

Bending the Curve: Implementation of the Energy Independence and Security Act of 2007

Lowell Ungar, Garrett Brinker, Therese Langer, and
Joanna Mauer

October 2015

Report E1503

© American Council for an Energy-Efficient Economy
529 14th Street NW, Suite 600, Washington, DC 20045
Phone: (202) 507-4000 • Twitter: @ACEEEDC
Facebook.com/myACEEE • aceee.org

Contents

About the Authors.....	iii
Acknowledgments.....	iv
Executive Summary	v
Introduction.....	1
Implementation of Energy Efficiency Provisions by Sector	4
Fuel Efficiency of Vehicles	4
Cars and Light Trucks.....	4
Medium- and Heavy-Duty Vehicles	8
Consumer Information	11
Loan Programs for Advanced Vehicle Technologies	12
Appliances and Equipment	14
Light Bulb Standard	15
Other Standards in the Law	19
Standards to Be Set by DOE	20
Changes to DOE Process and Authority	21
Electronics and Lighting Labels.....	23
Residential and Commercial Buildings	25
Manufactured Housing Standard	25
Codes and Federally Assisted Housing	26
Zero Net Energy Commercial Buildings Initiative	27
Reauthorization of Weatherization Assistance Program	28
Reauthorization of State Energy Program	29
Energy Efficiency and Conservation Block Grant Program	30
Federal Energy Management	32

Energy Intensity Reduction Goals for Federal Buildings	32
Management of Energy and Water Efficiency in Federal Buildings	33
Federal Building Fossil Fuel Use Standards	34
Permanent Reauthorization of Energy Savings Performance Contracts	34
Other Sectors.....	35
Investments in the Smart Grid.....	35
Industrial Programs.....	37
Energy Savings and Impacts.....	39
Comparison of Impacts to 2007 Projections	40
Discussion.....	41
EISA and ARRA	41
Lessons Learned	43
The Remaining To-Do List.....	44
Conclusion.....	44
References.....	46
Appendix A. List of Energy Efficiency Provisions in EISA.....	56
Appendix B. Appliance Standards in EISA	61
Appendix C. Detailed Savings Estimates for EISA Provisions	62
Appendix D. Savings Analysis Methodology and Assumptions	64
Vehicle Standards.....	64
Appliance and Equipment Standards.....	65
Other Provisions.....	65

About the Authors

Lowell Ungar supports effective federal energy efficiency policies for the American Council for an Energy-Efficient Economy (ACEEE). He promotes agency actions under existing authorities, develops legislative proposals, and analyzes existing and proposed policies and programs. Prior to joining ACEEE in 2013, Lowell was director of policy at the Alliance to Save Energy, working primarily to develop federal energy efficiency legislation and build stakeholder and policymaker support. He played a key role in enacting legislation on building energy codes, appliance efficiency standards, tax incentives, Department of Energy programs and funding, federal energy management, and other areas. He also co-wrote reports, mostly on buildings and utility policy issues. Before working at the Alliance, he was a legislative aide in both the US Senate and the House of Representatives. Lowell earned a PhD in physical chemistry from the University of Chicago and a BS in chemistry with distinction and with honors in humanities from Stanford University.

Garrett Brinker was the federal policy intern at ACEEE during spring 2015. He earned an MA in public policy from Georgetown's McCourt School of Public Policy, focusing on energy policy and political strategy, and a BA in political science from the University of Chicago. Prior to working at ACEEE, he interned at the White House in the Office of Digital Strategy. Before graduate school he was the director of undergraduate outreach for the University of Chicago's Office of College Admissions, leading a creative team in developing an outreach strategy through digital media, print publications, and external communications. He also has prior experience in urban policy as a researcher for the University of Chicago Crime Lab, in clinical research, and on political campaigns.

Therese Langer works to improve the efficiency of both vehicles and systems for the movement of passengers and freight. Her current areas of focus include: advancing technologies and policies to improve light- and heavy-duty fuel economy; integrating transportation into greenhouse gas reduction programs at the state and national levels; quantifying the economic impacts of overdependence on oil; expanding the multi-modal goods movement infrastructure; and understanding consumers' vehicle purchase decisions. She joined ACEEE in 2001. Prior to joining ACEEE, Therese was staff scientist for the Rutgers University Environmental Law Clinic, working to make the transportation system in the greater New York metropolitan area more sustainable. Therese holds a PhD in mathematics from UC Berkeley.

Joanna Mauer coordinates a coalition of efficiency advocates for the Appliance Standards Awareness Project (ASAP) that provides technical analysis and comments on US Department of Energy (DOE) efficiency standards rulemakings for residential appliances and commercial equipment. Prior to joining ASAP in 2010, Joanna was a physical scientist at the US Environmental Protection Agency (EPA). Before that she worked as a research assistant at the Center for Integrative Environmental Research, where she contributed to studies on energy efficiency in Maryland. She also served as a Peace Corps volunteer in the Dominican Republic, working on rural water and sanitation. Joanna earned a bachelor of science degree in civil and environmental engineering from Cornell University and a master's in public policy from the University of Maryland with a specialization in environmental policy.

Acknowledgments

This report was made possible in part through the generous support of the Energy Foundation and the Tilia Fund. The authors gratefully acknowledge the many colleagues, external experts, and sponsors who provided assistance on this report. Siddiq Khan and Shruti Vaidyanathan at ACEEE also did analysis for this report. External reviewers included Karen Palmer and Ben Leard of RFF, David Goldstein and Noah Horowitz of NRDC, Michael Freedberg of HUD, and Joe McGuire of AHAM. (External review and assistance do not imply affiliation or endorsement.) Internal reviewers included Steve Nadel, Neal Elliott, Jennifer Amann, Jim Barrett, and Andrew DeLaski. We also would like to thank Fred Grossberg for managing the editorial process and Sean O'Brien and Roxanna Usher for copy editing. Thanks to Eric Schwass for help with publication design and to Patrick Kiker and Maxine Chikumbo for their help in launching this report.

Experts interviewed for this study include:

- Jennifer Amann, ACEEE
- Karim Amrane, AHRI
- Brendan Bell, DOE
- Alex Boesenberg, NEMA
- Danielle Byrnett, DOE
- David Calabrese, Daikin
- Tom Catania, U. Michigan
- Keith Cook, Philips
- Dru Crawley, Bentley
- Stacy Davis, ORNL
- Andrew DeLaski, ASAP
- Dan Delurey, ADS
- Joseph Eaves, NEMA
- Tom Eckman, NWPPC
- Neal Elliott, ACEEE
- Peter Faguy, DOE
- Christina Finkenhofner, AIA
- Jeff Genzer, Counsel for NASEO
- Jeff Harris
- Cathy Higgins, NBI
- Noah Horowitz, NRDC
- Scott Hutchins, DOE
- Sarah Jensen, DOE
- Kevin Kampschroer, GSA
- Steve Nadel, ACEEE
- Chris Payne, LBNL
- Kyl Pitsor, NEMA
- Colleen Rizey, ORNL
- Jennifer Schafer, FPCC
- Skye Schell, DOE
- Steve Selkowitz, LBNL
- John Smegal, DOE
- David Terry, NASEO
- Dan Ton, DOE
- Chris Tremper, DOE
- Jay Wrobel, DOE
- Joann Zhou, ANL

Executive Summary

The Energy Independence and Security Act of 2007 (EISA) was remarkable in its genesis and its impacts. This ambitious bill was passed by bipartisan majorities in a Democratic-led Congress and signed by a Republican president. It sought to reduce our nation's dependence on oil and address climate change in large part through energy efficiency, including vehicle fuel economy standards, equipment efficiency standards, major new efficiency programs, and federal energy management.

These measures have helped change the trajectory of energy use in the United States. We now estimate that by 2030 EISA will reduce total annual energy use by 8 quadrillion Btu (roughly 8% of projected energy use), reduce oil use by almost 3 million barrels a day (15%), and cut annual carbon dioxide emissions by 550 million tons (10%). The law will save money as well. We estimate total net savings over \$2 trillion (net present value of savings after investments for the lifetime of measures through 2040).

The implementation of the bill has been marked by the Great Recession, the election of President Obama in 2008, and subsequent stimulus legislation and political backlash. Key outcomes include the following:

Projected Impacts of EISA Energy Efficiency Provisions

- Save consumers over \$2 trillion
- Reduce oil use by almost 3 million barrels a day in 2030
- Reduce total energy use by 8 quads (8%) in 2030
- Cut cumulative CO₂ emissions by 17 billion metric tons

- *Vehicle standards.* EISA required the first major increase in and expansion of vehicle fuel economy standards since they were created three decades earlier. For cars and light trucks it directed an increase from about 25 miles per gallon (mpg) to 35 mpg in 2020. But the administration leveraged authority in EISA with federal support for the automakers in crisis to go well beyond, to 45 mpg in 2025. (Note that on-road mpg figures are about 20% lower than these numbers, which are used for standards.)
- *Equipment standards.* Even though the political opposition has suspended federal enforcement of it, the light bulb standard continues to promote new technology options that are saving consumers billions of dollars a year. And the Department of Energy is implementing and updating a broad array of other standards.
- *Efficiency programs.* The Recovery Act and other stimulus legislation poured billions of dollars into programs authorized by EISA for state and local governments, the auto industry, utilities, and others. Other programs and standards have yet to save energy because, seven years out, they have not yet been funded or implemented.

Here are some of the findings for specific provisions in the bill.

Cars and light trucks. The Obama administration has set standards that will almost double fuel economy by 2025, well beyond what was required in EISA. Federal assistance, including loan guarantees under EISA, has helped with the transformation.

Heavy-duty vehicles. The administration set the first standards for these vehicles in 2011 with broad support, and has proposed stronger standards this year.

Light bulbs. Although halogen incandescent bulb sales have grown fastest during implementation of the standard, LED bulbs are expected to win over time, providing consumers with light they like and large savings. Neither technology was widely available in 2007. A ban on funding to implement the standard has only made it slightly harder for manufacturers to comply.

Other appliances. The Department of Energy has ramped up to set an unprecedented wave of standards and test procedures with major energy savings. However there have been some controversy and delays, most notably on furnaces.

Housing. While energy codes have been updated to achieve large energy savings, long delays have slowed their application to manufactured housing and new homes with federally assisted mortgages.

Cities and counties. The Recovery Act included \$3 billion in new funding to thousands of local governments through the Energy Efficiency and Conservation Block Grants. This resulted in many cities engaging in energy efficiency initiatives for the first time, but the impacts are still unclear. An additional \$5 billion went to local programs for low-income weatherization and \$3 billion to states for clean energy.

Other programs. Promising programs not funded in the Recovery Act were never funded or implemented, including grants and loans for institutions and, to a large extent, the Zero-Net-Energy Commercial Buildings Initiative. However funding for other commercial buildings programs did increase.

Figure ES1 shows the growth in energy savings over time from the provisions.

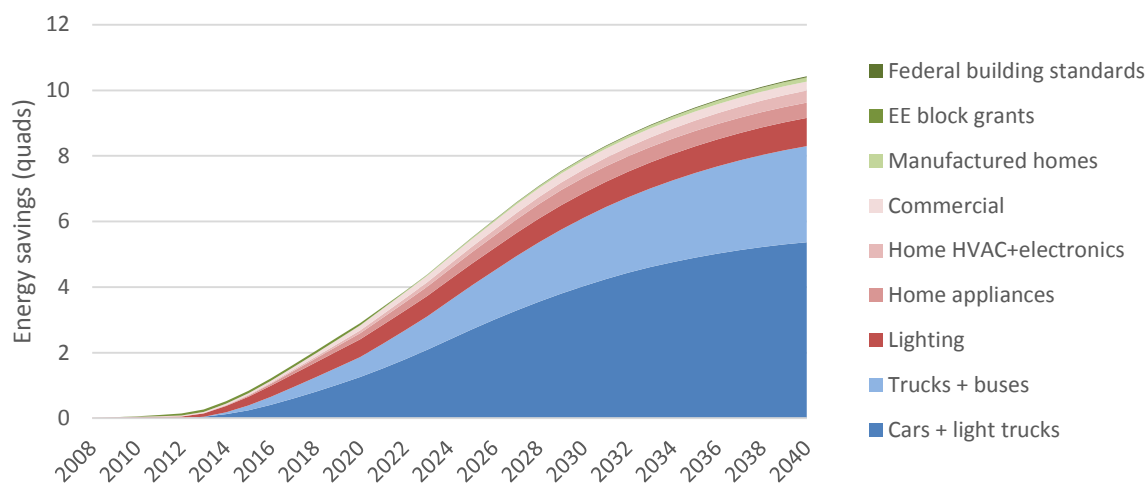


Figure ES1. Growth in energy savings each year from key policies in EISA

Even though implementation of EISA provisions has shown the difficulty of interpreting broad legislation, the pitfalls of political shifts, the slow pace of agency deliberative process, and other barriers, it also has shown that bipartisan legislation, a committed administration, and stakeholder support can make a real difference. They have saved consumers billions of dollars, reduced our dependence on oil, and improved the environment.

Introduction

CONTEXT OF THE LAW

The Energy Independence and Security Act of 2007 (EISA) sought to reduce our nation's dependence on oil and address climate change in large part through energy efficiency. The law was overwhelmingly approved in Congress, passing by a margin of 314–100 in the House of Representatives and 86–8 in the Senate. On December 19, 2007, President George W. Bush signed EISA into law.

EISA developed in the wake of the election of the 110th Congress, which saw the Democrats regain majority control of both the House and the Senate. It was an election in which President Bush described the Democratic Party takeover as a “thumpin’” (Grieve 2006). Although the bill started as part of the House Democrats’ 100-Hour Plan, a set of policies that Speaker Nancy Pelosi pursued in the first 100 legislative hours of the 110th Congress (Hulse 2007), the original provisions, which addressed fossil fuel subsidies, were not enacted. The Senate passed its bill in June, followed by the House version and then an agreed version in December.

The legislation also emerged in response to rising and volatile oil and natural gas prices, continuing instability in the Middle East, and a growing concern about the consequences of climate change. President Bush responded to these challenges by calling on Congress, in his 2007 State of the Union address, to reduce gasoline usage in the United States by 20% over the next 10 years and fund additional research into alternative fuel vehicles and technologies—a goal known as the “Twenty in Ten” initiative (The White House 2007).

EISA also followed another piece of major energy legislation, the Energy Policy Act of 2005. EAct 2005 was primarily about energy supply issues, but it did include provisions to encourage energy efficiency in the residential, commercial, and transportation sectors, primarily through appliance efficiency standards and new tax incentives. EAct 2005 was the first comprehensive law addressing energy efficiency since the Energy Policy Act of 1992 (abbreviated as EAct 1992).

Ever since the energy crisis in the 1970s, the federal government has implemented energy efficiency policies and funded projects to create jobs and spur economic growth, reduce energy costs for consumers, increase national security, and improve the environment. EISA, signed by the Republican President Bush, helped the Democratic President Obama springboard many of these efforts, demonstrating the vast potential of bipartisan action on energy efficiency.

THE LAW

EISA built on EAct 1992 and EAct 2005, but turned the focus to energy efficiency and alternative energy sources, with bolder and more aggressive approaches to reducing energy use. The law sought to improve vehicle fuel economy, the efficiency of buildings and appliances, industrial energy productivity, and federal energy management. The key energy efficiency provisions in EISA included the following.

Corporate average fuel economy (CAFE) standards. EISA included the first legislative increase in fuel economy standards for cars and light trucks since CAFE standards were created in

1975, and also initiated standards for larger trucks and buses. Responding to President Bush's "Twenty in Ten" initiative, these new standards set a goal of a 40% increase in car and light truck fuel economy by 2020, with "maximum feasible" increases beyond that date. At the time ACEEE estimated that these standards would account for 44% of all the primary energy savings in the law (ACEEE 2007).

Appliance and lighting energy efficiency standards. Another principal component of EISA were new minimum energy efficiency standards along with reforms to the Department of Energy (DOE) appliance standards program. These provisions were based on consensus agreements between efficiency advocates and industry stakeholders. The law included new standards for ten products, with the largest energy savings coming from the first standards for regular light bulbs, requiring 25–30% less energy usage compared to traditional incandescent bulbs by 2012–2014, and 60% energy savings by 2020. These standards collectively accounted for another 25% of ACEEE's 2007 estimated savings.

Authorizations and federal energy management. EISA authorized several new energy efficiency grant and loan programs, including Energy Efficiency Community Block Grants to help local governments establish energy programs, and reauthorized ongoing programs including the Weatherization Assistance Program. Many other provisions set new targets for reducing energy usage and new energy management requirements for new and existing buildings owned by the federal government, the single largest energy user in the country.

Some other House and Senate provisions were dropped in order to get the bill through to enactment, including requirements for utilities to meet an increasing share of electricity demand through energy efficiency and renewable fuels, further tax incentives, and a provision on strengthening building energy codes. A complete list of energy efficiency provisions in the law is in Appendix A.

CONTEXT OF IMPLEMENTATION

When EISA passed in December 2007, the 2008 presidential campaign was already well underway. Then-Senator Obama campaigned on a promise to make the United States a global leader in addressing climate change. In a speech to the Clinton Global Initiative in September 2008 he made a case for the importance and urgency of this cause: "No single issue sits at the crossroads of as many currents as energy... This is a security threat, an economic albatross, and a moral challenge of our time" (Obama 2008).

By the time President Obama assumed office in January 2009, the economy was in a free fall. In response to the Great Recession, President Obama and Congress passed the American Recovery and Reinvestment Act of 2009 (ARRA or the Recovery Act). The primary purpose of ARRA was to inject large sums of money into the economy in order to save and create jobs immediately. One of its secondary purposes was to develop a clean energy economy, and hence also address climate change. ARRA invested billions of dollars into energy efficiency projects including the weatherization of homes, energy upgrades in federal and commercial buildings, electric vehicle technologies, smart electric grids, and state and city investments in energy efficiency (ACEEE 2015).

EISA provided the statutory authorization language for several programs that were funded under ARRA. Some existing programs that had been reauthorized by EISA received funding because they were well established and had the infrastructure to spend large influxes of money in a short amount of time, while other programs newly authorized by EISA were funded for the first time.

Then in 2010 Republicans regained the majority in the House and gained seats in the Senate. In the face of congressional gridlock President Obama, especially after he was reelected in 2012, turned to agency actions to advance his climate agenda, many of them authorized under EISA. On June 25, 2013, President Obama unveiled an ambitious climate change agenda on a sweltering hot day at Georgetown University. With rolled-up sleeves and sweat dripping down his face, the president outlined steps to cut greenhouse gases, with energy efficiency playing a key part. The *President's Climate Action Plan* included reducing US greenhouse gas emissions and doubling US energy productivity through efficiency standards for vehicles, appliances, and federal buildings under EISA (Executive Office of the President 2013).

The presidential focus on climate change, economic collapse, federal stimulus funding, shifting politics, congressional gridlock, and the administration's attention to existing legislative authority all played important roles in how EISA provisions were implemented.

THIS REPORT

Implementation of policies never goes exactly as expected. But this report will illustrate how energy efficiency legislation can both be bipartisan and make a real difference in promoting policies, programs, and technologies that move the needle for energy efficiency.

Its purpose is to look back and examine the implementation and actual impacts of energy efficiency provisions in EISA. ACEEE has regularly evaluated the implementation of major energy efficiency legislation, including EPAct 1992 (ACEEE and ASE 1997) and EPAct 2005 (Gold and Nadel 2011).

The bulk of this report is a qualitative look at the implementation of a few dozen of the energy efficiency provisions in EISA. We rely heavily on interviews with experts both within and outside of ACEEE, although we also examined government documents and other analyses where available. The experts are acknowledged at the beginning but not generally cited directly in the text.

We also estimate the impacts of selected key provisions on energy use, carbon emissions, and dollar savings, and we compare those estimates to our 2007 projections of likely savings from the law (ACEEE 2007). We end the report with summaries of broad lessons learned and of implementation measures that are still needed.

As noted above, several of the EISA provisions were funded under ARRA. We touch on these provisions and the unique characteristics of implementation in a stimulus package, but will reserve more in-depth analysis and discussion of ARRA programs for future research.

Implementation of Energy Efficiency Provisions by Sector

FUEL EFFICIENCY OF VEHICLES

The passage of EISA was a milestone in the history of vehicle fuel efficiency standards. It restarted an upward trajectory of fuel economy for personal vehicles that had all but come to a halt for decades and mandated the establishment of the first fuel efficiency standards for commercial vehicles.

Cars and Light Trucks

As shown in figure 1 below, Corporate Average Fuel Economy (CAFE) standards for cars and light trucks, first adopted in 1975 in the wake of the oil embargo, resulted in a 69% increase in new vehicle fuel economy over the next 12 years. Following this period of rapid gains were two decades of slowly declining fuel economy. Ongoing technological advances were applied to increasing horsepower and reducing acceleration times rather than saving fuel. In addition, larger sport utility vehicles (SUVs) grew from a negligible share to 40% of personal vehicle sales between 1980 and 1995.

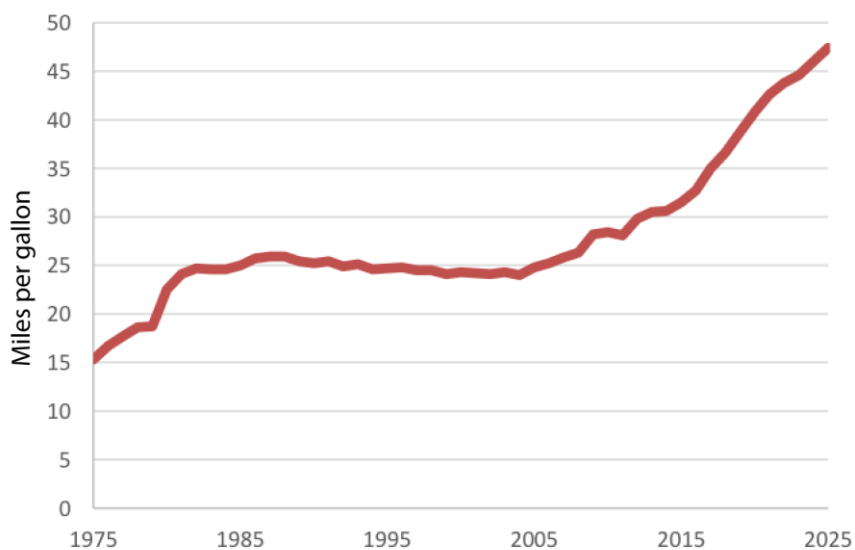


Figure 1. Combined car and light truck fuel economy compliance values, 1975 to 2025 (projected). Fuel economy values through 2013 are historical values. For 2014 onward, values shown are projected average values under the standards set pursuant to EISA.

Attempts to increase CAFE standards legislatively in 1990 and in the early 2000s were unsuccessful, and from 1995 to 2000 Congress used appropriations riders to prohibit the Department of Transportation (DOT) from raising CAFE standards administratively. The administration of George W. Bush adopted rules increasing light truck standards for model years 2005–2011, but the increases were modest and did not apply to cars.

Then came the passage of EISA, requiring that DOT prescribe annual fuel economy increases for cars and light trucks beginning in 2011. The standards were to achieve at least

35 miles per gallon on average by 2020 (as compared with the model year 2006 average of 25 mpg), and the “maximum feasible” level thereafter.¹

STRATEGIC CONSIDERATIONS

A key ingredient of the fuel economy provisions of EISA was the requirement that fuel economy standards be “based on 1 or more vehicle attributes related to fuel economy,” meaning that the specified fuel economy would be a function of some vehicle attribute, presumably one reflecting the utility of the vehicle. This meant that the standards, which previously had been defined as a single number for cars and a single number for trucks in a given year, could be set so that a smaller vehicle would be subject to a higher mile-per-gallon target than a larger vehicle. This change addressed two obstacles that previous bills had been unable to overcome, namely: (1) domestic vehicle manufacturers’ view that they would be disadvantaged by more stringent standards, by virtue of their production of a larger, heavier vehicle mix; and (2) the assertion that higher CAFE standards would have adverse safety impacts.

The attribute that DOT chose as the basis for the standards was vehicle “footprint,” defined as track width times wheelbase, or roughly speaking the area defined by the points of contact between the four wheels and the ground. While this approach arguably was key to breaking the CAFE logjam, it should be recognized that having an attribute-based system reduces the certainty of fuel savings from the program. In particular, if the market shifts toward larger-footprint vehicles, savings will be reduced.

Other notable features of the EISA CAFE provisions included: (1) that credit trading between manufacturers would be permitted under the standards, (2) that manufacturers would be permitted to transfer a limited number of credits between their car and light truck fleets, and (3) that the flexible fuel vehicle (FFV) credit program, dating from the passage of the Alternative Motor Fuels Act of 1988, would be extended through 2019 but phased out beginning in model year 2015. These and other credit provisions provide flexibility to the manufacturers in meeting the standards; in most cases EISA prohibited DOT from taking into account nominal fuel economy gains from the credits in setting “maximum feasible” standards. As described below, the FFV credit counted toward meeting the standard do not generally deliver fuel savings.

IMPLEMENTATION

In 2008, DOT proposed the first post-EISA fuel economy standards, which were to apply to model years 2011-2015 (NHTSA 2008). Average fuel economy under the proposed standards was projected to reach 31.6 miles per gallon in 2015. The rule would have preempted vehicle greenhouse gas standards that had been enacted in California in 2004, but it was never finalized. In 2009, the new Obama administration adopted standards only for model year

¹ Unless otherwise noted, light-duty fuel economy values in this report refer to laboratory values, i.e. those determined through the test procedures specified in the original CAFE law. These are known to be considerably higher than the fuel economy values achieved under real-world driving conditions; fuel economy shown on a new vehicle’s window sticker, which is meant to approximate on-road miles per gallon, is approximately 20% lower than the compliance value, on average.

2011 cars, intended in part to bring cars into the regulatory program for light trucks established by the George W. Bush administration prior to the passage of EISA.

A 2010 rule set standards for both cars and light trucks for model years 2012 through 2016. The standards were projected to achieve an average fuel economy of 34.1 miles per gallon in 2016, thereby setting a pace for fuel economy gains beyond the minimum called for by EISA (35 mpg by 2020). This rule did not preempt California's vehicle greenhouse gas (GHG) emissions standards, and in fact the stringency of these CAFE standards was strongly influenced by the California standards. The US Environmental Protection Agency developed the first federal GHG standards for vehicles in parallel with DOT's rule. In light of the large overlap between technologies to improve fuel economy and those to reduce GHG emissions, DOT, EPA, and the California Air Resources Board (CARB) coordinated their standards to produce a single national program that would regulate both fuel economy and GHG emissions from vehicles starting in the 2012 model year.

A crucial ingredient in the success of this CAFE rulemaking was the support of the auto industry, reversing its longstanding opposition to higher standards. Manufacturers' concern that California might retain its own standards, more stringent than federal standards, led them to be more open to strong federal standards, and the Obama administration obtained commitment letters from most auto makers in support of the "single, national program," as the harmonized rules of the agencies were known. Federal loans to US automakers beginning in the 2008 auto crisis and the subsequent bankruptcy of two manufacturers (General Motors and Chrysler) in 2009, which led to the government's becoming a significant shareholder in both, are also generally believed to have been factors in domestic manufacturers' willingness to support the standards.

The next rule, adopted in 2012, set standards for model years 2017 to 2025 that are projected to achieve an estimated average of between 48.7 and 49.7 miles per gallon in 2025 (EPA and NHTSA 2012). This rule, which also received broad industry support, was intended to provide certainty regarding fuel economy requirements far enough into the future to allow manufacturers to develop new technologies to meet the standards while continuing to fulfill other business requirements. Fuel economy standards set pursuant to EISA will result in roughly a doubling of average fuel economy between model years 2008 and 2025.

Expectations are that this dramatic increase in fuel economy will be achieved largely through evolutionary improvements to conventional gasoline-powered vehicles. In setting the standards, the agencies sketched out a plausible technology compliance path, in which conventional vehicles make up two-thirds of sales in 2025, with mild hybrids accounting for most of the remainder, as shown in figure 2.

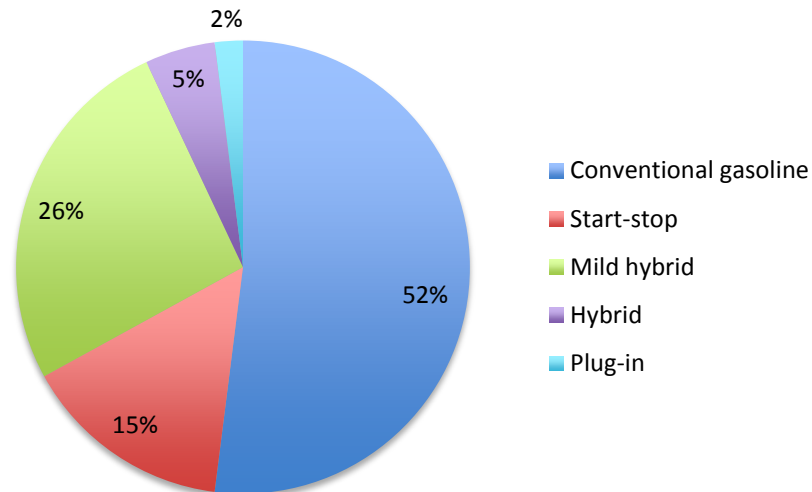


Figure 2. Powertrain types in 2025 CAFE compliance scenario.
Source: EPA and NHTSA 2012.

Among the technologies expected to contribute most to raising the fuel economy of conventional vehicles is turbocharging, together with engine downsizing. The rate of turbocharged vehicles entering the market has accelerated with the adoption of the standards, as shown in figure 3.

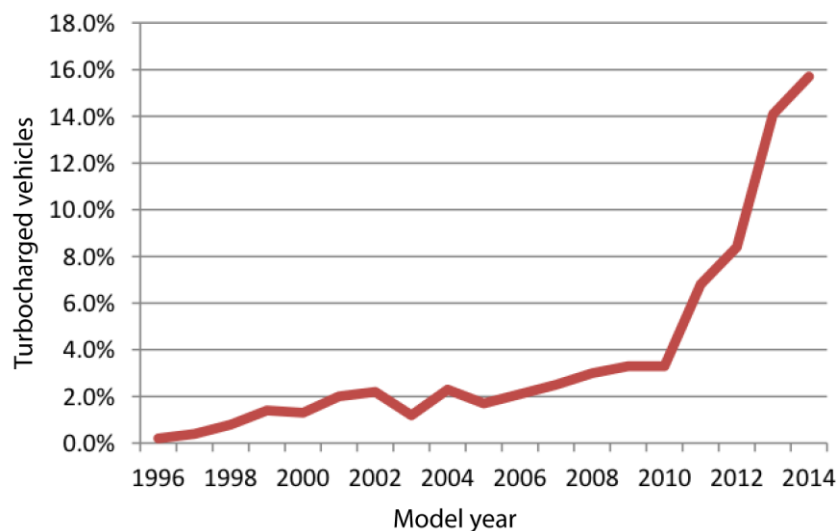


Figure 3. Penetration of turbocharging in new vehicles, 1996–2014. Source: EPA 2014.

DOT estimates that the technologies to meet the standards for MY 2012–2025 will raise the price of the average light-duty vehicle in 2025 by between \$1,870 and \$2,120 (NHTSA 2012a). Using the Energy Information Administration's (EIA's) fuel price projections at the time of \$3.87 in 2025 yielded a payback of the incremental price of the more efficient vehicles in less than three years.

Credits and other flexibilities provided in the EISA CAFE provisions and built upon by the rules that followed have proven an important part of manufacturer compliance. Using data

from EPA's manufacturer compliance report for the GHG emissions program in model year 2013 (EPA 2015a), it is possible to calculate the approximate effects of certain credits. Prior to the application of credits, average fuel economy of cars and trucks would have fallen short of the value required under the standards by about 0.3 miles per gallon. With credits applied, primarily FFV credits and to a lesser extent credits for air-conditioning efficiency improvements, average compliance values exceeded the required value by about 0.9 miles per gallon. Manufacturers are seeking to use "off-cycle technology" credits to a significant degree in the future as well.² Another flexibility of the program that arises from EISA provisions and has already been used extensively is the sale and purchase of credits between manufacturers. While there was skepticism early on regarding manufacturers' willingness to engage in such transactions with competitors, this market has attracted participation not only of electric vehicle manufacturers (credit sellers) and luxury vehicle manufacturers (credit buyers), but from the largest manufacturers as well.

Many of the credit provisions of the program provide flexibility to manufacturers without detracting from fuel savings, but others, including the FFV credit, lower the real fuel economy delivered by the standards. Flexible fuel vehicles can run on two different fuels, usually gasoline and ethanol (E85). They generate credits but do not save petroleum because they run almost entirely on gasoline due to limited availability of E85 and lack of a sufficient or steady price advantage. This consideration was built into the agencies' estimates of the fuel savings due to the new standards, however.

With regard to the dependence of fuel savings on sales mix, vehicles have indeed been larger than predicted by the agencies and therefore have achieved a lower average fuel economy than projected in the rules. To date this discrepancy has been small; data from EPA's compliance report indicates a required average fuel economy in 2013 that was 0.6 miles per gallon lower than would have been required for the agencies' projected sales mix. If gasoline prices remain well below the agencies' assumed values (\$3.87 in 2025), average fuel economy, and hence fuel savings, achieved under the program could fall substantially short of projections. The possibility exists that the structure of the standards has helped to push the market toward larger vehicles (Whitefoot and Skerlos 2012), but there is no consensus on this point.

Medium- and Heavy-Duty Vehicles

EISA directed DOT to set fuel efficiency standards for heavy-duty vehicles, i.e. trucks, buses, and other vehicles having gross vehicle weight rating of more than 8,500 pounds. These vehicles had not previously been subject to fuel efficiency standards. They currently consume less than half (44%, EIA 2015a) as much fuel as light-duty vehicles consume in the aggregate, but their fuel use is projected to grow in the coming decades, while light-duty consumption should decline. Although fuel is among the largest expenses of truck fleets, a trend toward greater fuel efficiency has not been evident in the new heavy-duty vehicle

² Off-cycle credits are for technologies that yield real-world fuel savings that are not detected in certification testing. For example, start-stop systems save fuel by turning off the vehicle at idle.

market. In particular, tractor-trailer miles per gallon remained roughly the same for several decades prior to the implementation of the standards (Davis, Diegel, and Boundy 2014).³

EISA did not prescribe a particular stringency for the heavy-duty standards, but required only that they be “designed to achieve the maximum feasible improvement.” It set out a timeline for the first rule, along with requirements for lead-time and regulatory stability. Recognizing the complexity of this vehicle sector and the shortage of information about its technological opportunities and operation, EISA called for a study by the National Academy of Sciences (NAS) to assess the applicable fuel efficiency technologies, to be followed by a DOT study to determine appropriate test procedures and metrics to measure fuel efficiency performance and the various factors affecting the fuel consumption of heavy-duty vehicles. The NAS study, which was issued in 2010, provided substantial technical input to the agency rulemaking (NRC 2010).

IMPLEMENTATION

DOT adopted the first phase of the program in 2011, setting standards for tractor trucks, heavy-duty pickups and vans, and vocational vehicles (all other trucks and buses) for the 2014 to 2019 model years, though the standards were voluntary for years 2014 and 2015. While certification protocols for pickups and vans are similar to those for their light-duty counterparts, the program for tractor-trailers and vocational vehicles is quite different. DOT set separate engine standards in these categories, and the certification of the vehicles themselves is accomplished through a vehicle simulation model, rather than by physical testing. In addition, the standards for tractor-trailers and vocational vehicles are set for each vehicle category (currently a dozen of them), while the standard for pickups and vans varies with payload and other capabilities (the light-duty standard varies with footprint, as described above).

As in the case of the light-duty program, the Obama administration gained buy-in from key stakeholders in advance of proposing the first rule. Major heavy-duty vehicle and parts manufacturers signed letters in 2010 indicating their support for standards that would reduce vehicles’ fuel consumption by up to 20% by 2018 using existing technologies, and they appeared in a White House Rose Garden ceremony to announce the program one year after a similar event for the car and light truck standards.

The first heavy-duty standards are projected to reduce new heavy-duty vehicle fuel consumption by 16% on average by model year 2018 (ACEEE et al. 2014). Putting in place a workable program for this diverse sector was a substantial achievement, but the standards did not take full advantage of the technologies available, or promote the development of more advanced technologies. A second phase of standards was proposed in June 2015 (EPA and NHTSA 2015) and will be finalized in early 2016. These standards, which would apply to vehicles out to model year 2030, would drive greater technology advances and fuel

³ According to a report by the National Research Council (NRC 2010), gallons per ton-mile (gallons of fuel used to transport one ton of freight one mile) – arguably the appropriate metric for freight truck fuel efficiency – has dropped sharply over the past 30 years. However this appears to be largely the result of increased load factor, rather than improved vehicle efficiency.

Truck Efficiency Standards: User Satisfaction

While both vehicle manufacturers and the trucking industry are typically wary of the tightening of tailpipe standards due to the cost of reducing conventional pollutant emissions, they have been more open to fuel efficiency and greenhouse gas standards due to the potential for reducing fuel costs. EPA estimated that most vehicles meeting the Phase 1 standards would pay for the added cost with fuel savings in under one year.

The industry's take on implementation of the standards to date has been positive. Ryder President Scott Perry saw strong truck orders in 2014 as "accruing from a number of distinct factors. First are operational advantages—predicated upon fuel efficiencies—achieved from trucks built to meet the 2014 greenhouse gas regulation" (Transport Topics 2015a). In anticipation of the second phase of the standards, Brian Mormino of Cummins, Inc. noted that "the government implemented its previous greenhouse-gas regulation last year 'without a bump in the road'" (Transport Topics 2015b).

savings through powertrain integration, better tractor aerodynamics, more realistic test cycles, and inclusion of trailers in the rule, among other improvements. The proposal omits certain important savings opportunities, especially in tractor engines, but this could change in the final rule. The Phase 2 standards as proposed would achieve up to 24% reduction in fuel consumption for high-consuming tractor-trailers relative to the Phase 1 standards; other regulated categories would realize lesser savings (EPA 2015b).

Along with the technical challenges of developing the more ambitious Phase 2 program have come greater political challenges as well. Manufacturers have been at odds on key features of the program under development, especially the question of whether separate engine and vehicle standards should be continued into the second phase. However the industry's public response to the proposal thus far has been largely positive.

Figure 4 shows oil savings projected for the light- and heavy-duty fuel economy standards adopted to date and the proposed Phase 2 heavy-duty standards, relative to levels that would have been achieved without the EISA provisions.

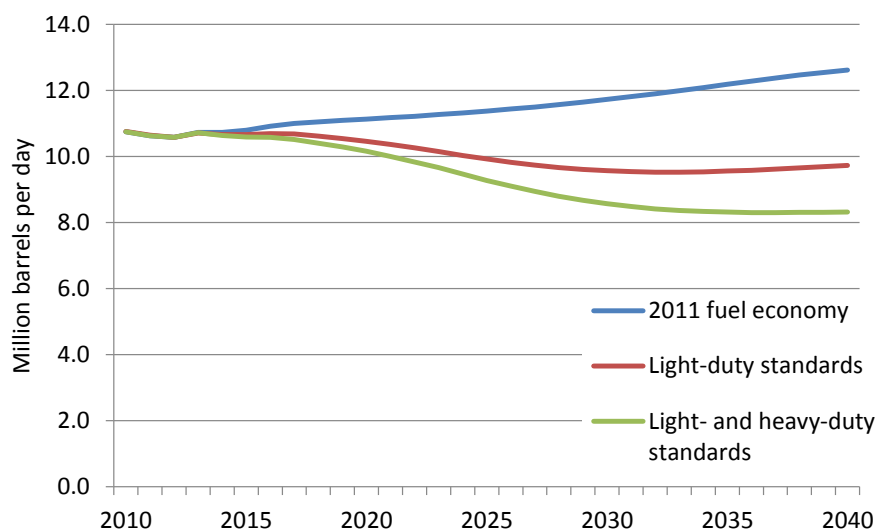


Figure 4. Light- and heavy-duty vehicle consumption with and without fuel efficiency standards pursuant to EISA

Consumer Information

EISA contained provisions to improve consumer information on vehicle fuel economy and related matters. On-road fuel economy had long been known to lag substantially behind fuel economy certification values, and consequently EPA applied adjustments to vehicles' certified fuel economies to create the mile-per-gallon values on the Monroney sticker (see figure 5) affixed to the window of a new vehicle.



Figure 5. New fuel economy and environment label. *Source:* EPA 2011.

In a 2006 rule, EPA updated its approach to the adjustment methodology to reflect changes in vehicle technologies and driving patterns. EISA required that EPA review the accuracy of the labeling procedures at least every five years and determine whether a change is warranted. It also required that information be included on vehicle labels regarding greenhouse gas and other emissions of the vehicle, as well as a clear indication, when appropriate, that the vehicle is capable of operating on an alternative fuel.

EISA also directed DOT to promulgate rules establishing a tire fuel efficiency consumer information program and to “conduct periodic assessments” to gauge the effectiveness of the program for consumers, the level of industry cooperation, and the ability to contribute to national energy consumption goals. Generally, manufacturers equip new vehicles with tires that contribute to high fuel efficiency, because tire performance is reflected in the vehicle’s CAFE value. There is no such incentive for high efficiency in the replacement tire market, however, and consumer information on replacement tire efficiency has been limited.

IMPLEMENTATION

In 2011, EPA and NHTSA jointly adopted a rule revising the Monroney label for vehicles, applicable starting in the 2013 model year (EPA 2011). The new labels are technology specific, and provide environmental and fuel cost information that was not part of the previous label. The new fuel economy label for a plug-in hybrid vehicle is shown in figure 5.

DOT adopted the rule nominally establishing the tire fuel efficiency consumer information program (TFECIP) required by EISA in 2010. The rule specified test procedures for tire manufacturers to measure rolling resistance, wet traction, and treadwear, which are key indicators of fuel efficiency, safety, and durability, respectively. It did not include requirements for the consumer information and education components of the program, however, because comments to the agency indicated that further consumer research was needed in order to design an effective program (NHTSA 2012b). In December 2014, DOT announced its goal of finalizing a rule establishing a tire fuel efficiency consumer information program by 2017 (The White House 2014).

Loan Programs for Advanced Vehicle Technologies

EISA included several loan programs aimed at promoting vehicle fuel efficiency, advanced battery technologies, and green manufacturing jobs. Section 134 of the act modified a grant program in EPAct 2005 to include loan guarantees for the production of parts for hybrid and advanced diesel vehicles; Section 135 authorized loan guarantees to private companies developing advanced vehicle batteries and battery systems; and Section 136 authorizes the Advanced Technology Vehicles Manufacturing (ATVM) loan program, supporting loans to automobile manufacturers and components suppliers for advanced technologies for vehicles under 8,500 pounds.

Section 134 suffered the same fate as Section 712 of EPAct 2005, the provision it amended – the program has so far received no funding.

The Advanced Battery Loan Guarantee Program created under Section 135 authorizes “such sums as necessary” for loan guarantees for applicants who are unable to secure credit on reasonable terms and can provide sufficient assurance of repayment. This loan program has not been implemented as defined under EISA, though a similar grant program was created under ARRA. The Electric Drive Vehicle Battery and Component Manufacturers Initiative provided \$2 billion in ARRA funding to 30 awardees, with 20 facilities focused on producing advanced batteries and 10 facilities building electric drive components. Federal funds were matched by \$2 billion in private financing by grant recipients. In 2009 only two facilities in the United States were manufacturing advanced vehicle batteries, accounting for less than 2% of the world’s advanced vehicle batteries (DOE 2009a). These grants were essential to building an advanced battery supply chain in the United States, and now the Chevy Volt and several other electric and hybrid vehicles use domestic batteries (Canis 2013; Howell 2014).

In contrast to the loan guarantee programs for vehicle technologies described above, the Advanced Technology Vehicles Manufacturing Incentive Program was funded as authorized in Section 136 of EISA (with small amendments). EISA authorized up to \$25 billion in loans to promote energy efficiency in vehicles and bolster domestic

manufacturing. Congress subsequently funded the program in fiscal year (FY) 2009 appropriations, providing \$7.5 billion for credit subsidy costs of the loans, enough for up to \$25 billion in loans.

As shown in table 1, between 2009 and 2011 DOE awarded \$8.4 billion in loans to five companies: Fisker, Ford, Nissan, Tesla, and The Vehicle Production Group (VPG). Two of these loans defaulted shortly after they were issued. DOE lost \$139 million on a loan to Fisker Automotive, which declared bankruptcy in 2013, and \$42 million when VPG went under that same year (Canis and Yacobucci 2015). As a result of these public failures, the ATVM program has been especially criticized by Republicans, arguing that DOE invests in unsuccessful business at a detriment to the American taxpayer. However DOE records show that their Loan Programs Office (LPO) has historically been quite successful in “picking winners and losers.” LPO’s losses are only 2% of total loan commitments, and those losses have been exceeded by more than \$1.1 billion earned in interest (LPO 2015a). For the ATVM program the losses have been a similar percentage.

Table 1. Approved ATVM loans before 2015

Company	Date	Status	Loan amount
Fisker Automotive	April 2010	Defaulted	\$529 million
Ford Motor Company	September 2009	Ongoing	\$5.907 billion
Nissan North American, Inc.	January 2010	Ongoing	\$1.448 billion
Tesla Motors	January 2010	Repaid	\$465 million
The Vehicle Production Group LLC	March 2011	Defaulted	\$50 million

Source: Canis and Yacobucci 2015; LPO 2015b.

However partisan bickering was not the only source of criticism that the ATVM program received. ATVM loan program applicants and other auto manufacturers claimed in a US Government Accountability Office (GAO) report that the costs of participating in many cases outweighed the benefits. The loan application process was complicated and burdensome, with restrictive loan and reporting requirements. The negative publicity of other DOE programs, such as the high-profile failure of the solar company Solyndra after a DOE loan and a presidential visit, caused automakers to be more hesitant when attaching their names to a government-supported program (GAO 2014). Besides reduced demand, the program has been limited by the need for appropriations to pay for administrative costs, as EISA limited loan fees to \$100,000 or 0.1% of the loan amount. The program has also been limited by the EISA language to light-duty vehicles, although there may be a similar need for financing for heavy-duty vehicle facilities. Arguably, in addition, the program is only contributing to meeting the CAFE standards rather than resulting in additional fuel savings (although it can also be argued that complementary policies are important to achieving CAFE savings).

The same GAO report recommended that Congress consider rescinding the remaining \$4.2 billion in credit subsidy appropriations unless DOE could provide evidence that demand for the program still existed and there were competitive applicants. The House has voted several times to transfer the remaining funds. The House Budget Committee’s FY 2015

budget resolution cited a lack of demand for these vehicles and one project that unintentionally funded jobs overseas (House Budget Committee 2014). However the Senate has never agreed.

Despite the criticism, the ATVM program moved the needle for investments in advanced vehicle technologies for several companies. Ford upgraded US facilities to manufacture new technologies such as the Ecoboost engine and increase fuel efficiency of more than a dozen vehicles, and converted an estimated 33,000 employees to “green” manufacturing jobs. Nissan retrofitted a facility in Smyrna, Tennessee, converting it to one of the largest advanced battery manufacturing facilities, capable of producing more than 200,000 batteries per year (LPO 2015b). This upgrade enabled Nissan to move the production of their Leaf electric car from Japan to the Smyrna plant in 2012. Tesla reopened the former Toyota–GM plant in Fremont, CA to manufacture an all-electric midsize sedan, the Model S, and built a manufacturing facility to produce battery packs, motors, and other electric components (GAO 2011a). In February 2013, Elon Musk announced Tesla had paid off its loan five years early. To date, DOE estimates the ATVM program has “resulted in the manufacture of more than 4 million fuel-efficient advanced vehicles, supported approximately 35,000 direct jobs, and saved more than 900 million gallons of gasoline” (Davidson 2015).

In April 2014, Secretary of Energy Ernest Moniz announced that DOE was revamping the ATVM loans program to be more flexible and responsive to the needs of automobile manufacturers. With over \$16 billion in remaining loan authority under the ATVM loan program, DOE indicated that it is eager to work with manufacturers to more effectively achieve higher fuel economy standards, respond to rising consumer demand for fuel efficient vehicles, and support green jobs in the United States. In March 2015, DOE announced its first new loan recipient in four years. Alcoa Inc. received a \$259 million loan to expand a facility in Tennessee to manufacture high-strength and lighter-weight aluminum that will improve gas mileage (Ramsey 2015). Applications for more than \$2 billion in loans are now in the pipeline.

APPLIANCES AND EQUIPMENT

The second key component of EISA was energy and water efficiency standards for appliances, equipment, and lighting, as well as energy use labeling. Appliance efficiency standards have been among the most effective government energy efficiency policies. Starting in the 1970s, Congress first authorized and then required the Department of Energy (DOE) to set minimum efficiency standards for energy-using equipment. With DOE making very slow progress, Congress intervened and established a dozen standards in the National Appliance Energy Conservation Act of 1987 (NAECA) along with a firm schedule for future updates. Yet DOE continued to have difficulty setting standards. Only two standards were set under President Bush in the seven years before EISA, and by 2007 a number of required rules were years or even decades past due. Instead, over the years dozens of standards were negotiated between manufacturers and efficiency advocates, and then enacted in legislation—in NAECA, the Energy Policy Act of 1992, the Energy Policy Act of 2005, and then EISA, which were signed by Presidents Reagan, George H.W. Bush, and George W. Bush, respectively (Lowenberger et al. 2012, Appendix B; DOE 2015a).

Thus EISA included ten standards specified in the law, specific direction to DOE to update six of those ten standards and to set or update three others, and several reforms to the DOE standards program. The most important of these standards, and most controversial in its implementation, concerned light bulbs. In this section, we will first discuss the light bulb standard, then the other standards in the law followed by the standards DOE was directed to set, and, finally, the reforms to the program. A list of the EISA standards and key implementation dates is in Appendix B.

As shown in the Energy Savings and Impacts section below, these standards are achieving large electricity savings. We estimate that the standards collectively will save 92 terawatt-hours of electricity in 2020, rising to 170 terawatt-hours in 2030, about 4% of expected US electricity use in that year. The present value of net savings after additional costs comes to \$240 billion. About a third of the energy savings, and more than a third of the monetary savings, are from the light bulb standard.

Light Bulb Standard

The light bulb standard has been one of the most important provisions of EISA and one of the most controversial. The standard sets required efficiency levels for regular light bulbs, as shown in table 2.

Table 2. Light bulb standards and effective dates

Standard	Covered bulbs	Brightness	Standard	Effective date	Bulbs that comply
Initial standard	40 W equiv.	~450 lumens	≤ 29 W	January 2014	Halogen, CFL, LED
	60 W	~800	≤ 43 W	January 2014	
	75 W	~1100	≤ 53 W	January 2013	
	100 W	~1600	≤ 72 W	January 2012	
First update	All		≤ ~11-36 W?	January 2020?	CFL, LED?
Second update	All		TBD	January 2025?	

The first update is due by January 1, 2017, is to take effect at least three years after it is issued, and is to yield at least as much savings as a backstop standard of 45 lumens per watt (W), which otherwise takes effect January 1, 2020. The second update is due January 1, 2022, is to take effect at least three years after it is issued, and is to be at least as stringent as the previous update. See text for more explanation on the bulbs.

The standards in the law are performance based and technology neutral. Although traditional incandescent bulbs use more energy than allowed, the standards are met by compact fluorescent lamps (CFLs) and by two technologies that were only beginning to come onto the market in 2007: halogen incandescent (incandescent bulbs with a halogen capsule inside) and light-emitting diode (LED — a semiconductor technology). Figure 6 shows examples. DOE is directed to set a stronger standard by January 2017. This revised standard must save at least as much energy as a “backstop” standard of 45 lumens per watt for all covered bulbs (a level exceeded by LED and CFL light bulbs).

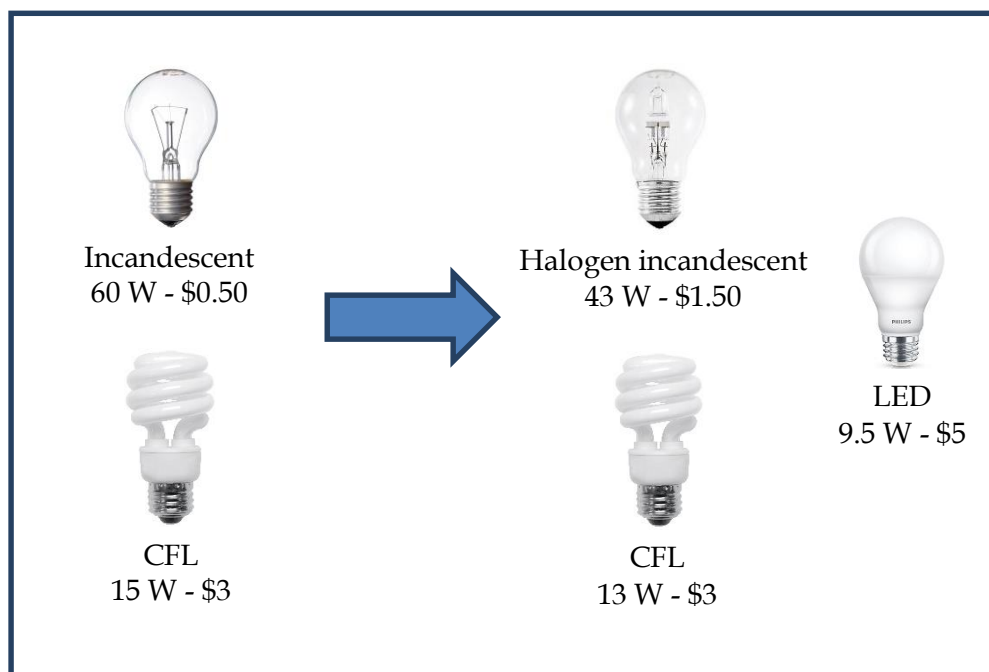


Figure 6. New light bulb options available in the wake of the light bulb standard. Wattages and prices are typical values for bulbs equivalent to a 60 W incandescent, but can vary widely.

POLITICS

The light bulb standard, like others in the bill, was based on a consensus agreement between the major manufacturers, efficiency advocates, and others. Although it received significant media attention at the time as the end of the Edison light bulb, it was not particularly controversial. Both the House and Senate supported standards on a bipartisan basis, and there was no attempt to remove the provision from the bill. That changed with the rise of the Tea Party movement in the summer of 2010, which considered the standard a prime example of government overreach. Although key stakeholders, including the manufacturers, continued to support the standard, ideological opposition grew. When Republicans became the majority in the House of Representatives in 2011, serious efforts to overturn the standard began, culminating in a rider in the FY 2012 appropriations bill that bars DOE from implementing or enforcing the standards, as well as the EISA standards on incandescent reflector lamps. The rider has been continued in subsequent appropriations bills.

Contrary to some media reports, the rider did not end the standard; it barred federal implementation and enforcement of the standard. The standard remains the law, and there are even other potential avenues of enforcement by states and through citizen lawsuits. There is no evidence of manufacture or import of light bulbs in violation of the standard (though a few retailers are still selling light bulbs that were stockpiled before the standard came into effect).

Instead opponents of the standard have succeeded only in making it slightly more onerous for manufacturers and consumers, and perhaps in making the next standard more challenging to meet. DOE believes it cannot help interpret the standard, leaving manufacturers to interpret it in different ways. Thus at least one manufacturer has decided

it cannot offer a product that it is not sure meets the standard (a halogen bulb to replace a 75 W traditional incandescent) even though competitors are selling the same product. DOE also believes it cannot work on the follow-on standard, thus leaving a fixed backstop in place (45 lumens per watt for all bulbs) instead of allowing DOE to develop a standard more tailored to capabilities for different bulbs. The rider also is preventing DOE from developing standards for some currently unregulated incandescent reflector bulbs (the kind often used in track lighting), including bulbs such as the 65 watt (bulged reflector) BR bulb that now constitute more than half the reflector lamp market, even though halogen and LED reflector bulbs yield similar savings as for regular bulbs.

Although the rider continues in force, political interest in the issue appears to have dwindled. 2011, 2014, and 2015 votes on the issue in the House of Representatives had nearly identical results. And as shown in figure 7, Google searches for “light bulb ban” peaked in 2011 and early 2012, and have dropped rapidly since the standard began to take effect (with a brief blip around the last effective date in January 2014).

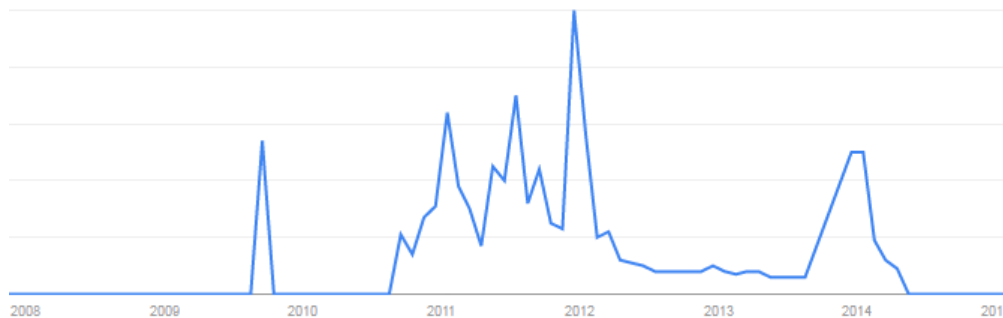


Figure 7. Relative number of Google searches for “light bulb ban” in the United States over time.
Source: Google Trends 2015.

IMPLEMENTATION

While the politics swirled around the light bulb standard, its actual implementation has proceeded. As manufacture and import of traditional incandescent bulbs have phased out, manufacturers have been introducing replacement halogen incandescent and LED bulbs, as well as selling more CFLs. Retailers have stockpiled incandescent bulbs and continued to sell them a year or more after the standard took effect (Dimetrosky and Parkinson 2014).

As those stocks have dwindled, consumers have switched to the three alternatives. At the time the standard was negotiated, CFLs were the cheapest alternative. However the newer halogen incandescents came down rapidly in price and in many stores are the cheapest option (considering only initial purchase price). In addition, many consumers dislike CFLs for various reasons. Thus, as shown in figure 8, the halogen bulbs have taken most of the market share of traditional incandescents since the standard began taking effect (although CFL and LED sales also have grown). As halogen bulbs use close to three times as much

electricity as equivalent CFLs, this has substantially reduced energy savings from the standard, though perhaps reduced opposition as well.⁴

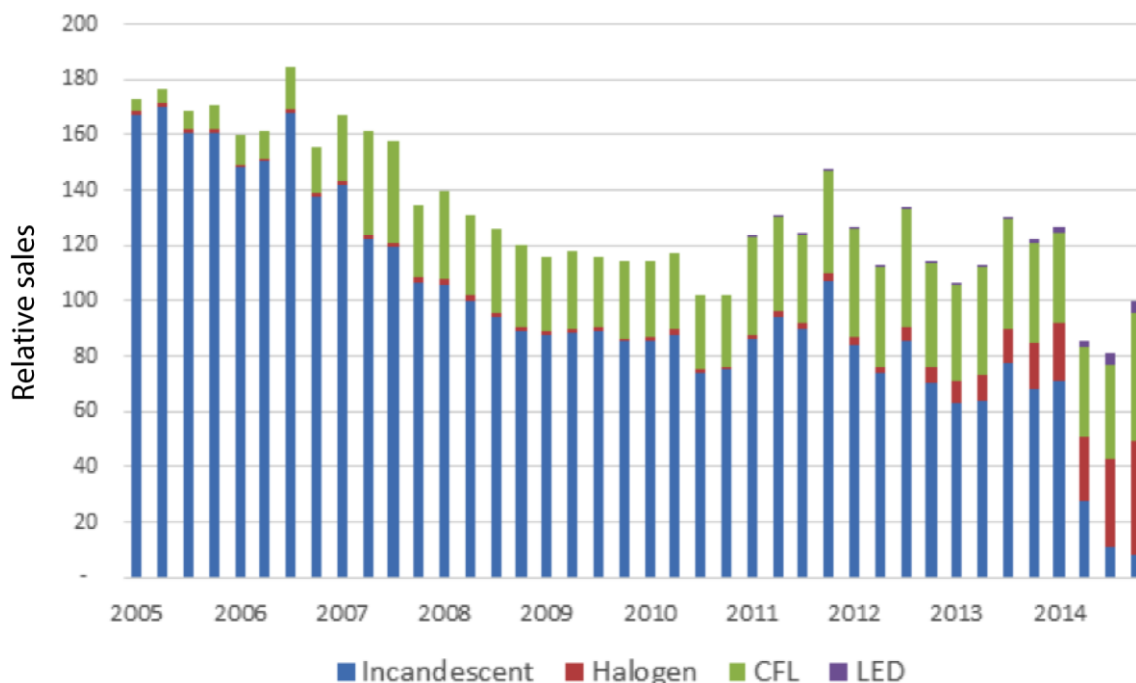


Figure 8. Changing sales of various kinds of light bulbs by quarter shows rise of incandescent halogen bulbs. *Source:* Based on data from National Electrical Manufacturers Association (as in NEMA 2015).

The price of LEDs has also come down rapidly and is expected to continue doing so—as of the time of this writing 60 W equivalent LED bulbs are available in some stores for under \$3. In addition, manufacturers have expanded LED product lines to cover the full range of light output and shapes and sizes of bulbs. Consumers generally like the light, as well as the long life, instant brightness, lack of mercury, and for most bulbs dimmability. But they are confused by the variety of color, directionality, and dimmability (see below on labeling). And there have been some quality issues, including a successful lawsuit by the Federal Trade Commission on false labels and marketing (FTC 2014)—unlike for CFLs, the federal standards do not address quality. ENERGY STAR does have quality criteria, and California is considering a quality standard for LED bulbs.

As they become competitive, LEDs may squeeze the market share of both CFLs and halogens. McKinsey & Company predicts 70% of the lighting market by revenue will be LEDs by 2020 (McKinsey & Company 2012); Navigant predicts almost half of bulb sales (adjusted for usage) will be LEDs by 2020 and 100% by 2031 (Navigant Consulting 2014).

⁴ The sales data may present a misleading picture of the relative preference. As CFLs and LEDs last much longer than halogens, the portion of such bulbs in sockets is presumably much greater than the relative sales. An additional factor affecting energy savings is that, although there are no public sales data, modified spectrum bulbs now take up a significant portion of shelf space in stores. As these have weaker standards and give off up to 25% less light than comparable halogen bulbs, users are likely to migrate to higher wattage bulbs.

Since LEDs are more efficient even than CFLs, and increasingly so, this should increase the long-term savings from the standard, as well as enabling the follow-on standard.

Other Standards in the Law

In addition to setting a new standard for regular light bulbs, EISA updated standards for some incandescent reflector bulbs and metal halide light fixtures; residential clothes washers, dishwashers, dehumidifiers, and boilers; and electric motors. It also set new standards for external power supplies and commercial walk-in coolers. Perhaps the most notable change was that the standards for clothes washers and dishwashers regulated water use as well as energy use for the first time. For residential boilers design requirements (e.g., no pilot light for gas boilers) were added to the performance standards. These standards achieved through legislation approaches that DOE did not believe it had the authority to adopt under existing law.

The standards have largely been implemented without major controversy or problems, which may be a benefit of the process in which the manufacturers that have to meet the standards agreed to them. For all but boilers it took DOE more than a year, until March 2009, to finalize a rule that transferred the standards from the law to federal regulation. But as the standards were in law, they applied and were largely followed anyway.

White Goods: The Value of Cooperation

Efficiency advocates and manufacturers have a history of cooperating on standards for refrigerators, clothes washers, dishwashers, and other white goods. A series of negotiated agreements have provided flexibility and avoided controversy.

Agreement on the EISA standards on clothes washers, dishwashers, and dehumidifiers was possible because they were part of a package that also included direction to DOE to update the standards, an extension of and changes to a tax credit for manufacturers of efficient appliances, and recommended criteria for ENERGY STAR appliances. These standards included water efficiency requirements that DOE did not believe it could add to the existing energy standards, as well as an effective date for dishwashers that DOE could not have set. A standard for refrigerators was not included because of the difficulty of raising the bar for what had become a very competitive, low-margin product. In the end, all tax provisions were removed from EISA, so manufacturers did not receive that important carrot for greater efficiency until October 2008 (PL 110-343).

In 2010, manufacturers and advocates agreed on another package that included standards EISA required DOE to set for refrigerators, clothes washers, and dishwashers, as well as standards for clothes dryers and room air conditioners, and further tax credit changes and ENERGY STAR recommendations. The standards further reduced energy use by up to 30% for refrigerators, 26-52% for clothes washers, and 14% for dishwashers, with estimated net savings to consumers of almost \$30 billion (ASAP 2010). These levels were much more stringent than those considered just three years earlier, including for refrigerators, in part because of market changes due to the tax credits and ENERGY STAR. This time the legislation was blocked, but DOE implemented the standards in 2011 and 2012 (using the direct final rule authority granted in EISA for clothes washers and dishwashers). The tax credit changes had already been enacted in 2010 (PL 111-312).

Some issues did come up in applying the standard for external power supplies (the little boxes that connect a wide range of electronics to wall outlets), perhaps because the manufacturers and customers of this product, which had no efficiency standard, were not as attuned to potential problems. Two technical fixes were later negotiated and enacted, one to address a concern on security systems and one to exempt some replacement parts for existing equipment (PL 111-360 and PL 113-263). Meanwhile, under a revised standard hundreds of millions of boxes will soon be turning less electricity into heat, saving consumers hundreds of millions of dollars.

Standards to Be Set by DOE

Despite DOE's track record of delays, EISA directed DOE to update four of the standards in the bill, on clothes washers, dishwashers, walk-in coolers, and external power supplies (all except dishwashers to be set within about four years of enactment). EISA also directed DOE to update the refrigerator standard and set a standard for furnace fans, and it modified directions to set a standard for battery chargers. In addition, a broad provision on regular updates of the standards applied to many more products, and is discussed below. These rulemakings were added on top of an aggressive schedule from a 2006 settlement of a lawsuit over rulemaking delays as well as other existing deadlines for updates from previous laws.

Besides the spur of congressional oversight and the lawsuit, President Obama came into office with a commitment to appliance standards as an energy efficiency policy, and signed a presidential memo in February 2009, shortly after taking office (The White House 2009). DOE work on appliance standards surged. Almost all of the standards specifically required in EISA have been completed, although three of them were more than a year late.

The walk-in cooler and freezer standard was one of those. DOE had trouble setting the standard, and was over two years late in issuing it (in part due to a long delay in the Office of Management and Budget [OMB] review). When they did, manufacturers challenged it in court. Walk-in coolers and freezers typically are assembled in the field using components that often are purchased from multiple manufacturers. EISA set prescriptive requirements on components of the walk-ins but directed DOE to set broad performance-based standards. Performance standards allow manufacturers more flexibility; manufacturers generally prefer them, and they can lower the cost of achieving energy savings. But for this product a single performance standard was not feasible, so DOE set performance standards for separate components. Although there was broad support for this approach, manufacturers believed that DOE made errors in developing the actual standard levels.⁵

Battery charger standards also have been challenging, in part due to the interplay of state and federal requirements. DOE proposed a standard on battery chargers in March 2012, almost nine months after the final standard was due. However efficiency advocates and the

⁵ The furnace fan standard required by EISA is another example of a new component standard. Previously only the natural gas use of furnaces was regulated. Rather than try to come up with a new metric encompassing the electricity use by the furnace fan, there now are separate standards on the natural gas and electricity use. The same issue comes up in regulating standby power, as described below.

State of California objected that the proposal would actually cause greater energy use by preempting a stronger California standard (also adopted by Oregon). Thus, counterintuitively, they supported further delay to allow DOE to reconsider its analysis. Some manufacturers sought to have the proposal issued promptly in order to create a more efficient national market. When DOE did further analysis, it found that at least 95% of products sold nationally comply with the California standards. DOE issued a supplemental proposed standard in September 2015 that is at least as stringent as the state standard for all product categories. Thus the standards are years overdue, but the impact of the delays on energy savings has been relatively small due to the national effects of California regulation.

Changes to DOE Process and Authority

Given the major delays that continued to beset the DOE appliance standards program at the time, EISA also included several provisions intended to speed up rulemaking and allow more effective standards. These provisions also were negotiated between manufacturers and advocates, although a couple were first proposed by DOE.

UPDATES TO STANDARDS AND TEST PROCEDURES

For most products, technology improves over time, production becomes more efficient, and markets shift, allowing more stringent cost-effective efficiency standards. Many of the negotiated agreements included not only the legislated standards but also deadlines for one or more future updates. However the law did not require updates for some standards, and for others the updates themselves became outdated. In addition, deadlines to update test procedures were rare despite changes in technology and usage. Thus EISA section 305 included provisions requiring DOE to consider updating test procedures every seven years and standards every six years; for standards if DOE determines an update is warranted, it has another two years to finalize any change to the standard.

These updates have been added onto DOE's packed agenda. Combined with the standby power requirement (see below), this has meant that DOE has updated most test procedures before setting updated standards. In one snapshot, there were 43 test procedures on DOE's rulemaking schedule in 2010 (DOE 2010).

A number of standards also were added to DOE's plate: more than 10 rulemakings are on DOE's docket due to the update provision, and more are planned. This provision may become more important as there are more products without specified update timetables in the law.

Manufacturers have expressed concern that the review cycle is too fast, that DOE is forced to do analysis on products before the previous standard has taken effect (and also on lack of time for input, discussed below under Elimination of ANOPR). In some cases those products have their own deadlines specified in law. However this is a potential issue for standards that take effect in five years rather than three, notably residential heating and cooling equipment, for which DOE would only have one additional year for the next draft rule. It also may be an issue for products, such as a current update on dishwashers, for which DOE attempts to revise a rule well before the deadline.

Despite the vetting of this provision through reviews and negotiations, some questions arose over what equipment categories were covered. An amendment was enacted in 2012 to clarify that the requirement applies to commercial heating and cooling equipment for which the last standard predated enactment of EISA (PL 112-210).

REGIONAL STANDARDS

The cost effectiveness of heating and cooling technologies depends on climate, but it was unclear whether DOE had the authority to set standards that varied by region. EISA section 306 allowed DOE to set two levels (North and South) for residential furnaces, and three for residential central air conditioners and heat pumps (humid and dry regions in the South and Southwest). It also directed DOE to address thorny enforcement issues, as appliance standards generally apply to manufacturers, but distributors and installers determine in what region equipment is installed.

Manufacturers and advocates subsequently agreed to regional standards for furnaces and air conditioners in 2009. However equipment distributors and contractors objected to the difficulty of meeting a standard that varies by region, and to the possibility of being subject to enforcement. Gas utilities objected to the proposed furnace standard in the North. These parties had not been part of the negotiation. In the face of this opposition, Congress was unable to enact the agreement, but DOE issued the standards (without accompanying legislative provisions) under the new direct final rule authority in 2011.

The air conditioner standard has moved forward. DOE convened a formal negotiated rulemaking on enforcement of the standard, which concluded successfully (if not easily), and has issued a proposed rule. However some opponents sued DOE over the furnace standard. DOE settled by agreeing to begin the rulemaking again. It recently issued a proposed nationwide standard that would be higher than the previous proposed standard in either region (and would avoid regional enforcement issues). The controversy means an outdated furnace standard that has barely changed since it came into effect in 1992 will now remain the standard not until 2013 but until 2021 or later, despite great improvements in technology over the decades.

EXPEDITED RULEMAKING

Given the great difficulties it was having in issuing standards, DOE proposed an expedited procedure for issuing standards based on a consensus agreement, using a direct final rule to avoid the need for a notice of proposed rulemaking and comment period and for added flexibility. Both manufacturers and advocates agreed with some changes, which were enacted in EISA section 308.

DOE has used this authority in some cases, successfully for clothes washers, dishwashers, clothes dryers, and room air conditioners, and for central air conditioners and heat pumps, and not so successfully for furnaces. For refrigerators and freezers and motors DOE chose to issue the negotiated standards through the normal rulemaking process.

The experience with furnaces, in which stakeholders not included in the negotiations halted the direct final rule, appears to have made DOE more wary of the expedited process. In 2012 DOE established the Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) to oversee formal negotiated rulemakings. Manufacturers are increasingly seeking

to use this process, which allows for detailed technical discussions and, if consensus is reached, ensures that their major concerns are addressed. But although it addresses other issues, it is hard to call the painstaking process “expedited.” DOE has only issued one draft appliance standard so far based on a consensus agreement under ASRAC; it took several months to form the group on pumps, several more months to reach consensus, and almost another year for DOE to issue a draft standard. Four other working groups have reached consensus, including on a standard for commercial air conditioners that DOE may issue as a direct final rule, and five other negotiations are ongoing.

ELIMINATION OF ANOPR

In another attempt to speed up an often delayed rulemaking process, DOE proposed another provision, section 307, to eliminate the requirement for an Advanced Notice of Proposed Rulemaking (ANOPR), a formal notice of possible standards under consideration with opportunity for public comment. Instead DOE generally has been releasing a Technical Support Document with detailed analysis of costs and savings from different possible standards and holding public workshops to get input, and then going straight to proposing a draft rule in a Notice of Proposed Rulemaking.

As discussed above, DOE has been getting many more rules out and faster, and there have been some concerns about the process, but the elimination of the ANOPR in EISA is at most a contributing factor. DOE has placed much more emphasis on appliance standards and devoted far more resources to them. Generally people have praised the program for vastly reducing delays. However some manufacturers have voiced concerns about lack of transparency and lack of opportunity for technical discussions and input into DOE’s analyses, especially when DOE had not published a Technical Support Document in advance of the Notice of Proposed Rulemaking (including in the current rulemaking on dishwashers). It is not clear that the elimination of the ANOPR contributed to these concerns. The tight schedules and relentless press of deadlines may be more of a factor.

STANDBY POWER

Standby power, the electricity an appliance uses when it is “off,” is a growing portion of all electricity use as the amount of electronics grows. This power is used for continuous displays, waiting for remote controls, networked communications, power transformers, and other functions. Yet many test procedures only included power used in “active” mode. EISA section 310 required that test procedures for all products be amended to include standby power (or if that is not feasible, to consider setting a separate standard for standby power for the product). It also set deadlines for addressing standby power in 14 products.

DOE has been successfully incorporating standby power into most test procedures, resulting in greater energy savings. In general this requires developing a new metric, such as a modified energy factor, or including standby use in an energy metric, such as kilowatt-hours per year. However this has been a lot of work, and has revealed the need for better field data on actual power use of many products.

Electronics and Lighting Labels

Major appliances and heating and cooling equipment have long carried the yellow EnergyGuide informational label that shows the average energy use and cost of the model

(not to be confused with ENERGY STAR endorsement labels). EISA section 325 extended labeling and disclosure requirements to certain electronic products and urged alternative approaches for light bulbs. The new labels show the challenge of providing consumer information in very dynamic markets.

The Federal Trade Commission (FTC) is to set labeling requirements for televisions, personal computers and monitors, cable or satellite set-top boxes, and digital video recorders within 18 months after DOE issues energy use test procedures for these products. They may also identify a different test procedure or label other consumer products, and may change the format of disclosure.

In January 2011, FTC adopted requirements for televisions to be labeled starting in May 2011 using the ENERGY STAR test procedure (DOE would not issue a usable test procedure until October 2013) (FTC 2011). The label is similar to other Energy Guide labels, although some changes in shape are allowed, and it compares TVs in narrow size ranges (an example is shown in figure 9). FTC also required that the information be provided on websites and in paper catalogs. DOE has not issued test procedures for the other products, and FTC has not yet required that any be labeled.

Between 2007 and 2012, energy use for each new TV dropped by almost 60% even as the average size increased (Fryer 2013). This remarkable progress is often attributed to California efficiency standards, ENERGY STAR labels, utility incentives, and technology shifts for reasons other than efficiency, such as the use of LED backlights; it is not clear that the Energy Guide labels accelerated the shifts starting in 2011. Indeed the rapid developments left the labels highly misleading; virtually all TVs are more efficient than even the best end of the ranges set in 2011 – they are not only all above average but all literally off the charts. New labels are required to use updated ranges as of July 15, 2015, but many older labels are still in use. More frequent updates could better inform consumers.

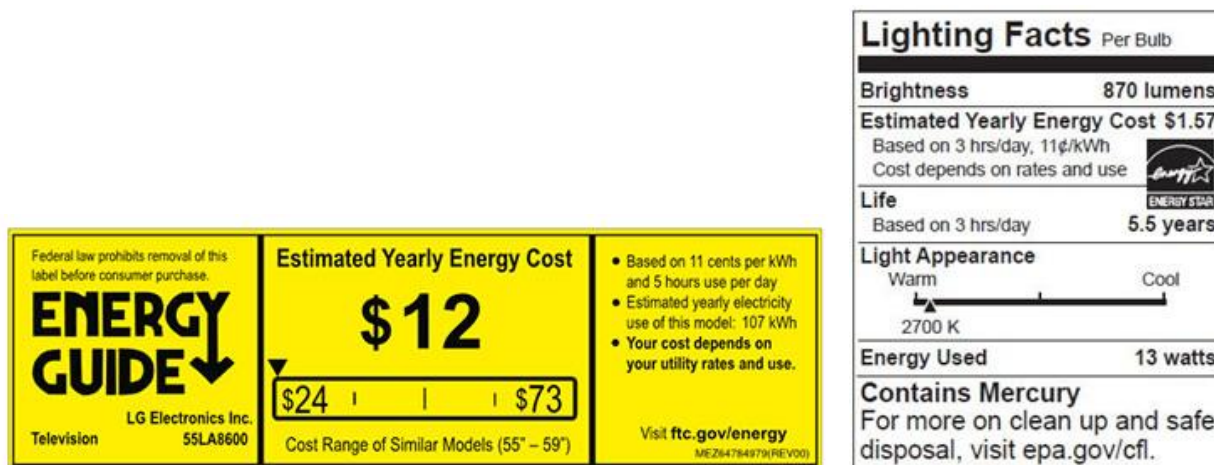


Figure 9. New labels for televisions and for light bulbs

Along with the light bulb standard, EISA section 321 directed FTC to consider alternative labeling approaches. FTC in July 2010 revised the labeling requirements for light bulbs, effective July 2011 (FTC 2010). Most people associate the brightness of a bulb with the

wattage, even though the lumens per watt now varies widely. In addition, the new technologies allow wide variation in color, light quality, lifetime, and other characteristics. Thus the FTC switched to lumens as the primary brightness indicator, and in addition to brightness, wattage, and lifetime, it added required labeling of energy cost, color temperature, and, where relevant, mercury and voltage. The labeling, shown in Figure 9, is much clearer. However anecdotal evidence suggests many consumers still think of brightness in terms of watts for an incandescent bulb that can no longer be made, and still are confused by color temperature. Changing consumer shopping habits can be a long-term process, and there was very limited funding for the consumer information campaign that also was authorized in EISA.

RESIDENTIAL AND COMMERCIAL BUILDINGS

In addition to standards and labels on equipment, EISA included many provisions intended to improve the overall efficiency of homes and commercial buildings. Building insulation, windows, sealing, and other characteristics are as important to energy use as the equipment and appliances. Although a proposed provision on improving building energy codes was not included in EISA, there were subsequent rapid improvements in ASHRAE Standard 90.1 for commercial buildings and the International Energy Conservation Code (IECC) for residential buildings. Along with rapid advances in green and zero-net-energy buildings, these have created the opportunity for large energy savings.

However, without the focus President Obama placed on vehicle and appliance standards, implementation of the EISA buildings provisions—including standards, programs, and federal efficiency requirements at multiple departments—has been notably slow and halting. Indeed it should cause some embarrassment that many states, with encouragement in federal legislation and assistance from DOE, are far ahead of the federal government in advancing building standards. An exception is buildings programs that were funded under the American Recovery and Reinvestment Act.

Manufactured Housing Standard

Manufactured homes are regulated by the federal government rather than under state building codes because the factory where they are built may not know where the home will end up.⁶ The Department of Housing and Urban Development (HUD) sets the standard, but the energy provisions of the “HUD Code” have not been updated since 1994. Over this time, there have been at least eight residential model energy code revisions. Thus EISA section 413 directed DOE by December 2011 to set an energy efficiency standard for manufactured homes based on the most recent model energy code (IECC).

Seven years after enactment DOE has yet to issue even a draft standard. DOE issued an ANOPR in 2010, and a putative draft standard was apparently leaked but never issued. Then in June 2014, DOE announced a formal negotiated rulemaking process on the content

⁶ These are often called mobile homes although they are placed on a foundation and are rarely moved once installed (the industry does call homes that predate the 1976 federal standards mobile homes). The federal standards do not apply to modular homes and buildings, which are assembled on-site from components manufactured in a factory and are covered by state and local building codes.

of a standard under the Appliance Standards and Rulemaking Federal Advisory Committee, which was successfully completed in October 2014. Further work is indicated by a request for information in February 2015 (DOE 2015g).

The successful negotiated rulemaking suggests that there is no technical roadblock to an improved standard. The legislation said very little about administration and enforcement of the standard, but again there are available pathways. The main reasons DOE has not been able to issue a standard appear to be not technical but political. Some smaller manufacturers oppose any DOE standard, other manufacturers have been concerned about what DOE will do, and many stakeholders are worried about increasing the first cost of some of the cheapest homes available.

In the meantime, 64,300 new homes were shipped in 2014, and well over 300,000 a year as recently as the 1990s (the number of new manufactured homes has fluctuated for decades, and in the late 2000s dropped with the overall housing market) (Census 2015a). The vast majority of new manufactured homes are inefficient; their owners will pay unnecessarily high energy bills. Based on analysis by Pacific Northwest National Laboratory (PNNL 2014), we estimate the negotiated rulemaking proposal would save an average of about \$450 per year in energy bills, or 25% of the cost for heating, cooling, and lighting, at an average initial cost of around \$2,900 (compared to an average new home price, not including land, of around \$67,000).

Codes and Federally Assisted Housing

New homes with federally assisted mortgages and new public housing are required to meet energy efficiency criteria. This requirement applies to a significant, though declining, fraction of new single-family homes: about 11% are purchased with Federal Housing Administration (FHA) loans, 9% with Department of Veterans Affairs (VA) loans, and a somewhat smaller number with US Department of Agriculture (USDA) loans; thousands of multifamily units are covered as well (Census 2015b; HUD and USDA 2015). However the larger number of mortgages backed by Fannie Mae and Freddie Mac are not covered.

EISA section 481 updated the criteria to the 2006 IECC, or ASHRAE Standard 90.1-2004 for multifamily high rises. It also directed HUD and USDA to update the criteria within one year after either of these is updated (unless they find an update is not justified); if the agencies do not set their own criteria within a year, the new code applies if the agencies make a determination that the revised codes “do not negatively affect the availability or affordability” of new homes under the requirement. DOE under previous law makes a separate determination that the revisions save energy.

It took HUD until early 2013 just to implement the update that was in law. It updated its Builder’s Certification to require builders to check off whether the home complies with the 2006 IECC (after OMB took seven months to sign off on the form). HUD and USDA subsequently issued the final determination on the 2009 IECC/ASHRAE Standard 90.1-2007 in May 2015 (HUD and USDA 2015), two years after submitting the preliminary determination to OMB. The confusing legislative language with new and undefined determinations and unclear deadlines may have contributed to the long delays.

Meanwhile the model codes have each been updated twice more, most recently in October 2013 for ASHRAE Standard 90.1-2013 and June 2014 for the 2015 IECC. In the May 2015 determination the agencies indicated an intent to issue an ANOPR on the 2015 IECC/ASHRAE Standard 90.1-2013, but have not yet done so. HUD has not yet done any significant educational outreach to builders or enforcement actions on this provision to date.

Zero Net Energy Commercial Buildings Initiative

Prior to EISA, DOE had a limited focus on commercial buildings. In FY 2006, just over \$3 million was appropriated for DOE's Commercial Buildings Integration Program. The Commercial Buildings Initiative (CBI), created under EISA section 422, elevated commercial building efficiency by establishing zero net energy commercial building goals and increasing authorized funding. Zero net energy (ZNE) buildings, as defined here, use much less energy and meet the balance of energy needs from sources that do not produce greenhouse gases. This initiative set goals for new commercial buildings to use zero net energy by 2030, for 50% of the commercial building stock to use zero net energy by 2040, and for all commercial buildings to meet this standard by 2050. CBI also authorized a High Performance Green Building Consortium "to develop and carry out the initiative" in a public-private partnership with DOE that would focus on research and development and dissemination at an accelerated pace. Section 422 was authorized at \$20 million for FY 2008, with a gradual increase to \$200 million for FY 2013-2018.

Since FY 2008, funding for the overall Commercial Buildings Integration Program has increased from \$12 million, peaking in FY 2010 at \$39 million (figure 10).

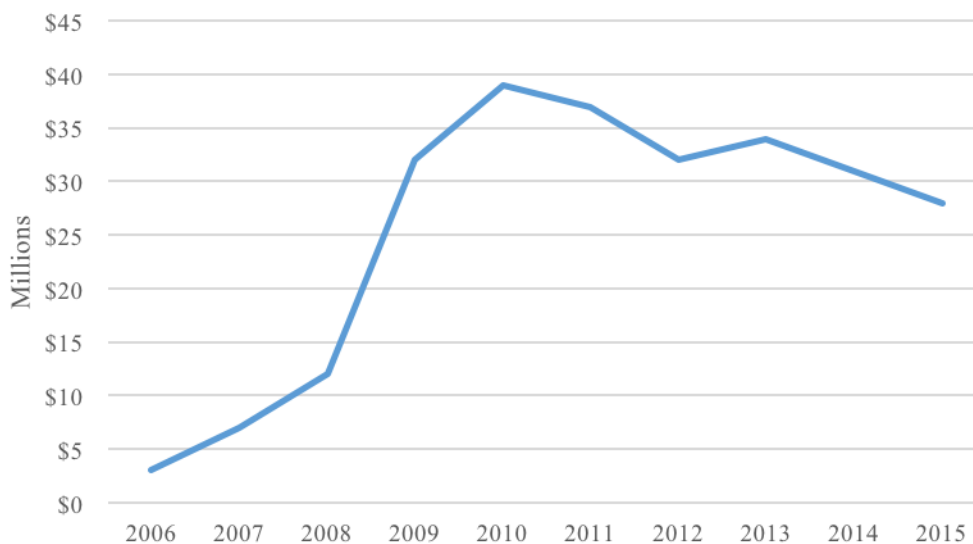


Figure 10. DOE Commercial Buildings Integration funding in FY 2006–2015 in nominal dollars.
Source: CFO 2015.

But little of that has gone to CBI. The consortium that was selected brought together almost 500 public and private members, representing several industries and many organizations. Yet, the consortium never had much support from DOE, and its role was less central than originally intended. DOE, hesitant about ceding too much control to the consortium, provided meager funding—a total of \$1 million from FY 2010–2013 (Fazeli 2013)—and no

authority. DOE considered the goal of ZNE to be difficult, if not impossible. Three reports were eventually released by the consortium: *Next Generation Technologies: Barriers and Recommendations for Commercial Buildings* (CBC 2011a), *Analysis of Cost & Non-Cost Barriers and Policy Solutions for Commercial Buildings* (CBC 2011b), and *Getting to Zero 2012 Status Update: A First Look at the Costs and Features of Zero-Energy Commercial Buildings* (NBI 2012). They presented the current status of commercial buildings and industry recommendations moving forward.

The direct impacts of CBI are unclear, but there are successful examples of ZNE commercial building projects across the country, if nowhere near the ambitious initiative goals. Prior to 2008, there were 33 buildings considered to be “zero energy-capable buildings” (NBI 2012), many of them demonstration buildings with low levels of occupancy. In 2014, the number of “ZNE verified” and “ZNE emerging” buildings had risen to 160, with an interim count this year totaling 191 buildings (NBI 2015), including multi-story, large-scale ZNE buildings. In June 2010, the National Renewable Energy Laboratory (NREL) completed the first phase of its Research and Support Facility, a 220,000 square foot building that achieves the zero net energy goal. The Bullitt Center, on Seattle’s Capitol Hill, is a 50,000 sq. ft. office building that is 83% more energy efficient than the typical commercial building in Seattle, and is expected to be ZNE. The Energy Trust of Oregon’s Path to Net Zero Pilot program launched in May 2009, and California’s Pacific Gas and Electric Company Zero Net Energy Pilot Program debuted in 2010. The latter supports California’s 2008 Long Term Energy Efficiency Strategic Plan, which sets goals for all new residential construction to be ZNE by 2020 and all new commercial construction to be ZNE by 2030 (Cortese and Higgins 2014; PG&E 2015).

While this provision was not implemented as authorized, it created aspirational goals for commercial buildings, stimulated additional funding for commercial building programs within DOE, and elevated the importance of ZNE in the private sector and at the state level. Instead of implementing the CBI, DOE shifted to other programs focused on improving existing buildings, like the Better Buildings Initiative. Equipped with shorter-term goals and more funding, the Better Buildings programs eclipsed the efforts of the CBI and defined the path forward for commercial buildings within DOE.

Reauthorization of Weatherization Assistance Program

The Weatherization Assistance Program (WAP) increases energy efficiency and reduces energy costs in low-income households. Energy costs are a significant portion of low-income families’ budgets: the energy burden comprised 16.3% of total income for households that are eligible under this program in FY 2014, compared to only 3.5% of income for non-eligible households (Eisenberg 2014). WAP combines DOE funds, other federal funds, and utility funding to help states and community service programs weatherize low-income homes at no cost to the owners.

EISA section 411 reauthorized WAP and increased authorized funding to \$750 million in FY 2008, rising to \$1.4 billion in FY 2012, for a total of \$5.3 billion authorized over five years. EISA also authorized a new grant program under WAP, known as Sustainable Energy Resources for Consumers (SERC) grants. In any year in which WAP funding exceeds \$275 million, up to 2% of funding may be used through SERC grants to pay for “materials,

benefits, and renewable and domestic energy technologies” that are not eligible under the main WAP program.

WAP’s increase in authorized funding did not result in a clear effect on the level of funds appropriated annually. WAP appropriations started at \$204 million in FY 2007, peaked in FY 2009 with \$450 million, declined to \$68 million (FY 2012), and rose again to \$193 million in FY 2015 (figure 11). ARRA, however, provided \$5 billion in additional funding for WAP over three years, exceeding levels of authorization outlined in EISA.

A recent study of programs in Michigan under ARRA questioned the level of WAP savings and their cost-effectiveness (Fowler, Greenstone, and Wolfram 2015). However a broader program evaluation suggests the program is cost effective when health and safety benefits are considered, and that costs are lower and energy savings higher for the normal WAP retrofits than they were under ARRA. The evaluation estimated a present value of \$340 million in lifetime energy savings from retrofits in 2008 and \$1.1 billion from retrofits in 2010 (DOE 2015h).

SERC received \$90 million in funding under ARRA, which was the first and only time that SERC grants have been funded (see text box). SERC was followed by a broader program in 2010, the Weatherization Innovation Pilot Program (WIPP), which is intended to accelerate weatherization of low-income households by working with new and non-traditional partners to leverage additional non-federal funds.

SERC Projects: Successful Case Studies

DOE has awarded SERC grants to nearly 100 local agencies in 27 states for renewable technologies; highly efficient heating and cooling equipment, hot water heaters, windows, and roofs; and testing the efficacy of home energy monitors (DOE 2011). Montana received almost \$1 million, targeting low-income homeowners across 13 counties, conducting client education workshops, and installing solar hot water systems, photovoltaics, and home energy monitors. In all, the SERC projects in Montana benefited 147 households, leading to an estimated 30% reduction in energy bills (DOE 2013c).

Maryland received almost \$2.6 million in SERC grants to increase energy efficiency and maximize savings. Projects included: installing residential wind turbines; solar photovoltaics; geothermal heat pumps; hybrid heat pump water heaters; and high-efficiency heating, ventilating, and air conditioning (HVAC). These upgrades are expected to save an estimated 20% to 30% in energy costs for participating households. In Maryland, 215 households received upgrades through SERC grants (DOE 2013b). DOE provides additional information on several state-level impacts of SERC projects, but a comprehensive analysis of the program has not yet been released.

Reauthorization of State Energy Program

EISA section 531 reauthorized the State Energy Program (SEP) and increased authorizations to \$125 million per year for FY 2007–2012. SEP provides cost-shared resources directly to the states to use for energy efficiency projects, technical assistance, or demonstration activities, among other purposes. This mechanism gives states the ability to tailor the funds to their specific needs and individual energy goals.

Similar to WAP, the increase in authorization of funds had no clear effect on SEP funding in the years following EISA. From FY 2004–2008 SEP was funded at levels between \$36 and \$49 million. From FY 2009–2015, the program received between \$47 million and \$50 million in funding each year (figure 11). Separately, SEP was funded under ARRA at levels far above its authorization, with an additional \$3.1 billion provided over three years. This program, like WAP, was attractive for ARRA funding as the SEP program was already well established, and money could be quickly shuttled to states, resulting in relatively quick outcomes and job creation or retention.

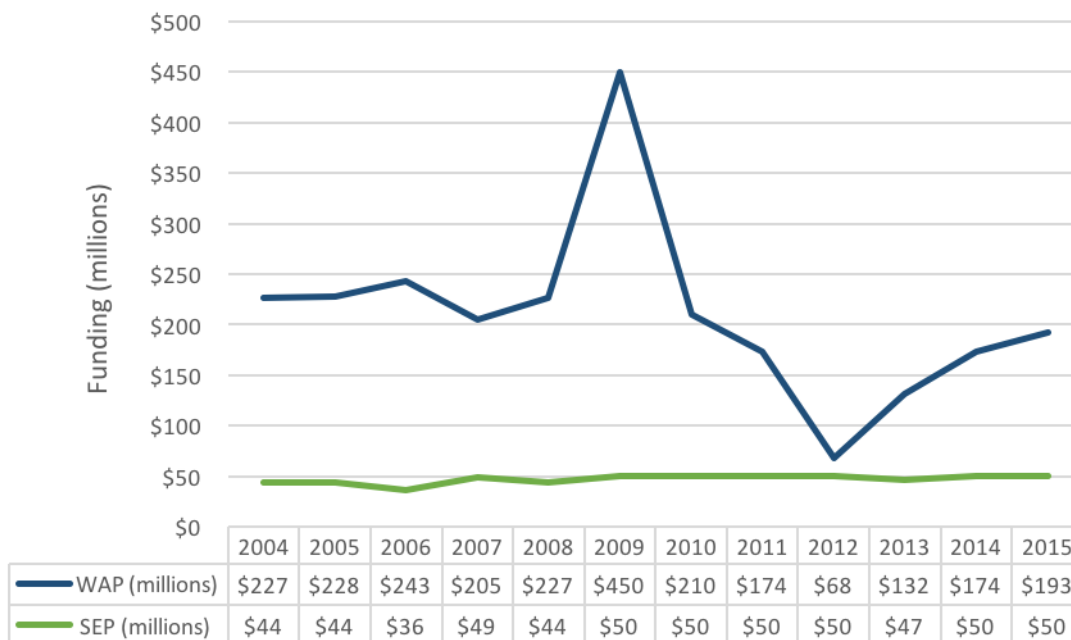


Figure 11. DOE funding for WAP and SEP programs, FY 2004–2015, in nominal dollars. *Source:* CFO 2015.

A recent evaluation of SEP looked at activities in 2008 (with regular appropriations) and during the period of ARRA funding. It found that program participants from 2008 will receive \$95 million in lifetime energy bill savings, about \$4.50 for each dollar spent (not including loans). Program participants in 2009–2013 will receive \$7.8 billion in savings, about \$3.50 for each dollar spent. The evaluation also estimated job creation peaking in 2011 with 15,000 additional jobs (DNV GL 2015).

Energy Efficiency and Conservation Block Grant Program

The Energy Efficiency and Conservation Block Grant Program (EECBG) was a new initiative authorized under EISA. It was the brainchild of the US Conference of Mayors, designed to support cities and counties in developing energy policies and programs. Other than municipal utilities, cities had mostly not been active on energy issues. EECBG authorized DOE grants to state and local entities to reduce fossil fuel emissions and total energy use, create direct and indirect jobs, and improve energy efficiency in the transportation, building, and other sectors. Section 548 authorized \$2 billion annually over five years, FY 2008–2012, more than the entire DOE Energy Efficiency and Renewable Energy Office budget then or now.

No funding was appropriated for this program until ARRA, which provided \$3.2 billion over three years. DOE allocated \$2.7 billion through formula grants,⁷ with the remaining \$454 million for a new initiative, the Better Building Neighborhood Program (BBNP), to encourage innovative models for residential and commercial building retrofits. EECBG was seen as an opportunity to create jobs and support struggling city governments. But DOE and local governments struggled to set up the necessary infrastructure for this new program to quickly expend ARRA funds, which included: creating rules; hiring staff; designing programs; and establishing appropriate evaluation, measurement, and verification methods. Many of the smaller communities had never received a federal grant before, so they had no prior knowledge about the process. Several inexperienced DOE program administrators compared managing the EECBG program to “flying a plane while it is still being built” (GAO 2011b). With resources at DOE stretched thin, the National Association of State Energy Officials (NASEO) took up the task of creating “how to” documents to help local entities in filling out grant forms, as well as conducting weekly phone calls with states.

About two-thirds of funding was used for three of the fourteen eligible activities for EECBG funding: energy efficiency retrofits (36.8%), which includes providing funds to nonprofit and government facilities for energy efficiency improvements; financial incentive programs (18.5%); and energy efficiency and conservation programs for government buildings and facilities (9.8%), which includes projects such as installing solar hot water technology or storm windows (GAO 2011b). Many cities and local governments (62%) used these funds to develop new programs under city energy and climate plans (USCM 2014). These activities contributed to widespread energy efficiency upgrades and energy savings. As of June 2014, the grant program installed 197,000 energy-efficient streetlights, more than 278,000 energy-efficient traffic signals, and energy upgrades on approximately 86,000 buildings, covering 699 million sq. ft. (DOE 2015c). The final EECBG National Evaluation on formula grants is under way.

This rapid infusion of money into cities and local governments produced wide-ranging benefits and strengthened the relationship between the federal government and many local entities. Since then, funding has dried up, and cities have experienced an “unprecedented decline” in the federal government serving as a funding partner for cities (USCM 2014).

The Better Buildings Neighborhood Program awarded 34 grants with ARRA funds, some to multiple governments, as well as additional State Energy Program funds. The projects have increased the energy efficiency of 119,000 homes and commercial buildings, with an estimated total of near \$700 million in lifetime energy savings for consumers, and they added over 10,000 net jobs (Research into Action 2015; DOE 2015b). While projects in many cities and local governments have ground to a halt, some effects of this provision continue to reverberate within DOE. As a result of BBNP, two additional programs were created: the Better Buildings Residential Network, a peer-sharing group, and the Better Buildings Program Solutions Center, an online repository of lessons learned from BBNP.

⁷ As authorized, the grants went to cities with populations above 35,000, counties larger than 200,000, and tribal governments, along with funding to states to distribute to smaller municipalities.

FEDERAL ENERGY MANAGEMENT

As the country's single largest consumer of energy, and the owner of many old buildings, the federal government has a significant opportunity to reduce its own energy usage. EISA included many provisions on federal energy management and federal green buildings; four of the broadest are discussed here.

Energy Intensity Reduction Goals for Federal Buildings

For many years, goals outlined in executive orders and through congressional legislation have helped to push federal energy consumption downward. EPCA 2005 set a federal goal of a 2% reduction in energy intensity per year, with a cumulative 20% reduction by the end of FY 2015 compared to 2003. Energy intensity is the energy use per unit of building floor space, interpreted as overall nonrenewable Btu/square foot delivered to the site. In January 2007, President Bush signed Executive Order 13423, which increased that goal to a 3% annual reduction with a cumulative 30% reduction by the end of FY 2015 (again with a 2003 baseline). This target was then codified later in 2007 under Section 431 in EISA.

There were initial concerns as to how these more ambitious energy reductions would be funded. With stagnant appropriations, the main available mechanism was through private financing. However, in 2009 ARRA provided GSA with \$5.55 billion to invest in more energy-efficient federal buildings, courthouses, and land ports of entry; this included \$4.5 billion to convert federal buildings into high-performance green buildings. This funding was used for a total of 270 projects (GSA 2015).

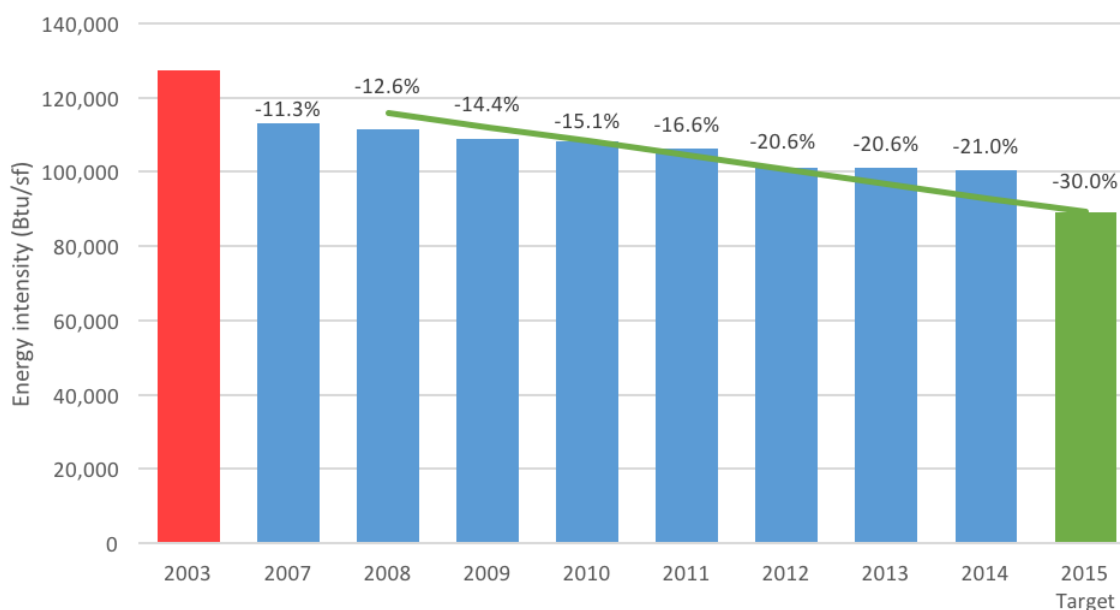


Figure 12. Federal agency progress toward federal energy reduction goals. The green line shows the intensity targets in EISA, and the blue bars show actual values. *Source:* Tremper 2014; Chris Tremper, program analyst, DOE, pers. comm., March 6, 2015.

Federal agencies reduced their buildings' energy intensity by 21% relative to 2003 levels as of 2014. The government as a whole met the intensity goals through 2012 (with the help of a head start), but then fell behind, as shown in figure 12. Besides the long-term trend of

reduced energy use, intensities can be affected by fuel switching, weather, and building space. For example in FY 2012 the number of heating degree days nationwide was about 15% lower than average (EIA 2015b). The relatively constant building space since 2007 was confirmed in the 2013 “Freeze the Footprint” policy, which directs Executive Branch departments and agencies to maintain their domestic real estate inventory at FY 2012 levels (OMB 2013).

Management of Energy and Water Efficiency in Federal Buildings

EISA section 432 was directed at energy management in existing federal facilities. It directed federal agencies, for buildings that account for at least 75% of the agency’s total building energy use, to designate an energy manager for each facility, conduct comprehensive energy and water evaluations including recommissioning on 25% of facilities each year, establish a “web-based tracking system” to monitor progress in implementing recommended measures, and benchmark and disclose the energy use for each building.⁸ Following an executive order it also directed OMB to issue a semiannual scorecard for each agency to monitor energy management activities. To fund these activities, agencies may use a combination of appropriated funds and private financing.

These directions were successful in creating additional transparency that enabled federal agencies and the public to have a better understanding of federal energy management performance. However implementation of these initiatives was slower than expected. DOE was given one year to implement the “web-based tracking system,” now known as the Compliance Tracking System (CTS), but it did not come online until May 9, 2013, with its development and deployment funded through ARRA (Tremper 2013; DOE 2015e). Federal agencies have met some of the requirements outlined in EISA, though they are still lagging behind in others. As of April 2, 2015, 90.6% of the total facility energy use is attributable to covered facilities, which is above the goal of 75%, and there are energy managers designated at 98.1% of covered facilities. However, after seven years only 65.6% of covered facilities have completed a comprehensive evaluation. In all, agencies have reported through the CTS over \$3.3 billion in energy efficiency and conservation projects initiated (DOE 2015d).

In April 2011, OMB released the first Sustainability and Energy Scorecards (OMB 2015), as required under EISA, producing subsequent annual scorecards every year since. The scorecards do not specifically cover the implementation of this provision (and are not semiannual) as directed in EISA, but do include related metrics on reduction in energy intensity, reduction in potable water intensity, and sustainable green buildings, among other sustainability indices. Each target is scored by a green (“success”), yellow (“mixed results”), or red (“unsatisfactory”) standard, as outlined by the individual agency’s strategic sustainability performance plan. For the most recent scorecard (FY 2014), of the 25 reporting agencies, 12 scored green on energy intensity reduction, 22 scored green on reduction in

⁸ Commissioning is a process that occurs after construction to ensure that all building systems and controls are working together correctly as designed. Recommissioning is done after a period of use to ensure the systems continue to work together in order to meet current occupant needs.

potable water intensity, and 3 scored green on hitting their sustainable green buildings targets.

Federal Building Fossil Fuel Use Standards

Section 433 requires new federal buildings and buildings with major renovations to reduce their fossil fuel energy use by 55% by 2010, relative to a baseline of average commercial buildings in 2003, and to eliminate their fossil fuel use by 2030. This timeline was based on Architecture 2030's "2030 Challenge" on greenhouse gases. The same bill section also directs DOE to establish rules for green building certification and sustainable design standards.

The fossil fuel elimination rule has been controversial. DOE has not yet issued a rule implementing the requirement. The first notice of proposed rulemaking was published in October 2010. A second heavily revised supplemental notice of proposed rulemaking was published in October 2014 (DOE 2014b). DOE is hoping to issue a final rule in the near future. As a result, this provision has not yet seen the anticipated savings that were modeled in ACEEE's 2007 analysis.

The language of this provision left many difficult questions of interpretation, including how to treat electricity, whether off-site non-fossil fuel electricity or renewable electricity credits can be used, how to treat combined heat and power, how to compare building designs to an incomplete baseline of average actual energy use, how to treat renovations in a whole-building energy use standard, and more. In addition, there has been strong political resistance from several key stakeholders including gas and electric utilities and energy service companies. Opponents of the rule believe that it distracts from the focus on energy efficiency by singling out particular energy sources, restricts building retrofits and the adoption of combined heat and power, and above all, is currently an unattainable goal. Multiple bills in the House have sought to repeal it outright; in the Senate repeal has been combined with provisions strengthening federal energy management requirements and incorporating energy efficiency in mortgage underwriting (with ACEEE involvement).

Permanent Reauthorization of Energy Savings Performance Contracts

Energy Savings Performance Contracts (ESPCs) enable private energy service companies (ESCOs) to contract with federal agencies to improve the energy efficiency of facilities with no up-front capital costs or appropriations from Congress. ESCOs implement the measures using private financing and then are paid back out of the energy cost savings. It is a way of achieving the improvements despite limited appropriations. ESPCs were originally authorized in 1986 by Congress and extended in 1998, but authority went into sunset in October 2003, restricting the use of these contracts for about a year. ESPCs were renewed in October 2004, and authorization was extended through 2016 in EPAct 2005.

The permanent reauthorization of ESPCs under EISA section 514 has enabled continued investments in energy efficiency, reductions in greenhouse gases, and job creation (figure 13). As of May 2011, more than 570 ESPC projects worth \$3.9 billion had been awarded, resulting in an estimated energy savings of 32.8 trillion Btus annually and a net savings of \$3 billion (Oliver 2011). There has been some debate about the amount of savings. A 2013 ORNL analysis of a representative project suggested that ESPCs are actually saving federal agencies almost twice as much money as guaranteed by the contractor due to conservative

assumptions (Shonder 2013). However a recent GAO report found that savings were over-reported in more than half of the contracts examined, primarily because of actions by the agencies that reduced savings; due to the large number of factors that can affect savings, the report did not attempt to determine the net effect and compare to projected savings (GAO 2015).

Acknowledging the value of ESPCs to both the federal government and the private sector, President Obama issued a Presidential Memorandum in December 2011, directing federal agencies to enter into \$2 billion worth of performance contracts over the course of two years. Federal agencies did commit to a pipeline of nearly \$2.7 billion in projects, although actual awards, as shown in figure 13, were far lower. Doubling down on these efforts, in May 2014 the Obama administration announced a goal of an additional \$2 billion in energy efficiency upgrades to federal buildings over three years (Office of the Press Secretary 2014).

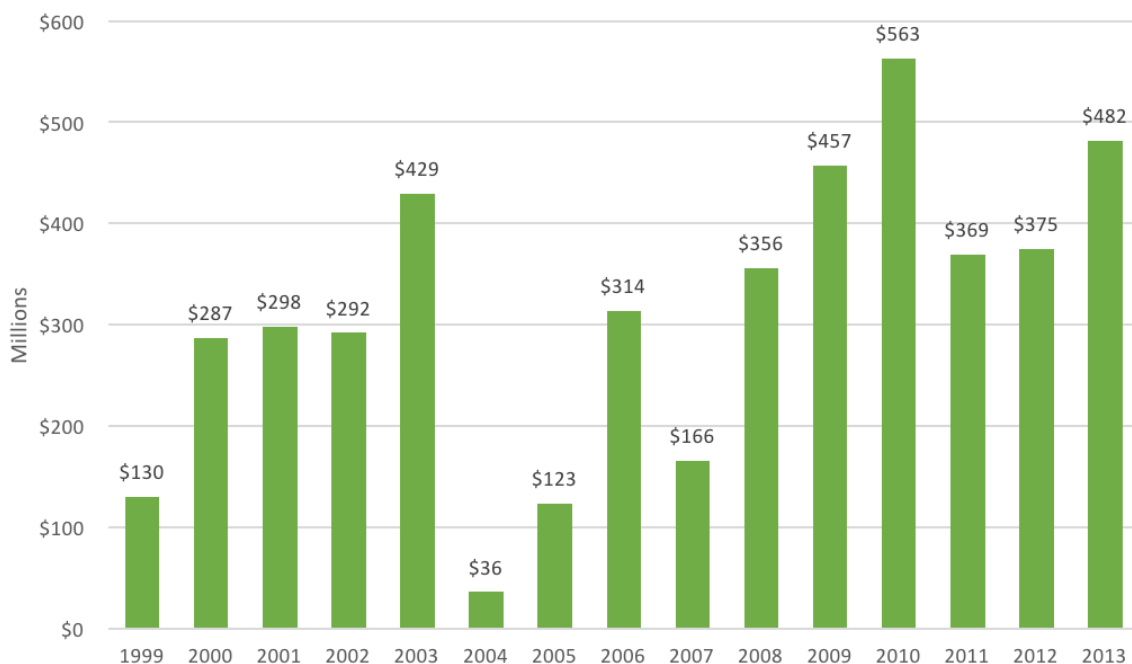


Figure 13. Annual awarded project investment in ESPCs in nominal dollars. *Source:* DOE 2015d.

The permanent reauthorization of ESPCs under EISA ensures that federal agencies have a steady mechanism by which to partner with ESCOs to reduce their energy usage and reduce the financial burden on the American taxpayer.

OTHER SECTORS

Investments in the Smart Grid

EISA authorized two grant programs focused on facilitating the uptake of smart technologies across the electric grid. Section 1304 authorized the Smart Grid Regional Demonstration program, with the goal of demonstrating the potential benefits of the smart grid and facilitating the transition to a smart grid system. Funds were authorized at \$100 million per year for FY 2008–2012. Section 1306 authorized the Smart Grid Investment Matching Grant Program to provide a 20% reimbursement for qualifying smart grid

investments, with funds authorized “as are necessary” for FY 2008–2012. Qualifying investments include sensors, control devices, and software that enable a wide variety of appliances, equipment, vehicles, generators, and transmission and distribution equipment to engage in smart grid functions.

These provisions provided the legislative framework for two programs funded under ARRA: the Smart Grid Demonstration (SGD) program and the Smart Grid Investment Grant (SGIG) program. The SGD program provided \$620 million in funding for 32 smart grid regional demonstration and energy storage projects, leveraging an additional \$1 billion from the private sector. ARRA amended Section 1304 by creating a “smart grid information clearinghouse,” making data from smart grid projects available to the public. Sixteen awards totaling \$435 million in 21 states supported regional demonstrations to test smart grid viability and establish systems that could be replicated across the country. The other 16 awards totaling \$185 million helped fund utility-scale energy storage projects focused on enhancing the reliability of the grid, improving frequency regulation and peak energy management, and reducing the need for new power plants (DOE 2009b).

The Recovery Act’s SGIG program amended Section 1306 by increasing federal matching funds from 20% to 50%, and appropriated \$3.4 billion. DOE used a competitive process to award 99 projects in rural, urban, suburban, and tribal areas, including both public power and privately owned transmissions systems. In addition to federal funding, industry contributed \$4.5 billion, for a public-private investment worth \$7.9 billion (DOE 2013a).

SGIG projects launched in early 2010 with a primary objective of accelerating the deployment of smart grid technologies and systems (see figure 14 below). The majority of projects were completed by 2013. Twenty-six SGIG projects are implementing voltage and volt-ampere reactive (VAR) optimization (VVO) technologies to reduce electric line losses and increase energy efficiency through better real-time control of the power supply. For the 31 feeders within the projects that have reported initial results, 16 are producing line loss reductions between 0% and 5%, with five feeders experiencing loss reductions greater than 5%. The rest of the feeders are experiencing increased line losses, with most increases between 0% and 5%. (DOE 2012). Sixty-two projects are implementing advanced metering infrastructure (AMI), installing an estimated 15.5 million smart meters, representing almost 24% of the 65 million smart meters that are expected to be installed nationwide by 2015. Initial results of one AMI project of 500 residential customers reduced peak demand during three critical peak events by an average of about 37%, while another project involving 600 mostly residential customers reduced their peak demand by 5–25% during seven peak events (DOE 2013a). However, how much of the AMI infrastructure is being used to affect customer demand, and the impact on total electricity use, are not clear. Where smart devices are being deployed for conservation voltage reduction (CVR), which lowers power use by consumers by keeping voltage to the lower end of the acceptable range, there is an average 2.2% energy reduction and 1.8% peak load reduction per distribution circuit (DOE 2014a). If similar CVR projects were applied across the entire grid, this would result in energy demand reductions of approximately 6,500 MW per year (Schneider et al. 2010).

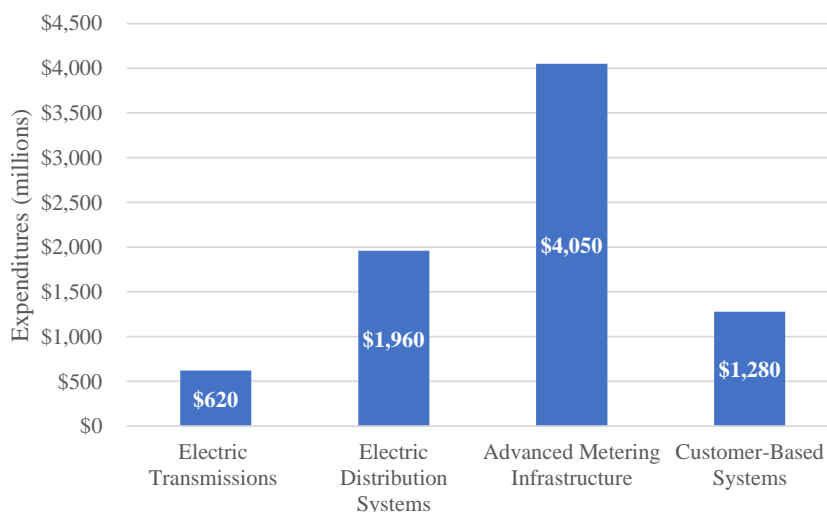


Figure 14. Estimated total SGIG project expenditures by categories of technologies and systems as of March 2013. *Source:* DOE 2013a.

Reporting is still continuing for both programs. SGDP award winners are required to submit interim reports and final Technology Performance Reports to DOE. Most interim reports are available on www.smartgrid.gov. However few companies have so far released a final report detailing project impacts. A program-level interim SGDP report for regional demonstration projects was due out in May 2015, with many projects continuing past this date. Reporting on ARRA-funded SGIG projects is continuing through 2015, and the SGIG program's final report was projected to be released in July 2015 (DOE 2015f).

Industrial Programs

The industrial sector presents large energy uses and potential for energy savings that will benefit the economy but that may not be appropriate for standards or regulation. EISA provisions focused on energy intensive industries, training and technical assistance, combined heat and power (CHP), and waste heat recovery.

Energy intensive industries such as aluminum and steel manufacturers had long been the focus of DOE's Industries of the Future program, the bulk of what was then called the Industrial Technologies Program, but by 2007 funding had dropped precipitously (Trombley 2012). EISA authorized the Energy-Intensive Industries Program, designed as a reworking of the Industries of the Future program, to develop cost-sharing partnerships for research, development, and demonstration activities between DOE and energy-intensive industries. The program was authorized at \$184 million in FY 2008, rising to \$208 million for 2012. It also authorized the existing Industrial Assessment Centers (IACs), which use college students to conduct energy audits at small facilities.

While funding for work with specific industries continued to taper off, funding for cross-cutting research and deployment did begin to rise, including with the Save Energy Now program for audits and technical assistance for large factories, and research on Energy Intensive Processes. In the last couple years funding has risen even more, but with a new focus on next generation manufacturing and materials; such projects include the Institutes for Manufacturing Innovation, along with the administration's Better Buildings/Better

Plants partnership and commitment program (and the overall program was renamed the Advanced Manufacturing Office). The IAC program has continued at a low funding level (figure 15).

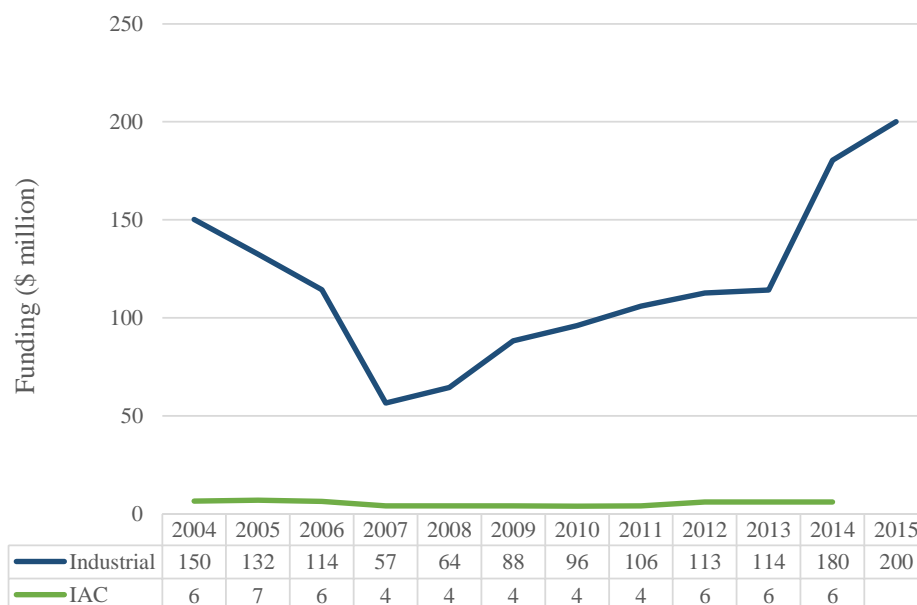


Figure 15. DOE funding for Industrial Assessment Centers and for overall industrial and Industrial Assessment Center programs, FY 2004–2015, in nominal dollars. In addition, \$160 million in Recovery Act funds were allocated for industrial energy efficiency projects and \$47 million for data centers. *Source:* CFO 2015.

Large savings are also available through better use of heat. Traditional electric power plants are quite inefficient, with only about a third of the input fuel’s energy being converted into usable electricity. CHP systems generate electricity at an industrial or commercial site, and then use the remaining heat for industrial process or building needs. They can operate at efficiency levels of up to 80%. A 2008 report proposed more than doubling CHP capacity to 20% of US generating capacity by 2030, using \$234 billion in investments to create almost one million jobs and reduce annual carbon dioxide emissions by 848 million metric tons (Shipley et al. 2008). Waste energy recovery uses the waste heat from industrial processes for those processes or other uses. Approximately 5–13 quadrillion Btu per year of waste heat energy is left unrecovered from industrial processes (BCS, Inc. 2008).

EISA authorized new programs and reformed existing ones to increase the use of both of these processes. One new program directed EPA to establish a recoverable waste energy inventory program, which became known as the Waste Energy Recovery Registry, to create a survey and registry of sites for economically feasible projects. EISA gave EPA 270 days to establish the registry. However the proposed rule was not published until July 23, 2009, and a final rule has still not been issued.

The Waste Recovery Incentive Grant Program in EISA authorized a total of \$900 million for grants for waste energy recovery. However this program never received any funding, and therefore never got off the ground.

EISA also reformed an existing CHP program, renaming the Combined Heat and Power Application Centers the Clean Energy Application Centers and relocating administration of these centers under DOE's Office of Energy Efficiency and Renewable Energy. These centers are spread out across the country to assist in transforming the CHP market through providing outreach, technology deployment programs, and market opportunity analysis. EISA authorized \$10 million per year for FY 2008–2012 for the eight regional centers to continue their operations. In 2013, DOE renamed these regional centers again, this time to the CHP Technical Assistance Partnerships (Storie 2013).

In the years following EISA, CHP development stalled (as did power plant capacity as well). In response to this inactivity and the potential, in 2012 President Obama issued Executive Order 13624, calling for the acceleration of investment in industrial energy efficiency. The order set a national goal of 40 gigawatts of new CHP capacity by 2020. However, with Congress providing nominal funding to support this goal, beyond continuation of the CHP Technical Assistance Partnerships across the country, little progress has been made so far toward the goal.

Energy Savings and Impacts

In light of the first several years of implementation we made new projections of the energy savings and other impacts of key EISA provisions. The growth in energy savings is shown in figure 16, and the cumulative impacts by provision are shown in table 3. Detailed results for 2010, 2020, 2030, and 2040 are in Appendix C, and a description of the assumptions and methodology are in Appendix D. Several of the estimates are modifications of savings estimates that were included in an earlier paper (Ungar et al. 2014) and in some cases in other work.

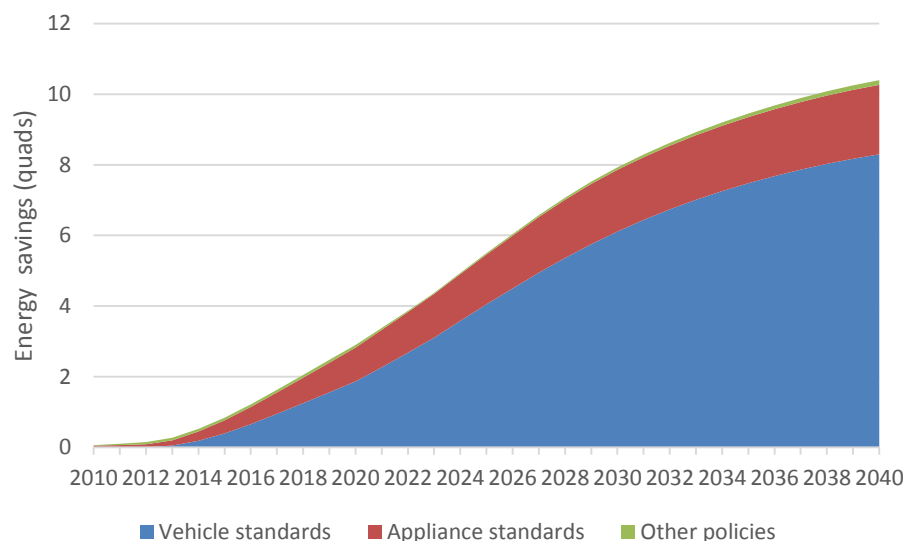


Figure 16. Growth in energy savings each year from key policies in EISA

The savings come in slowly but are remarkable. We estimate that EISA achieved little savings in the early years, but will reach a quad of total energy savings (one quadrillion Btus, or roughly 1% of total US energy use) in 2016, primarily from the CAFE and lighting standards. By 2030 we project the total savings will be 8 quads, roughly 8% of currently

projected energy use (note that the projections by the EIA already take much of these savings into account). A large majority of those savings are from vehicle standards. These oil savings are 15% of predicted oil use and the same as the total predicted net oil imports in 2030. The energy savings result in large environmental benefits including about 550 million metric tons less CO₂ emissions in 2030, 10% of projected emissions.

Table 3. Cumulative impacts from key EISA provisions

	Consumer net savings (\$billion)	Benefit-cost ratio	Cumulative CO ₂ reductions (MMT)
Cars + light trucks	1,223	5.1	9,003
Trucks + buses	642	8.1	4,583
<i>Vehicle standards total</i>	1,865	5.8	13,586
Lighting	128	7.9	1,302
Home appliances	56	4.8	630
Home HVAC + electronics	35	4.2	456
Commercial equipment	22	2.9	391
<i>Appliance standards total</i>	240	5.3	2,778
Manufactured homes	9	2.2	208
Energy efficiency block grants	3	1.6	39
Federal building standard	1	1.3	41
<i>Other policies total</i>	13	1.9	288
Total	2,118	5.6	16,652

The impacts are estimated for the lifetime of new measures through 2040. Consumer savings are the discounted net present value of the energy (and in a few cases water) savings due to the EISA provisions minus the needed investments. The benefit-cost ratio is the ratio of the present values of the savings to the investments.

The financial savings are equally impressive. We estimate that the net present value of energy savings after needed investments is over \$2 trillion (this is for the lifetime of new measures implemented through 2040). Total benefits are more than five times the total costs. All the analyzed policies show net benefits (unless you count those that were never implemented). But the lighting standards, primarily general service bulbs, are especially remarkable. They show benefits eight times their costs as the long lifetime of the new bulbs makes up for the added initial cost (with a conservative assumption that LEDs never drop below \$5 average and using discounted present values).

COMPARISON OF IMPACTS TO 2007 PROJECTIONS

Another window on implementation of EISA is to compare our current impact estimates to projections ACEEE made in 2007 (ACEEE 2007). Both sets of estimates for primary energy savings in 2010, 2020, and 2030 are shown in figure 17.

The overall estimated savings are fairly similar. Our current projection of savings from vehicle standards in 2030 is significantly higher because we now see far more savings available for trucks and buses than we anticipated in 2007. Because there were no standards

for these vehicles, there had not been a close examination of how much efficiency the vehicles could achieve. On light-duty vehicles the Obama administration used the authority under EISA – and the political support EISA had shown – to set standards for light-duty vehicles well beyond EISA requirements, but the savings are offset by a lower projected amount of driving.

Estimated savings from appliance standards are somewhat lower, primarily because in our new analysis we assumed more of the savings from efficient light bulbs would have been captured in the baseline case without the lighting standard. Savings have also been lost due to the delay of the furnace standard.

Savings from other programs are dramatically lower. The primary reason is that a few programs for which we anticipated large savings (even after discounting heavily to account for the unlikelihood of full funding) were never funded at all. Our current estimates include no savings from such programs, though they do assume some additional standards will be issued. The savings from standards not only are larger than from funding programs but also appear to be more predictable.

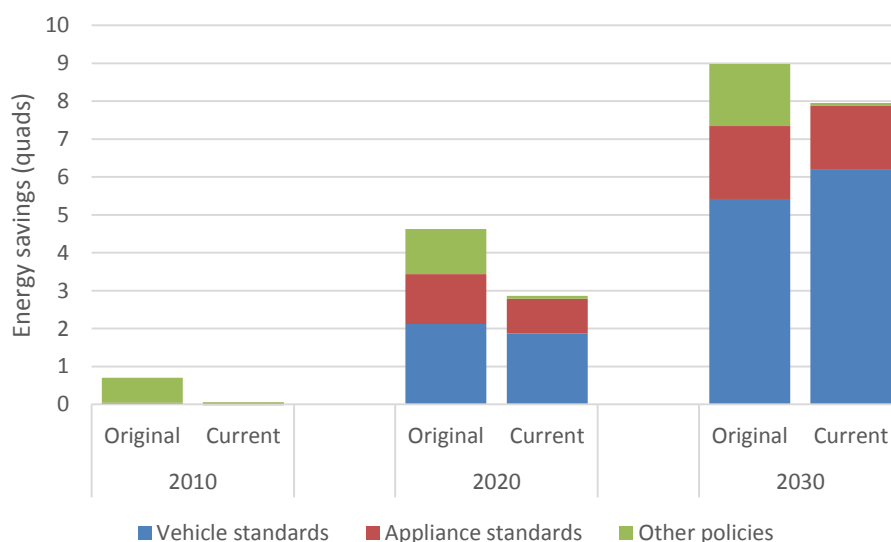


Figure 17. Estimated primary energy savings from EISA compared to projections when the bill was enacted

Discussion

EISA AND ARRA

EISA authorized billions of dollars for both existing and new energy efficiency programs.⁹ However, at the time appropriations for energy efficiency were a fraction of the new authorizations, and had been decreasing – there was no apparent prospect for new appropriations for these programs. That changed with the influx of stimulus funds in the

⁹ Since 2011 authorization of funds has often required an offsetting reduction in other authorizations (sometimes from EISA authorizations). In 2007 there was no concept of authorizations as a limited resource – unlike appropriations – and hence no expectation of offsetting reductions.

Recovery Act. ARRA funded several programs that had been authorized or reauthorized in EISA, but other EISA programs received no funds, as shown in table 4. Because the primary purpose of these funds was economic stimulus, to be funded a program needed to seem ready to disburse funds quickly (to be “shovel-ready”) and to have a clear impact on job creation; because the funding levels were high, a program needed to be large and to have significant political support.

Table 4. Funding of EISA energy efficiency programs under ARRA and other stimulus

Program funded	Funding level
Energy Efficiency and Conservation Block Grants	\$3.2 billion
Weatherization Assistance Program	\$5 billion
State Energy Program	\$3.1 billion
Smart Grid Investment Grants	\$3.4 billion
Smart Grid Demonstrations	\$0.62 billion
Energy Efficiency and Renewable Energy Worker Training	\$0.5 billion
Transportation Electrification	\$0.4 billion
Advanced Technology Vehicles Manufacturing Incentive (one-time funding in FY2009 appropriations)	\$7.5 billion
Electric Drive Vehicle Battery and Component Manufacturers Initiative (based on Advanced Battery Loan Guarantee Program)	\$2 billion
Program not funded	
ZNE Commercial Buildings Initiative	
Energy Sustainability and Efficiency Grants and Loans for Institutions	
Waste Energy Recovery Incentive Grants	

In addition to these programs in legislation, DOE allocated \$207 million for industrial programs, partly under EISA authorization.

Even with this selection, it was a major challenge to spend such large sums quickly and effectively. New programs, such as the block grants, needed staff, rules, grant mechanisms, training, and support. Even existing programs, such as weatherization, faced new requirements and eligibility in ARRA, as well as unprecedented resources. The goals of the program design and goals of the funding created some conflicts. We will examine the results of programs funded under ARRA more closely in a future paper.

Then after a few years of feverish activity the money and allotted time for most of the programs ran out. Not surprisingly for a stimulus program, none of the funding has been renewed. In some cases recipients used funds for revolving loan funds or other longer-term approaches. Others have had to lay off workers newly trained to do efficiency work. It may be too early to tell whether in the end this will lay “the groundwork for new green energy economies” and “transform the way we use energy” as President Obama hoped (Obama 2009). It certainly was both an unprecedented opportunity and a painfully hard way to run the programs.

LESSONS LEARNED

Although many of the factors and dynamics affecting implementation of the provisions of EISA are specific to the policies, agencies, and stakeholders of the individual provisions, there are some common themes that emerge. Here are a few of the broader lessons one might draw from experience with this law.

You can make a difference. In the last few years, legislation has mostly aimed to eke out gains without mandates or funding, or to push government out of markets. Examining implementation of the EISA provisions reminds us that legislation really can make a difference in helping people. As described above, overall we estimate that EISA provisions will save consumers over \$2 trillion over the lifetime of measures through 2040. EISA has changed the market for light bulbs, resulting in more choices for consumers and lower prices for new technologies. It helped to reverse a multi-decade slump in vehicle fuel economy, and to start cars on a path to fuel savings, lower imports of oil, and reduced emissions. It authorized a program that helped hundreds of cities enter the energy efficiency arena with billions of dollars in aid.

And a cloud of dust. While significant, EISA was not a game-winning play. Along with other efficiency legislation it has moved the ball down the field. It is most obviously part of a series with EPAct 2005 before it and the Recovery Act after. For example, the home appliance standards updates under EISA relied on advances due to a tax credit in EPAct 2005, and the block grant program was implemented with funding in the Recovery Act. But EISA also built on vehicle and appliance standards legislation from the 1970s. This incremental approach has made progress on efficiency even when blockbuster legislation has failed.

Follow the money. This might appear obvious, but it is important to note that programs and initiatives generally yield savings only if they are funded. A program like the energy sustainability and efficiency grants and loans for institutions may look great on paper, but it was never implemented. Partly for this reason it is very difficult to predict savings from program authorizations. Standards set in the law have more reliably yielded savings.

Be careful what you ask for. EISA authorized a number of programs for which there was no apparent source or possibility of funding. A year later an economic crisis led to the Recovery Act, which poured billions of dollars into some, though not all, of these programs. Programs with a base of political support and that appeared “shovel-ready” were most likely to get funding. Even then, quickly setting up programs was difficult.

Words matter. Poorly drafted legislative language has helped prevent implementation of standards and made it even harder to start up new programs. For example the fossil fuel standard for federal buildings has a clear goal but confusing details that have proven difficult to translate into a workable standard.

Can't we all just get along? Even with clear legislative direction, it has proven very difficult to issue standards without stakeholder support, including from the manufacturers to be regulated. Manufacturers have typically supported standards when they felt there was a real risk of imposed standards, either from the federal government or from states. But when

manufacturers have been brought to the table, we have been able to get meaningful standards that made a difference in the marketplace.

The buck stops here. The most successful programs have been those that had clear presidential support. Even though President Bush signed the bill, implementation proceeded very slowly for the remaining year of his term. President Obama has clearly committed to the vehicle standards, appliance standards, and Recovery Act programs, all of which have been implemented in a relatively timely manner. The other programs at DOE and at HUD have languished.

THE REMAINING TO-DO LIST

A great deal has been accomplished by implementing EISA provisions, but more work remains to be done. Of course, some programs have never been funded. More remarkably, more than seven years after enactment, there still are rulemakings that remain to be completed (some of which had no deadlines in the law). These include:

- *Tire fuel-efficiency consumer information.* DOT expects to complete by 2017.
- *Battery charger efficiency standard.* DOE just issued a revised draft rule.
- *Implementation of regional standard for air conditioners.* DOE is working on a draft rule based on a 2014 negotiated rulemaking.
- *Labels for personal computers and monitors, cable or satellite set-top boxes, and digital video recorders.* FTC awaits test procedures from DOE.
- *Manufactured housing efficiency standard.* DOE is working on a draft rule based on a 2014 negotiated rulemaking.
- *Fossil fuel standard for federal buildings.* DOE issued a second draft rule in 2014.
- *Multiple appliance test procedures and standards to incorporate standby power and update older standards.*
- *Waste Energy Recovery Registry.* EPA issued a notice of proposed rulemaking in July 2009, but there is no apparent work toward a final rule.

In addition, a number of updates to EISA standards are due in the remainder of the Obama administration. These include:

- *Heavy-duty vehicle standard.* DOT and EPA are due to complete in 2016.
- *Light bulb, dehumidifier, and external power supply standards.* Revised DOE standards are due by January 2017.
- *Efficiency requirement for federally assisted housing.* Second HUD and USDA determination is due in 2015.

We hope the agencies will move expeditiously to complete these measures and not leave the next administration a legacy of unfinished rules and lost savings.

Conclusion

Every year the EIA publishes a long-term forecast of the energy economy in the United States, the *Annual Energy Outlook*. It is usually difficult to discern the impact of legislation on the trillion-dollar energy sector. But in 2008 EIA revised its forecast primarily because EISA “has a significant impact on both projected total energy consumption and GHG emissions”

(EIA 2008). Looking at only a limited set of EISA provisions, EIA reduced its projected total energy consumption for 2030 by 4% (5 quads).

Our examination shows that the implementation of EISA is in broad terms achieving these projected savings. Some provisions have been disappointing—there has been no funding, or a rulemaking has been drawn out or nonexistent. Others were unexpectedly funded in the Recovery Act, but with little prospect of continuation. But the most important provisions, the efficiency standards for vehicles and appliances, are beginning to have a large impact, saving consumers money and reducing pollution.

The impacts of EISA are an important part of a broader revolution, shown in figure 18. From 1984 to 2007 total energy consumption in the United States grew by a third, to 101 quads. In 2006 EIA projected US energy use would grow by another third by 2030, to 134 quads. But by 2008 EIA had reduced its forecast growth by almost half, to reach 118 quads. So far US energy use remains below what turned out to be a 2007 peak, at 98 quads in 2014. And EIA now projects virtually no growth, reaching only 103 quads in 2030.

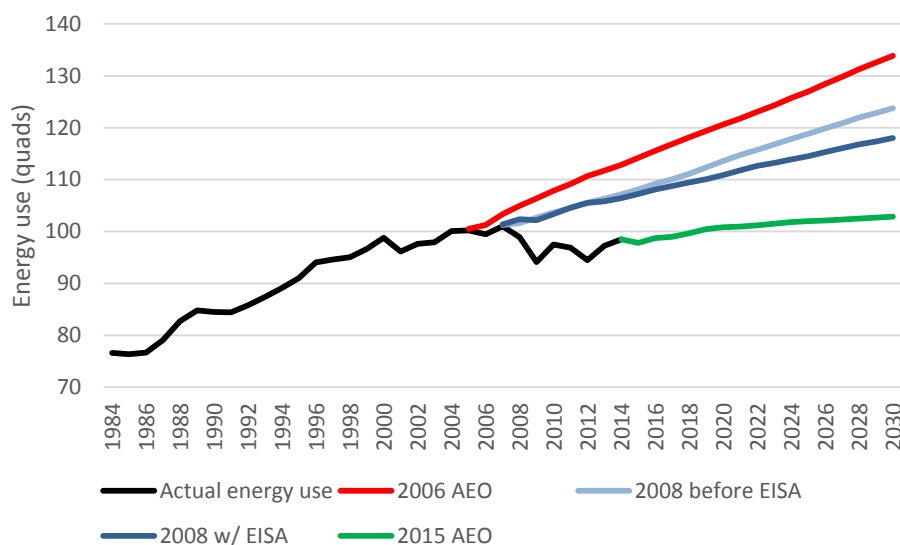


Figure 18. Actual total US energy use and change in projected energy use, in part due to impact of EISA.
Source: EIA 2008; EIA 2015a; EIA 2015c.

We can do even better than this. A 2012 ACEEE report estimated that an aggressive and concerted effort to increase energy efficiency through advanced technologies and infrastructure improvements could *reduce* energy usage in this country by 30–50% by 2050 compared to current usage (Laitner et al. 2012). Achieving these tremendous savings, and their benefits to the economy, the environment, and national security, will require strong policy support, including major additional energy efficiency legislation in the coming years. EISA shows that with broad bipartisan support such policies can be enacted and can make a difference.

References

- ACEEE (American Council for an Energy-Efficient Economy). 2007. *Energy Bill Savings Estimates as Passed by the Senate*. <http://aceee.org/sites/default/files/pdf/fact-sheet/EnergyBillSavings12-14.pdf>.
- _____. 2015. "American Recovery and Reinvestment Act of 2009." Accessed May 6. <http://aceee.org/topics/american-recovery-and-reinvestment-act-2009>.
- ACEEE and ASE (Alliance to Save Energy). 1997. *Missing the Mark: Five-Year Report Card on the Energy Efficiency Provisions of the Energy Policy Act*. Washington, DC: ACEEE and ASE. <http://aceee.org/research-report/e975>.
- ACEEE, Environmental Defense Fund, Natural Resources Defense Council, Sierra Club, and Union of Concerned Scientists. 2014. *Big Fuel Savings Available in New Trucks*. Washington, DC: ACEEE. <http://aceee.org/sites/default/files/pdf/fact-sheet/truck-savings-0614.pdf>.
- Argonne National Laboratory. 2015. "The VISION Model." Accessed April 15. <http://www.anl.gov/energy-systems/project/vision-model>.
- ASAP (Appliance Standards Awareness Project). 2010. *Energy Efficient and Smart Appliance Agreement of 2010*. Boston: ASAP. http://www.appliance-standards.org/sites/default/files/appliance-efficiency-standards-agreement080310_0.pdf.
- Bardsley, N., S. Bland, L. Pattison, M. Pattison, K. Stober, F. Welsh, and M. Yamada. 2014. *Solid-State Lighting Research and Development Multi-Year Program Plan*. Washington, DC: DOE. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf.
- BCS, Inc. 2008. *Waste Heat Recovery: Technology and Opportunities in U.S. Industry*. Washington, DC: Department of Energy. http://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf.
- Canis, B. 2013. *Battery Manufacturing for Hybrid and Electric Vehicles: Policy Issues*. Washington, DC: Congressional Research Service. <https://www.fas.org/sgp/crs/misc/R41709.pdf>.
- Canis, B., and B. Yacobucci. 2015. *The Advanced Technology Vehicles Manufacturing (ATVM) Loan Program: Status and Issues*. Washington, DC: Congressional Research Service. <https://www.fas.org/sgp/crs/misc/R42064.pdf>.
- CBC (Commercial Buildings Consortium). 2011a. *Next Generation Technologies: Barriers and Recommendations for Commercial Buildings*. February. Washington, DC: Zero Energy Commercial Buildings Consortium.

<https://www.naseo.org/data/sites/1/documents/publications/CBC-Technologies-Report-2011.pdf>.

—. 2011b. *Analysis of Cost & Non-Cost Barriers and Policy Solutions for Commercial Buildings*. February. Washington, DC: Zero Energy Commercial Buildings Consortium.

<http://www3.cec.org/islandora-gb/en/islandora/object/greenbuilding%3A48/datastream/OBJ-EN/view>.

Census (US Census Bureau). 2015a. "Manufactured Homes Survey." Accessed September 3. <http://www.census.gov/construction/mhs/mhsindex.html>.

—. 2015b. "New Residential Sales: Quarterly Sales by Price and Financing." Accessed April 4. <http://www.census.gov/construction/nrs/>.

CFO (Department of Energy Office of the Chief Financial Officer). 2015. "Budget (Justification & Supporting Documents)." Accessed May 21. <http://energy.gov/cfo/reports/budget-justification-supporting-documents>.

Cortese, A., and C. Higgins. 2014. *2014 Getting to Zero Status Update*. Vancouver, WA: New Buildings Institute. http://newbuildings.org/sites/default/files/2014_Getting_to_Zero_Update.pdf.

Davidson, P. 2015. "Financing the Growing American Auto Industry." Loan Programs Office, US Department of Energy, March 26. <http://energy.gov/lpo/articles/financing-growing-american-auto-industry>.

Davis, S., S. Diegel, and R. Boundy. 2014. *Transportation Energy Data Book: Edition 33*. Oak Ridge, TN: Oak Ridge National Laboratory. http://cta.ornl.gov/data/tedb33/Edition33_Full_Doc.pdf.

Dimetrosky, S., and K. Parkinson. 2014. "Midterm Results from EISA 2007." In *Proceedings of the ACEEE 2014 Summer Study on Energy Efficiency in Buildings*. Washington, DC: ACEEE. <http://aceee.org/files/proceedings/2014/data/papers/6-1270.pdf>.

DNV GL. 2015. *National Evaluation of the State Energy Program: An Evaluation of Select Activities Conducted Under the State Energy Program. Executive Summary*. Oak Ridge, TN: ORNL. <http://weatherization.ornl.gov/SepReportspdfs/ExecutiveSummarySEP.pdf>.

DOE (US Department of Energy). 2009a. *2008 Vehicles Technology Market Report*. Washington, DC: US DOE. <http://www.nrel.gov/docs/fy09osti/46018.pdf>.

—. 2009b. "Secretary Chu Announces \$620 Million for Smart Grid Demonstration and Energy Storage Projects." November 24. http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/SG_11-24-09_Demos_Energy_Storage%28OE%29.pdf.

- . 2010. *Multi-Year Program Plan: Building Regulatory Programs*. Washington, DC: DOE.
http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/regulatory_programs_mypp.pdf.
- . 2011. "SERC Grants Expand Weatherization Technologies."
http://energy.gov/sites/prod/files/2014/01/f7/serc_factsheet.pdf.
- . 2012. *Application of Automated Controls for Voltage and Reactive Power Management: Initial Results*. Washington, DC: DOE.
http://energy.gov/sites/prod/files/Voltage%26ReactivePower_Dec2012Final.pdf.
- . 2013a. *Smart Grid Investment Grant Program: Progress Report II*. Washington, DC: DOE.
https://www.smartgrid.gov/sites/default/files/doc/files/SGIG_progress_report_2013.pdf.
- . 2013b. *Sustainable Energy Resources for Consumers (SERC) Success Story: Maryland*. Washington, DC: DOE.
http://energy.gov/sites/prod/files/2014/01/f7/serc_md_highlight.pdf.
- . 2013c. *Sustainable Energy Resources for Consumers (SERC) Success Story: Montana*. Washington, DC: DOE.
http://energy.gov/sites/prod/files/2014/01/f7/serc_mt_highlight.pdf.
- . 2014a. *Smart Grid Systems Report: Report to Congress*. Washington, DC: DOE.
<https://www.smartgrid.gov/sites/default/files/doc/files/2014-Smart-Grid-System-Report.pdf>.
- . 2014b. Fossil Fuel-Generated Energy Consumption Reduction for New Federal Buildings and Major Renovations of Federal Buildings; Supplemental Notice of Proposed Rulemaking. 79 Fed. Reg. 61693-61735 (October 14).
<http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0031-0034>.
- . 2015a. "History and Impacts." Accessed March 9.
<http://energy.gov/eere/buildings/history-and-impacts>.
- . 2015b. "Accomplishments." Accessed September 3. <http://energy.gov/eere/better-buildings-neighborhood-program/accomplishments>.
- . 2015c. "About the Energy Efficiency and Conservation Block Grant Program." Accessed March 4. <http://energy.gov/eere/wipo/about-energy-efficiency-and-conservation-block-grant-program#evaluation>.
- . 2015d. "Federal Government Energy Management Conservation Programs Reports to Congress." Accessed April 1. <http://energy.gov/eere/femp/downloads/federal-government-energy-management-conservation-programs-reports-congress>.
- . 2015e. "FEMP EISA 432 Compliance Tracking System." Accessed April 3.
<http://ctsedweb.ee.doe.gov/CTSDDataAnalysis/ComplianceOverview.aspx>.

- . 2015f. *Grid Impacts, Benefits, and Lessons Learned*. Washington, DC: DOE.
<https://www.smartgrid.gov/sites/default/files/doc/files/Document-of-Documents-01-23-2015.pdf>.
- . 2015g. "Rulemaking for Manufactured Housing Energy Conservation Standard." Accessed September 3.
https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=97.
- . 2015h. *Weatherization Assistance Program: National Evaluations: Summary of Results*. Washington, DC: DOE.
http://www.energy.gov/sites/prod/files/2015/08/f25/WAP_NationalEvaluation_WxWorks_v14_blue_8%205%2015.pdf.
- EIA (Energy Information Administration). 2008. *Annual Energy Outlook 2008*. Washington, DC: EIA. [http://www.eia.gov/oiaf/aeo/pdf/0383\(2008\).pdf](http://www.eia.gov/oiaf/aeo/pdf/0383(2008).pdf).
- . 2015a. *Annual Energy Outlook 2015*. Washington, DC: EIA.
[http://www.eia.gov/forecasts/aeo/pdf/0383\(2015\).pdf](http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf).
- . 2015b. "Table 9c: US Regional Weather Data." Accessed March 11.
<http://www.eia.gov/forecasts/steo/tables/?tableNumber=28#>.
- . 2015c. "Monthly Energy Review." Accessed July 8.
<http://www.eia.gov/totalenergy/data/monthly/index.cfm>.
- Eisenberg, J. 2014. *Weatherization Assistance Program Technical Memorandum: Background Data and Statistics on Low-Income Energy Use and Burdens*. Oak Ridge, TN: Oak Ridge National Laboratory. http://weatherization.ornl.gov/pdfs/ORNLTm2014_133.pdf.
- EPA (US Environmental Protection Agency). 2011. *New Fuel Economy and Environment Labels for a New Generation of Vehicles*. Washington, DC: EPA.
<http://www.epa.gov/carlabel/documents/420f11017a.pdf>.
- . 2014. *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2014*. Washington, DC: EPA.
<http://www3.epa.gov/fueleconomy/fetrends/1975-2014/420r14023a.pdf>.
- . 2015a. *Greenhouse Gas Emission Standards for Light-Duty Vehicles: Manufacturer Performance Report for the 2013 Model Year*. Washington, DC: EPA.
<http://www.epa.gov/oms/climate/ghg-report.htm>.
- . 2015b. *EPA and NHTSA Propose Standards to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy-Duty Vehicles for Model Year 2018 and Beyond*. Washington, DC: EPA. <http://www.epa.gov/oms/climate/documents/420f15901.pdf>.

- EPA and NHTSA (National Highway Traffic Safety Administration). 2012. Model Year 2017-2025 Light-Duty Fuel Economy Standards. 77 Fed. Reg. 62624 (Oct. 15).
<http://www.gpo.gov/fdsys/pkg/FR-2012-10-15/pdf/2012-21972.pdf>.
- . 2015. Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2. 80 Fed. Reg. 40138 (July 13).
<http://www.gpo.gov/fdsys/pkg/FR-2015-07-13/pdf/2015-15500.pdf>.
- Executive Office of the President. 2013. “The President’s Climate Action Plan.” June 25.
<http://www.whitehouse.gov/share/climate-action-plan>.
- Fazeli, S. 2013. “Zero Energy Commercial Buildings Consortium.” Presentation to the BTO Program Peer Review. April 2.
http://www1.eere.energy.gov/buildings/commercial/pdfs/commblbldgs07_fazeli_040213.pdf.
- Fowler, M., M. Greenstone, and C. Wolfram. 2015. *Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program*. Berkeley: E2e.
<http://e2e.haas.berkeley.edu/pdf/workingpapers/WP020.pdf#page=1>.
- Fryer, A. 2013. “Why Recent Progress on Efficiency Should Make You Feel Better about Binge Watching Your Favorite Shows.” ACEEE blog, October 11.
<http://aceee.org/blog/2013/10/why-recent-progress-television-effici>.
- FTC (Federal Trade Commission). 2010. Appliance Labeling Rule. 75 Fed. Reg. 41696 (July 19). <https://federalregister.gov/a/2010-16895>.
- . 2011. Disclosures Regarding Energy Consumption and Water Use of Certain Home Appliances and Other Products Required under the Energy Policy and Conservation Act (Appliance Labeling Rule). 76 Fed. Reg. 1037 (January 6).
<https://federalregister.gov/a/2010-32704>.
- . 2014. “Lights of America, Inc., Usman Vakil, and Farooq Vakil.”
<https://www.ftc.gov/enforcement/cases-proceedings/092-3145/lights-america-inc-usman-vakil-farooq-vakil>.
- GAO (US Government Accountability Office). 2011a. *Advanced Technology Vehicle Loan Program Implementation Is Under Way, but Enhanced Technical Oversight and Performance Measures Are Needed*. Washington, DC: GAO.
<http://www.gao.gov/assets/320/316175.pdf>.
- . 2011b. *Recovery Act: Energy Efficiency and Conservation Block Grant Recipients Face Challenges Meeting Legislative and Program Goals and Requirements*. Washington, DC: GAO.
<http://www.gao.gov/assets/320/317486.pdf>.
- . 2014. *Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*. Washington, DC: GAO.
<http://www.gao.gov/assets/670/662327.pdf>.

- . 2015. *Energy Savings Performance Contracts: Additional Actions Needed to Improve Federal Oversight*. Washington, DC: GAO. <http://www.gao.gov/assets/680/670851.pdf>.
- Gold, R., and S. Nadel. 2011. *Assessing the Harvest: Implementation of the Energy Efficiency Provisions in the Energy Policy Act of 2005*. Washington, DC: ACEEE. <http://aceee.org/sites/default/files/publications/researchreports/E113.pdf>.
- Google Trends. 2015. Accessed March 26. <https://www.google.com/trends/explore>.
- Grieve, T. 2006. "Bush on the Vote: A Thumpin'." *Salon*. November 8. http://www.salon.com/2006/11/08/bush_conference_2/.
- GSA (US General Services Administration). 2015. "Recovery Act: Federal Buildings Fund Investments." Accessed March 20. <http://www.gsa.gov/portal/content/105326>.
- House Budget Committee. 2014. *The Path to Prosperity: Fiscal Year 2015 Budget Resolution*. http://budget.house.gov/uploadedfiles/fy15_blueprint.pdf.
- Howell, D. 2014. *Overview of the DOE Advanced Battery R&D Program*. Washington, DC: DOE. http://energy.gov/sites/prod/files/2014/09/f18/battery_rd_amr_plenary_june_2014_final.pdf.
- HUD (US Department of Housing and Urban Development) and USDA (US Department of Agriculture). 2015. Final Affordability Determination: Energy Efficiency Standards. 80 Fed. Reg. 25901-25924 (May 6). <http://www.gpo.gov/fdsys/pkg/FR-2015-05-06/pdf/2015-10380.pdf>.
- Hulse, C. 2007. "Democrats Plan First 100 Hours, Give or Take a Speech." *New York Times*, January 3. http://www.nytimes.com/2007/01/03/washington/03cong.html?_r=0.
- Laitner, J., S. Nadel, R. N. Elliott, H. Sachs, and A. Khan. 2012. *The Long-Term Energy Efficiency Potential: What the Evidence Suggests*. Washington, DC: ACEEE. <http://aceee.org/research-report/e121>.
- Lowenberger, A., J. Mauer, A. deLaski, M. DiMascio, J. Amann, and S. Nadel. 2012. *The Efficiency Boom: Cashing In on the Savings from Appliance Standards*. Washington, DC: ACEEE and ASAP. <http://www.appliance-standards.org/sites/default/files/The%20Efficiency%20Boom.pdf>.
- LPO (Loan Programs Office). 2015a. "LPO Portfolio Performance Summary." June.
- . 2015b. "Portfolio Projects." Accessed September 1. <http://energy.gov/lpo/projects>.
- McKinsey & Company. 2012. *Lighting the Way: Perspectives on the Global Lighting Market*. http://www.mckinsey.com/~media/mckinsey/dotcom/client_service/Automotive%20and%20Assembly/Lighting_the_way_Perspectives_on_global_lighting_market_2012.ashx.

- Navigant Consulting. 2012. *2010 U.S. Lighting Market Characterization*. Washington, DC: DOE. <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>.
- . 2014. *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*. Washington, DC: DOE. <http://energy.gov/sites/prod/files/2015/05/f22/energysavingsforecast14.pdf>.
- . 2015. *Adoption of Light-Emitting Diodes in Common Lighting Applications*. Washington, DC: DOE. http://energy.gov/sites/prod/files/2015/07/f24/led-adoption-report_2015.pdf.
- NEMA (National Electrical Manufacturers Association). 2015. "Compact Fluorescent Lamp Shipments Continue to Lag." January 20. <http://www.nema.org/news/Pages/Compact-Fluorescent-Lamp-Shipments-Continue-to-Lag.aspx>.
- NBI (New Buildings Institute). 2012. *Getting to Zero 2012 Status Update: A First Look at the Costs and Features of Zero Energy Commercial Buildings*. Washington, DC: National Association of State Energy Officials. <https://www.naseo.org/data/sites/1/documents/publications/Getting-to-Zero-Report.pdf>.
- . 2015. "2015 List of Zero Energy Buildings." <http://newbuildings.org/2015-list-zero-energy-buildings>.
- NHTSA (National Highway Traffic Safety Administration). 2008. *Notice of Proposed Rulemaking: Average Fuel Economy Standards Passenger Cars and Light Trucks Model Years 2011-2015*. Washington, DC: NHTSA. http://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/CAFE_11-15_NPRM_April_21.pdf.
- . 2010. Final Rule: Tire Fuel Efficiency Consumer Information Program. 75 Fed. Reg. 15894 (March 30). <https://federalregister.gov/a/2010-6907>.
- . 2012a. *NHTSA and EPA Set Standards to Improve Fuel Economy and Reduce Greenhouse Gases for Passenger Cars and Light Trucks for Model Years 2017 and Beyond*. Washington, DC: NHTSA. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/CAFE_2017-25_Fact_Sheet.pdf.
- . 2012b. Tire Fuel Efficiency Consumer Information Program. Notice of Public Workshop and Agenda. 77 Fed. Reg. 3726 (Jan. 25). <https://federalregister.gov/a/2012-1525>.
- NRC (National Research Council). 2010. *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*. Washington, DC: National Academies Press. <http://www.nap.edu/catalog/12845/technologies-and-approaches-to-reducing-the-fuel-consumption-of-medium--and-heavy-duty-vehicles>.

- NRDC (Natural Resource Defense Council). 2014. "Your Guide to More Efficient and Money-Saving Light Bulbs." July.
<http://www.nrdc.org/energy/lightbulbs/files/lightbulbguide.pdf>.
- Obama, B. 2008. "Remarks to the Clinton Global Initiative." September 25.
<http://www.presidency.ucsb.edu/ws/index.php?pid=84332>.
- . 2009. "Remarks of the President at Signing of the American Recovery and Reinvestment Act." February 17. <https://www.whitehouse.gov/the-press-office/remarks-president-and-vice-president-signing-american-recovery-and-reinvestment-act>.
- Office of the Press Secretary. 2014. "Fact Sheet: President Announces Commitments and Executive Actions to Advance Solar Deployment and Energy Efficiency." May 9. Washington, DC: The White House. <https://www.whitehouse.gov/the-press-office/2014/05/09/fact-sheet-president-obama-announces-commitments-and-executive-actions-a>.
- Oliver, L. 2011. "Weatherization and Intergovernmental Program." Presentation at the National Conference of Legislatures. November 29.
<http://www.ncsl.org/documents/energy/LOliver112911.pdf>.
- OMB (Office of Management and Budget). 2013. *Implementation of OMG Memorandum M-12-12 Section 3: Freeze the Footprint*. Washington, DC: Executive Office of the President.
<https://www.whitehouse.gov/sites/default/files/omb/financial/memos/implementation-of-freeze-the-footprint-guidance.pdf>.
- . 2015. "OMB Sustainability and Energy Scorecards." Accessed August 12.
<https://www.whitehouse.gov/administration/eop/ceq/sustainability/omb-scorecards%20%20>.
- PG&E (Pacific Gas and Electric Company). 2015. "PG&E Zero Net Energy (ZNE) Pilot Program." Accessed September 15.
<http://www.pge.com/en/myhome/saveenergymoney/rebates/zne/index.page>.
- PNNL (Pacific Northwest National Laboratory). 2014. Analysis provided to the ASRAC Manufactured Housing Working Group.
<http://www.regulations.gov/#!docketBrowser;rpp=25;so=DESC;sb=postedDate;po=0;dc=SR%252BO;D=EERE-2009-BT-BC-0021>.
- Ramsey, M. 2015. "Energy Department Revives Fuel-Efficient Vehicle Loan Program." *Wall Street Journal*, March 26. <http://www.wsj.com/articles/energy-department-revives-fuel-efficient-vehicle-loan-program-1427342461>.
- Research into Action. 2015. *Evaluation of the Better Buildings Neighborhood Program: Final Synthesis Report, Volume 1*. Prepared for DOE.
http://www1.eere.energy.gov/analysis/pdfs/bbnp_volume_1_final_evaluation_072215.pdf.

- Schneider, K., J. Fuller, F. Tuffner, and R. Singh. 2010. *Evaluation of Conservation Voltage Reduction (CVR) on a National Level*. Richland, WA: PNNL.
http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19596.pdf.
- Shipley, A., A. Hampson, B. Hedman, P. Garland, and P. Bautista. 2008. *Combined Heat and Power: Effective Energy Solutions for a Sustainable Future*. Oak Ridge, TN: Oak Ridge National Laboratory.
http://www.energy.gov/sites/prod/files/2013/11/f4/chp_report_12-08.pdf.
- Shonder, J. 2013. *Beyond Guaranteed Savings: Additional Cost Savings Associated with ESPC Projects*. Oak Ridge, TN: Oak Ridge National Laboratory.
<http://web.ornl.gov/sci/ees/etsd/btrc/publications/Publication%2041816.pdf>.
- Storie, K. 2013. "DOE Launches New CHP Technical Assistance Partnerships." October 22. Lakewood, CO: Western Area Power Administration.
<http://esnews.wapa.gov/wordpress/2013/10/22/doe-launches-new-chp-technical-assistance-partnerships/>.
- Transport Topics. 2015a. "Leasing Firms Able to Increase Business from Improved Market, Ryder Exec Says." January 5.
- . 2015b. "US Delays Greenhouse Gas Rule." April 6.
- Tremper, C. 2013. "FEMP EISA 432 Compliance Tracking System." Presentation at the ESSG Teleconference. May 15.
- . 2014. "Federal Progress toward Energy/Sustainability Goals." Presentation at the Federal Interagency Energy Management Task Force. May 22.
http://energy.gov/sites/prod/files/2014/08/f18/facility_sustainability_goals.pdf.
- Trombley, D. 2012. "ACEEE & AMMEX Respond to DOE's Industrial Program FY2013 Budget Request." ACEEE blog, March 16. <http://aceee.org/blog/2012/03/aceee-ammex-respond-doe-s-industrial->.
- Ungar, L., C. Kallakuri, and J. Barrett. 2015. *2015 Federal Energy Efficiency Legislation Projected Impacts*. Washington, DC: ACEEE. <http://aceee.org/white-paper/2015-ee-legislation>.
- Ungar, L. W., J. Mauer, S. Khan, and S. Vaidyanathan. 2014. *Government Works: Federal Agency Actions on Energy Efficiency*. Washington, DC: ACEEE.
<http://aceee.org/government-works-federal-agency-actions-energy-efficiency>.
- USCM (US Conference of Mayors). 2014. *Successful City Initiatives with Energy Efficiency and Conservation Block Grant (EECBG) Funding: A 204-City Survey*.
<http://usmayors.org/pressreleases/uploads/2014/0227-report-eecbgsurvey.pdf>.
- The White House. 2007. "Twenty in Ten: Strengthening America's Energy Security."
<http://georgewbush-whitehouse.archives.gov/stateoftheunion/2007/initiatives/energy.html>.

- . 2009. “Appliance Efficiency Standards.” Memorandum for the Secretary of Energy. February 5. <https://www.whitehouse.gov/the-press-office/appliance-efficiency-standards>.
- . 2014. “Fact Sheet: Increasing Safety and Efficiency While Saving Money at the Pump.” December 9. <https://www.whitehouse.gov/the-press-office/2014/12/09/fact-sheet-increasing-safety-and-efficiency-while-saving-money-pump>.
- Whitefoot, K., and S. Skerlos. 2012. “Design Incentives To Increase Vehicle Size Created from the U.S. Footprint-Based Fuel Economy Standards.” *Energy Policy* 41: 402–411.

Appendix A. List of Energy Efficiency Provisions in EISA

Provisions in **bold** were included in our 2007 projection of savings. Provisions in *italics* are also discussed in this report. The list is organized by subject, not by section number.

Transportation

- Fuel Economy Standards
 - **Sections 102-103: Average Fuel Economy Standards for Automobiles and Certain Other Vehicles**
 - CAFE standards increase
 - Standards for medium- and heavy-duty vehicles
 - Section 104: Credit Trading Program
 - Sections 107-108: National Academy of Sciences Studies
 - Section 109: Extension of Flexible Fuel Vehicle Credit Program
 - Section 112: Use of Civil Penalties for Research and Development
- Labels and Consumer Information
 - *Section 105: Consumer Information*
 - Directs DOT to modify vehicle fuel economy labels
 - *Section 110: Periodic Review of Accuracy of Fuel Economy Labeling Procedures*
 - *Section 111: Consumer Tire Information*
- Research, Development, and Deployment Programs
 - Section 131: Transportation Electrification
 - Section 132: Domestic Manufacturing Conversion Grant Program
 - *Section 134: Loan Guarantees for Fuel-Efficient Automobile Parts Manufacturers*
 - *Section 135: Advanced Battery Loan Guarantee Program*
 - *Section 136: Advanced Technology Vehicles Manufacturing Incentive Program*
 - Section 651: Lightweight Materials Research and Development
 - Section 1111: Advanced Technology Locomotive Grant Pilot Program
 - Section 1112: Capital Grants for Class II and Class III Railroads
- Federal and Fleet Fuel Use
 - Section 133: Inclusion of Electric Drive in Energy Policy Act of 1992
 - Section 141: Federal Vehicle Fleets
 - Section 142: Federal Fleet Conservation Requirements

Residential and Commercial Buildings

- Appliance and Equipment Standards and Labels
 - Appliance and Equipment Standards in Law
 - **Section 301: External Power Supply Efficiency Standards**
 - **Section 303: Residential Boilers**
 - **Section 311: Energy Standards for Home Appliances**
 - Residential dehumidifiers
 - Residential clothes washers
 - Residential dish washers
 - Directs DOE to update standards on refrigerators and freezers
 - **Section 312: Walk-in Coolers and Walk-in Freezers**

- **Section 313: Electric Motor Efficiency Standards**
- Section 314: Standards for Single Package Vertical Air Conditioners and Heat Pumps
 - Adopts ASHRAE standard
- Section 316: Technical Corrections
- DOE Directed to Set Appliance Standards
 - **Section 304: Furnace Fan Standard Process**
 - *Section 309: Battery Chargers*
- Appliance Standards Process
 - *Section 305: Improving Schedule for Standards Updating and Clarifying State Authority*
 - **Section 306: Regional Standards for Furnaces, Central Air Conditioners, and Heat Pumps**
 - *Section 307: Procedure for Prescribing New or Amended Standards*
 - Eliminates requirement for advanced notice of proposed rulemaking
 - *Section 308: Expedited Rulemakings*
 - Quicker process for standards based on consensus agreements
 - **Section 310: Standby Mode**
- Lighting Standards and Labels
 - **Section 321: Efficient Light Bulbs**
 - Performance standards for “general service” light bulbs
 - **Section 322: Incandescent Reflector Lamp Efficiency Standards**
 - **Section 324: Metal Halide Lamp Fixtures**
- Appliance Efficiency Labels
 - *Section 325: Energy Efficiency Labeling for Consumer Electronic Products*
- Building Codes
 - **Section 413: Energy Code Improvements Applicable to Manufactured Housing**
 - *Section 481: Application of International Energy Conservation Code to Public and Assisted Housing*
 - Updates efficiency criteria for new homes with federal mortgages and public housing
- Research, Development, and Deployment (RD&D) Programs
 - Commercial Buildings (see also Green Buildings)
 - **Section 422: Zero Net Energy Commercial Buildings Initiative**
 - Section 453: Energy Efficiency for Data Center Buildings
 - Small Business Programs
 - Section 1201: Express Loans for Renewable Energy and Energy Efficiency
 - Section 1202: Pilot Program for Reduced Fees for Purchase of Energy Efficient Technologies
 - Section 1203: Small Business Energy Efficiency
 - Section 1204: Larger 504 Loan Limits to Help Business Develop Energy Efficient Technologies and Purchases
 - Section 1205: Energy Saving Debentures
 - Section 1206: Investments in Energy Saving Small Businesses
 - Other RD&D

- Section 315: Improved Energy Efficiency for Appliances and Buildings in Cold Climates
 - Section 412: Study of Renewable Energy Rebate Programs
 - Section 652: Commercial Insulation Demonstration Program
 - Section 655: Bright Tomorrow Lighting Prizes
- Commercial Green Buildings (Private and Federal)
 - Section 421: Commercial High-Performance Green Buildings
 - Section 423: Public Outreach
 - Section 436: High-Performance Green Federal Buildings
 - Section 441: Public Building Life-Cycle Costs
 - Section 491: Demonstration Project
 - Section 492: Research and Development
- Federal Energy Management
 - Existing buildings and overall targets
 - *Section 431: Energy Reduction Goals for Federal Buildings*
 - Energy intensity goals for existing federal buildings
 - *Section 432: Management of Energy and Water Efficiency in Federal Buildings*
 - For large buildings requires energy managers, energy and water evaluations, recommissioning, and benchmarking
 - Section 439: Cost-Effective Technology Acceleration Program
 - GSA plan to reduce operational costs by 20%
 - New buildings and major renovations
 - *Section 433: Federal Building Energy Efficiency Performance Standards*
 - New buildings and major renovations to reduce fossil fuel use and follow sustainable design, including green building certification
 - Section 434: Management of Federal Building Efficiency
 - Energy efficiency in large capital investments, and gas and steam metering
 - Leased buildings
 - Section 323: Public Building Energy Efficient and Renewable Energy Systems
 - Section 435: Leasing
 - Leased buildings by federal agencies must have earned the ENERGY STAR label in the previous year, with a few exceptions
 - US Capitol Complex
 - Section 501: Capitol Complex Photovoltaic Roof Feasibility Studies
 - Section 503: Energy and Environmental Measures in Capitol Complex Master Plan
 - Section 504: Promoting Maximum Efficiency in Operation of Capitol Power Plant
 - Energy Savings Performance Contracts
 - Section 511: Authority to Enter Into Contracts; Reports
 - Section 512: Financing Flexibility
 - Section 513: Promoting Long-Term Energy Savings Performance Contracts and Verifying Savings
 - *Section 514: Permanent Reauthorization*

- Section 517: Training Federal Contracting Offers to Negotiate Energy Efficiency Contracts
- Section 518: Study of Energy and Cost Savings in Nonbuilding Applications
- Appliances and Products
 - Section 522: Prohibition of Incandescent Lamps by Coast Guard
 - Section 524: Federally-Procured Appliances with Standby Power
 - Section 525: Federal Procurement of Energy Efficient Products
- Status Reports
 - Section 527: Government Efficiency Status Reports
 - Section 528: OMB Government Efficiency Reports and Scorecards

Industry

- **Section 451: Industrial Energy Efficiency**
 - Survey and registry, grants, and state policies on waste energy and combined heat and power projects
- **Section 452: Energy-Intensive Industries Program**
 - DOE R&D programs and Industrial Assessment Centers

Utilities

- Section 529: Electricity Sector Demand Response
- Section 532: Utility Energy Efficiency Programs
 - State consideration of integrated resource planning and rate design changes
- Section 571: National Action Plan for Demand Response
- Section 1301: Statement of Policy on Modernization of Electricity Grid
- Section 1302: Smart Grid System Report
- Section 1303: Smart Grid Advisory Committee and Smart Grid Task Force
- *Section 1304: Smart Grid Technology Research, Development, and Demonstration*
- Section 1305: Smart Grid Interoperability Framework
- *Section 1306: Federal Matching Fund for Smart Grid Investment Costs*
- Section 1307: State Consideration of Smart Grid

Cross-Cutting

- Research, Development, and Deployment Programs
 - State and Local Programs
 - **Section 411: Reauthorization of Weatherization Assistance Program**
 - Section 493: Environmental Protection Agency Demonstration Grant Program for Local Governments
 - *Section 531: Reauthorization of State Energy Programs*
 - **Sections 541-548: Energy Efficiency and Conservation Block Grant Program**
 - Other Programs
 - **Section 471: Energy Sustainability and Efficiency Grants and Loans for Institutions**
 - Section 495: Advisory Committee on Energy Efficiency Finance
 - Section 641: Energy Storage Competitiveness

- Section 801: National Media Campaign
- Section 1002: Energy Efficiency and Renewable Energy Worker Training Program
 - May also be known as the “Green Jobs Act of 2007”
- Foreign Assistance and Trade
 - Section 911: United States Assistance for Developing Countries
 - Section 912: United States Exports and Outreach Programs for India, China, and Other Countries
 - Section 913: United States Trade Missions to Encourage Private Sector Trade and Investment
 - Section 914: Actions by Overseas Private Investment Corporation
 - Section 915: Actions by United States Trade and Development Agency
 - Section 916: Deployment of International Clean and Efficiency Energy Technologies and Investment in Global Energy Markets
 - Sections 921-927: International Clean Energy Foundation

Appendix B. Appliance Standards in EISA

Table B1. Appliance standards in EISA and required updates

Product	Standard in bill				Updates			
	EISA section	New product	Effective date in bill	Rule issued	1st update deadline	Rule issued (or progress)	Consensus agreement	2nd update deadline
Light bulbs (general service)	321	New	2012-14	3/23/09	1/1/17	TSD 12/11/14		1/1/22
Incandescent reflector lamps	322		1-6/2008	3/23/09	In prior law	7/14/09		Rule iss. 1/26/15
Metal halide lamp fixtures	324		1/1/09	3/23/09	1/1/12	2/10/14		1/1/19
Clothes washers	311		1/1/11	3/23/09	12/31/11	5/31/12 (DFR)	8/3/10	
Dishwashers	311		1/1/10	3/23/09	1/1/15	5/30/12 (DFR)	8/3/10	NOPR iss. 12/19/14
Dehumidifiers	311		10/1/12	3/23/09	NOPR in 6 years	NOPR 6/3/15		
Boilers	303		9/1/12	7/28/08	In prior law	NOPR 3/31/15		
Walk-in coolers and freezers	312	New	1/1/09	3/23/09	1/1/12	6/3/14		1/1/20
External power supplies	301	New	7/1/08	3/23/09	7/1/11	2/10/14		7/1/15
Electric motors	313		12/19/10	3/23/09	In prior law	5/29/14	8/20/12	
Refrigerators and freezers	311				12/31/11	9/15/11	8/3/10	
Furnace fans	304	New			12/31/13	7/3/14		
Battery chargers	309	New			7/1/11	NOPR 3/27/12, SNOPR 9/1/15		

Status where no final standard: TSD = Technical Support Document, NOPR = Notice of Proposed Rulemaking, SNOPR = Supplemental NOPR, DFR = Direct Final Rule. Scope of light bulb and incandescent reflector lamp updates limited by lighting rider. EISA delayed the deadline that had been set in EPCA 2005 for a standard on battery chargers. Additional deadlines for regional standards, regular updates, and standby power are discussed in the text. *Source:* DOE appliance standards and ASAP websites.

Appendix C. Detailed Savings Estimates for EISA Provisions

Table C1. Annual savings estimates by provision in 2010, 2020, 2030, and 2040

2010 savings						
	Electricity (TWh)	Natural gas (Tbtu)	Oil (mbd)	Total energy (quads)	CO ₂ emissions (MMT)	Energy bill (billion \$)
Cars + light trucks	-	-	-	-	-	-
Trucks + buses	-	-	-	-	-	-
Vehicle standards total	-	-	-	-	-	-
Lighting	3	-	-	0.04	2	0.4
Home appliances	0	0	-	0.00	0	0.0
Home HVAC + electronics	0	-	-	0.00	0	0.0
Commercial equipment	1	-	-	0.01	0	0.1
Appliance standards total	4	0	-	0.05	3	0.5
Manufactured homes	-	-	-	-	-	-
EE block grants	1	7	-	0.01	1	0.1
Federal building standard	-	-	-	-	-	-
Other policies total	1	7	-	0.01	1	0.1
Total	5	7	-	0.06	3	0.6
2020 savings						
	Electricity (TWh)	Natural gas (Tbtu)	Oil (mbd)	Total energy (quads)	CO ₂ emissions (MMT)	Energy bill (billion \$)
Cars + light trucks	-	-	0.59	1.26	92	32.3
Trucks + buses	-	-	0.28	0.61	45	14.4
Vehicle standards total	-	-	0.87	1.86	137	46.6
Lighting	53	-	-	0.54	29	6.6
Home appliances	17	7	-	0.19	10	2.3
Home HVAC + electronics	7	8	0.00	0.09	5	1.1
Commercial equipment	14	-	-	0.14	8	1.3
Appliance standards total	92	15	0.00	0.96	51	11.2
Manufactured homes	1	2	-	0.01	1	0.2
EE block grants	3	34	-	0.06	3	0.6
Federal building standard	0	0	-	0.00	0	0.0
Other policies total	4	36	-	0.08	4	0.8
Total	96	51	0.87	2.90	192	58.6

2030 savings						
	Electricity (TWh)	Natural gas (Tbtu)	Oil (mbd)	Total energy (quads)	CO ₂ emissions (MMT)	Energy bill (billion \$)
Cars + light trucks	-	-	1.88	4.03	296	121.2
Trucks + buses	-	-	0.97	2.08	154	59.4
Vehicle standards total	-	-	2.85	6.11	450	180.5
Lighting	75	-	-	0.76	39	9.8
Home appliances	45	19	-	0.47	25	6.4
Home HVAC + electronics	23	7	0.00	0.24	13	3.4
Commercial equipment	27	-	-	0.28	14	2.7
Appliance standards total	170	27	0.00	1.75	91	22.2
Manufactured homes	6	9	-	0.07	4	1.0
EE block grants	-	-	-	-	-	-
Federal building standard	2	1	-	0.02	1	0.2
Other policies total	8	10	-	0.09	5	1.2
Total	178	36	2.85	7.95	546	203.9
2040 savings						
	Electricity (TWh)	Natural gas (Tbtu)	Oil (mbd)	Total energy (quads)	CO ₂ emissions (MMT)	Energy bill (billion \$)
Cars + light trucks	-	-	2.49	5.37	396	199.0
Trucks + buses	-	-	1.36	2.93	217	103.3
Vehicle standards total	-	-	3.85	8.30	614	302.3
Lighting	87	-	-	0.86	43	12.0
Home appliances	45	19	-	0.47	23	6.7
Home HVAC + electronics	36	4	0.00	0.37	19	5.5
Commercial equipment	27	-	-	0.27	14	2.8
Appliance standards total	195	23	0.00	1.97	99	27.1
Manufactured homes	12	17	-	0.13	7	2.0
EE block grants	-	-	-	-	-	-
Federal building standard	3	1	-	0.03	1	0.3
Other policies total	15	18	-	0.16	8	2.4
Total	210	42	3.85	10.43	721	331.8

Savings are the impacts in the given year from all measures through that year. Natural gas savings are direct savings and do not include reduced gas use due to electricity savings. Energy bill savings do not include initial costs.

Appendix D. Savings Analysis Methodology and Assumptions

This appendix briefly describes the methodology and key assumptions used in the impact estimates in this report. Cost and savings estimates for individual measures are discussed below. They are assumed to be additive.

We estimated savings for the same policies for which we did projections in 2007 (ACEEE 2007). The estimates are for the impact of implementing measures in EISA compared to business as usual (BAU) if EISA had not been enacted. For some measures that have not yet been implemented (such as the manufactured housing standard), the estimates include assumptions on what the agencies will do and when they will do it. The baselines are discussed for each provision. We calculate impacts for products sold or measures taken through 2040; cumulative and cost-benefit numbers include savings through the lifetimes of those measures as late as 2080.

The energy prices by fuel, sector, and year, and the carbon intensity by fuel and in some cases year, are taken from the Annual Energy Outlook 2015 base case (EIA 2015a). For later years they are extrapolated from trends over 2021–2040. These projections do not incorporate the Clean Power Plan on existing power plants, which could capture some of the carbon reductions due to electricity savings estimated here. Net present values and benefit-cost ratios are calculated using present values in 2015 with a real discount rate of 5%. The costs in some cases are financed (see details below). All monetary impacts are in constant 2013 dollars.

For purposes of conveying the magnitude of the savings we compare estimated impacts to projections of energy use and related quantities in *Annual Energy Outlook* (AEO) 2015. Note that the AEO projection already incorporates rules and measures that have been implemented and is not a baseline for this analysis.

VEHICLE STANDARDS

Impact estimates for both light- and heavy-duty vehicle standards use Argonne National Laboratory's VISION 2014 AEO Base Case model (Argonne National Laboratory 2015), which in turn is based on the AEO 2014. Although commercial light trucks (8,500–10,000 pounds) are included with light-duty vehicles in the VISION model, they are covered by heavy-duty vehicle standards, so we separated them from light-duty and added their savings to the heavy-duty vehicle oil savings. The savings for the light- and heavy-duty vehicle standards are based on fuel use under the standards compared to fuel use assuming constant fuel economies from 2010, just before the standards were set. We believe this is a more accurate projection of fuel economy absent the standard than the AEO forecasts from before the standards. The savings from the Phase 2 truck standard are based on the draft standard from 2015. We do not include impacts on upstream (e.g., refinery) energy use or CO₂ emissions.

Costs to meet the standards are based on EPA and DOT's per-vehicle cost estimates. Light-duty standard costs rise to \$1,474 in 2013 dollars. Costs to meet the heavy-duty vehicle standards are estimated at an average of \$1,884 per vehicle for Phase 1 and an additional \$3,842 per vehicle for Phase 2. For simplicity, we do not include any financing of these costs or any reduction in costs due to learning (though we expect both to occur).

APPLIANCE AND EQUIPMENT STANDARDS

For the light bulb standard we used a stock model with incandescent, halogen, CFL, and LED bulbs. We assumed the total number of bulbs increases based on AEO's projection of residential floor area. We based market share of the bulbs on recent sales data and on projections prepared for DOE, with LEDs rising to 100% of sales in 2030 (NEMA 2015; Navigant Consulting 2014). In the absence of a standard we assumed market shares would have remained at 2012 levels (about 1/3 CFL and 2/3 incandescent). We took average wattages, lifetimes, and operating hours from DOE publications, with projected operating hours assumed to be more similar to the bulbs they are replacing (Navigant Consulting 2012, 2014, 2015). We assumed prices of bulbs would be constant in real terms, except for LEDs, which decline from \$13 to \$5 by 2020 (NRDC 2014; Bardsley et al. 2014). We do not assume any bulbs are financed.

The methodology used to estimate the impacts of appliance efficiency standards other than the light bulb standards is largely the same as in *The Efficiency Boom* report (Lowenberger et al. 2012), where it is more fully described. Annual savings per piece of equipment are based on the estimated energy use of the average equipment that just meets the new or proposed standard compared to the previous standard or the least-efficient products when the standard is set. The savings are assumed to last for the average lifetime of the product. For water-using products, the monetary savings also include water bill savings. Average added consumer cost of the more efficient equipment also is estimated for each product. We assume no financing of the costs. Shipments are assumed to be constant, and savings are discounted for the portion of shipments that already met the new standard. This static model neglects the fact that for most products, both efficiency and shipment levels rise over time; it assumes that those changes will cancel each other out.

OTHER PROVISIONS

Manufactured housing standards. The analysis uses AEO 2015 projections for the number of new manufactured homes (per the description of the residential module), rising to about 140,000 homes per year. The estimates of average savings and average cost per home are based on analysis the Pacific Northwest National Laboratory did for the negotiated rulemaking. We took estimates for buildings similar to the final proposed standard and aggregated across climate zones based on manufactured home sales by state. We assumed the standard would be updated every three years, with savings and cost both increasing by a percentage that starts at 7% the first cycle and declines, reaching 4%. Because effective compliance should be feasible in the factories, we assume 95% of homes comply beginning in 2017. Savings last for 30 years. We assume 75% of the homes are financed for 15 years at an interest rate 7% above the AEO projection of 10-year treasury rates, as most manufactured homes are financed with chattel loans.

Energy Efficiency Conservation Block Grants (EECBG). Because DOE's evaluation of the EECBG funding under the Recovery Act is not yet complete, we used the actual funding under ARRA but assumed the same relative impacts as we did in 2007. We assumed \$3.2 billion distributed evenly over 2010–2012 (but then adjusted for inflation). We assumed half the funding achieved electricity savings and half achieved natural gas savings, that the investments had a simple payback of 5 years, and that the measures had a lifetime of 10 years. We did not assume any outside investment.

Federal building standards. For these provisions we estimated the impact of the fossil fuel standard, which may have the largest potential impact even though it has not yet been implemented. Although potential savings in existing federal buildings are larger, they contribute to meeting targets that were already in place by executive order when the bill passed. Our estimate for the standard is the opposite of our estimate for the repeal of the standard in a recent paper (Ungar, Kallakuri, and Barrett 2015), and is described in more detail there. We only considered energy savings, not use of renewables. We assumed new buildings would meet the targets through efficiency until the 80% reduction in 2020, but that any further impacts would be from fuel switching. We assumed major renovations would be 30% better than just meeting code.

Provisions with no estimated savings. We did not estimate any savings for the other provisions that were analyzed in 2007. The Zero-Net-Energy Commercial Building Initiative was mostly not implemented as designed. The industrial provisions and Energy Efficiency and Sustainability Grants and Loans for Institutions were never funded. Although the Weatherization Assistance Program was funded and achieved significant savings, it is not clear in retrospect that the reauthorization affected the appropriations, which were primarily through the Recovery Act.