiative, EnergySmart Hospitals, EnergySmart Schools, the National Builder’s Challenge, and the Building Efficiency Application Centers. The National Builder’s Challenge is a program designed to support America’s homebuilding industry in its efforts to design, build, and sell 220,000 high performance homes by 2012. The Commercial Lighting Initiative is a high-profile campaign challenging commercial building owners to improve their building lighting efficiency by 30 percent or more. In FY 2010, BT will promote energy efficiency within existing homes by designing activities with local governments to help expand the availability of low cost financing for energy retrofits (e.g. using Energy Service Companies’ experience) and with retailers to promote energy efficient home remodeling and retrofits through innovative financing. BT will also expand its outreach and educational efforts by developing guidance for energy audits at the time of home resale, including appropriate training materials for real estate agents and lenders. The Building Energy Codes activities support upgrading building industry model energy codes and standards and their adoption, implementation and enforcement by State and local jurisdictions.

^a SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

Benefits

TVMI activities accelerate the adoption of clean, efficient, and domestic energy technologies. ENERGY STAR encourages the adoption of very efficient products through a large network of stakeholders using marketing and procurement tools and by training builders to retrofit existing homes through Home Performance with ENERGY STAR. The Rebuild America Program focuses on promoting energy efficiency to schools and hospitals. Building Energy Codes submits code proposals, supports the upgrading of the model building energy codes, and provides technical and financial assistance to States to update, implement, and enforce their energy codes to meet or exceed the model codes, in support of Section 304 of ECPA. It also promulgates standards for manufactured housing as required by Section 413 of EISA 2007. These activities and outputs increases the energy performance of homes and commercial buildings constructed today, targets consumer and assists them in reducing energy bills, and contributes to job creation in the construction industry.

Detailed Justification

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

Rebuild America

2,808

5,000

5,000

The Rebuild America Program is aligned with BT R&D activities to accelerate the adoption of advances in building integrated design, software tools, practices and advanced controls, equipment and lighting. The program will expand and update its technical assistance, delivery mechanisms, and partners to effectively transfer the technological advances in R&D. In particular, to promote energy efficiency within the large number of existing homes, the program will begin designing marketing activities (e.g., retailer partnerships to promote energy efficient home remodeling and retrofits through innovative financing).

The EnergySmart Schools activity collaborates with national and regional stakeholders to assist school decision makers in planning and financing energy-efficient high-performance schools, as well as provide education and training for building professionals. EnergySmart Schools promotes the building of new schools that exceed code by 50 percent or more. In addition, it promotes a 30 percent improvement in the energy efficiency of existing schools. In FY 2008 and FY 2009, the BT program invested resources to launch the EnergySmart Schools initiative, develop the 30 percent Advanced Energy Design Guide for K-12 School Buildings, Get Smart About Energy CD-Rom, the Guide to Financing EnergySmart Schools and initiate development of an Operations and Maintenance Manual for K-12 School Buildings. In FY 2010, BT will provide support for implementation of the 50 percent ASHRAE Advanced Energy Design Guide for K-12 School Buildings and develop and disseminate information on the Operations and Maintenance Manual for K-12 School Buildings.

Through targeted partnerships, design support, training, and marketing, EnergySmart Hospitals advances efficient and renewable energy technologies as highly effective strategies for hospitals to reduce energy usage while meeting mission critical goals. In FY 2008 and FY 2009, BT invested resources to launch the EnergySmart Hospitals initiative and the development of a suite of tools and technical resources. In FY 2010, the program will emphasize technical training for existing facilities and new hospital design and construction, as well as the development of targeted technology

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

assessments and technical case studies.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

ENERGY STAR **6,714** **7,484** **10,000**

DOE will continue its focus on raising the efficiency targets of ENERGY STAR products. The DOE ENERGY STAR team will also continue to work with EPA to help promote its current labeled products. A three-pronged strategy will be deployed in FY 2010 to support the portfolio of existing technologies: 1) developing and updating efficiency criteria for DOE-managed products to keep the label relevant and meaningful in the market; 2) working with EPA and participating manufacturers, retailers, and energy efficiency program sponsors on product marketing and deployment activities; and 3) working with EPA to conduct outreach campaigns and initiatives to educate consumers about the benefits of select products and technologies. DOE will work through regional and national organizations to disseminate information throughout the U.S., create inter- and intra-State partnerships to promote best practices and increase the number of ENERGY STAR State Partners, as well as fund Energy Efficiency Partnerships.

In addition, these funds may be used to support efforts such as peer reviews, data collection and dissemination, and technical, market, economic, and other analyses.

Building Energy Codes **3,717** **5,376** **10,000**

In FY 2010, BT will initiate analyses and support to upgrade the next generation of ASHRAE 90.1 codes and set substantial new efficiency targets. Upgrades will include performance criteria based on size, internal functions, and envelope characteristics (beyond the current prescriptive criteria) permitting the next substantial increase in code stringency. DOE will conduct the analysis needed to support an increased code stringency of five percent in the next residential model building energy code (the 2012 International Energy Conservation Code (IECC)). DOE will also conduct analyses and publish determinations in the Federal Register as to whether each new edition of the baseline model codes will improve the energy efficiency of buildings. It will improve energy code compliance tools, integrating them with the design process and non-energy code enforcement. Technical assistance will be provided to States to update, implement, and enforce their energy codes to update their residential code to meet the 2009 IECC and Standard 90.1-2010.

DOE will also propose standards for energy efficiency in manufactured housing that will meet or exceed the 2009 International Energy Conservation Code.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Solar Decathlon **0** **3,400** **5,000**

The Solar Decathlon, transferred from the Solar Energy Program to BT in FY 2008, is a high-profile university competition held in Washington, D.C., that promotes public awareness of highly efficient building technologies and ZEHs using solar energy. The competition also fosters innovation and encourages incorporation of new building technologies and design practices into engineering and

Energy Efficiency and Renewable Energy/

Building Technologies/

Technology Validation and Market Introduction

FY 2010 Congressional Budget

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

architecture university curricula.

The Solar Decathlon is held in September/October every other year. Activities in FY 2010 will start with concluding the 2009 event in October and recruiting new teams for the 2011 Solar Decathlon. A request for proposals will be issued in October 2009 to all universities throughout the country. The proposals will be reviewed and ranked, and the top twenty universities will be selected and each awarded grants to support their projects. New participants will be announced in January 2010. Activities in FY 2010 will also include monitoring the 2009 competition houses to gain long-term performance data after the homes are relocated to a permanent site.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Total, Technology Validation and Market Introduction

13,239 21,260 30,000

Explanation of Funding Changes

FY 2010 vs. FY 2009 (\$000)

Rebuild America

No change.

0

ENERGY STAR

Increased funds will be used to assess possible approaches and develop a standardized portfolio of product testing and performance verification of ENERGY STAR technologies conducted in partnership with current testing programs (windows, CFLs, SSL, etc.) and other stakeholders to include complementary appliance standards test procedures and correcting confusion in the marketplace.

BT will also revise window, door, and skylight program requirements and ENERGY STAR criteria for appliances starting August 2009, based on the President Obama's memorandum dated February 5, 2009. The memo states that DOE take all necessary steps, consistent with the consent decree, EAct 2005, and EISA 2007, to finalize legally required efficiency standards as expeditiously as possible in a manner consistent with all applicable judicial and statutory deadlines.

+2,516

Building Energy Codes

In FY 2010 BT will use increased funds to improve code compliance tools and deployment of code compliance evaluation assistance to States, in support of their compliance plans. It will also be used to shift model code focus to development of

+4,624

**Energy Efficiency and Renewable Energy/
Building Technologies/
Technology Validation and Market Introduction**

FY 2010 Congressional Budget

FY 2010 vs. FY 2009 (\$000)

performance criteria and to enable the setting of realistic new efficiency targets for the next generation model codes.

Solar Decathlon

The increase in funding will be used for long-term performance monitoring of the 2009 Solar Decathlon homes after the competition.

+1,600

Total Funding Change, Technology Validation and Market Introduction

+8,740

**Equipment Standards and Analysis
Funding Schedule by Activity**

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Equipment Standards and Analysis	21,981	20,000	35,000
Total, Equipment Standards and Analysis	21,981	20,000	35,000

Description

The goal of the Equipment Standards and Analysis subprogram is to develop minimum energy efficiency standards that are technologically feasible and economically justified. During FY 2005 and FY 2006, DOE identified and implemented significant enhancements to the implementation of rulemaking activities. DOE committed to clearing the backlog of delayed actions that accumulated during prior years, while simultaneously implementing all new requirements instituted by EAct 2005. In FY 2010, DOE will continue to implement productivity enhancements that will allow multiple rulemaking activities to proceed simultaneously while maintaining the rigorous technical and economic analysis required by statute.

Appliance and equipment standards help drive energy savings. It is estimated that Federal residential energy efficiency standards that took effect by the end of 2007 will save a cumulative total of 34 quads of energy by 2020, and 54 quads by 2030. Comparably, the total U.S. consumption of primary energy was about 100 quads in 2004. Standards scheduled to be issued in 2009 have the potential to save an additional 25.5 quads of energy cumulatively over 30 years.

Benefits

Equipment Standards and Analysis activities lead to improved efficiency of appliances and equipment by conducting analyses and developing standards that are technologically feasible and economically justified by EPCA, as amended. Analyses performed under this program will also support related program activities such as ENERGY STAR to ensure consistent methodology is used in setting efficiency levels for related programs. These activities raise the bar on energy performance in appliances and equipment, thus leading directly to decreased energy use in buildings and reduced energy bills.

Detailed Justification

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

Equipment Standards and Analysis	21,981	20,000	35,000
---	---------------	---------------	---------------

In 2010, DOE will continue to take all necessary steps, consistent with the consent decree, EAct 2005, and EISA 2007, to finalize legally required efficiency standards consistent with all applicable judicial and statutory deadlines. The Equipment Standards and Analysis subprogram will continue ongoing rule-makings or begin rulemakings for the following product categories in FY 2010:

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

- Residential Water Heaters
- Direct Heating Equipment
- Pool Heaters
- Small Electric Motors
- 1-500 hp Electric Motors
- Fluorescent Lamp Ballasts
- Clothes Dryers
- Room Air Conditioners
- Central Air Conditioners and Heat Pumps
- Battery Chargers
- External Power Supplies
- Residential Clothes Washers
- Walk-In Coolers and Freezers
- Residential Refrigerators
- Lighting Products
- Elliptical Reflector (ER)/Bulged Reflector (BR)/Reflector (R) Lamps
- Metal Halide Lamp Fixtures
- Microwave Ovens
- Commercial Refrigeration Equipment
- Furnace Fans
- High Intensity Discharge Lamps

The specific standards and test procedure activities listed above have been identified considering existing obligations and new legislative directives. To meet these deadlines in 2009, DOE initiated standards rulemakings for four products (ER/BR/R lamps, walk-in coolers and freezers, metal halide lamp fixtures, and residential clothes washers) and test procedure rulemakings for six products (battery chargers, external power supplies, clothes washers, fluorescent ballasts, and central air-conditioners, 1-500 hp electric motors).

In accordance with EISA 2007, DOE will continue work on incorporating standby and off mode power consumption into test procedures for residential products. In addition to increasing the number of products for which DOE must develop standards, EISA 2007 significantly alters the scope of certain rulemakings by authorizing DOE to consider regional standards for certain space conditioning products. The central air conditioning rulemaking will explore an expanded scope of the analysis to consider the potential impacts of regional standards, including the impact on consumers, manufacturers, distributors, contractors, and installers.

Activities in FY 2010 will also include responses to waiver requests from manufacturers and requests for input and recommendations to the DOE Office of Hearings and Appeals. Resource planning becomes critical to minimize delays and availability conflicts of DOE staff and contractor

(dollars in thousands)

FY 2008	FY 2009	FY 2010
---------	---------	---------

support. Funds may also be used to prepare for challenges such as new technologies utilized in appliances including compound use appliances, networked or interconnected appliances, and test procedure sensing devices that can give false readings of efficiency levels.

In addition, these funds may be used to support efforts such as: peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Total, Equipment Standards and Analysis	21,981	20,000	35,000
--	---------------	---------------	---------------

Explanation of Funding Changes

FY 2010 vs. FY 2009 (\$000)

Equipment Standards and Analysis

In FY 2010, DOE will initiate energy conservation standard rulemakings on furnace fans, 1-500 hp electric motors, and commercial refrigeration equipment.

Additionally, on February 5, 2009, the President issued a Memorandum to the Secretary of Energy requesting that DOE “work to complete prior to the applicable deadline those standards that will result in the greatest energy savings.” DOE will initiate and accelerate up to three additional rulemakings not currently on its multi-year schedule and consider the potential energy savings when evaluating which products to accelerate. This could include products such as televisions, commercial automatic ice makers, and/or plumbing products.

+15,000

Total Funding Change, Equipment Standards and Analysis	+15,000
---	----------------