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DOE's Office of Energy Efficiency and Renewable Energy: FY2016 Appropriations

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Summary

Since 2005, the Energy and Water Development (E&W) appropriations bill has funded all Department of Energy (DOE) programs, including those operated by the Office of Energy Efficiency and Renewable Energy (EERE). That office conducts two types of programs: research and development (R&D), usually conducted in partnership with private sector firms, and grant funds that are distributed to state governments. EERE administers a wide range of R&D programs, each with its own set of goals and objectives.

President Obama has declared energy efficiency and renewable energy to be a high priority, stressing their importance to jobs, economic growth, and U.S. manufacturing competitiveness. Also, efficiency and renewables are a focus of the President's Climate Action Plan and both are key strategies for the Environmental Protection Agency's Clean Power Plan regulation.

DOE's FY2016 request for EERE sought $2.723 billion, an increase of $809 million (42%). Nearly half of the proposed EERE increase would have gone to two R&D programs: manufacturing ($204 million) and vehicle technologies ($164 million). For manufacturing, most of the increase ($140 million) would have supported two new Clean Energy Manufacturing Institutes—part of the President's National Network for Manufacturing Innovation (NNMI). For vehicles, the increase would have mainly supported the Electric Vehicle (EV) Everywhere Grand Challenge—with funds spread over several subprograms.

The next largest requested increases would have gone to two more R&D programs: solar ($104 million) and building technologies ($92 million). Most of the remaining increase would have gone to three other R&D programs: geothermal ($41 million), wind ($39 million), and bioenergy ($21 million). Also, $75 million would have gone to increases for three grant programs: weatherization ($35 million), state energy ($20 million), and local energy ($20 million).

At several House and Senate appropriations and oversight hearings, testimony and Member questions revealed differing views about the requested funding amount and the role of market barriers and national interests in EERE program design and funding.

For the EERE portion of the FY2016 E&W bill (H.R. 2028), the House approved $1.652 billion (includes a $17 million rescission of prior year funds and $11 million added by non-program-specific floor amendments) and the Senate Appropriations Committee approved $1.933 billion (includes a $17 million rescission). However, the Administration issued a veto threat, in part because it found that H.R. 2028 would "underfund critical activities" at EERE. Ultimately, E&W appropriations appeared as Division D of the Consolidated Appropriations Bill (H.R. 2029). The bill was enacted as P.L. 114-113. The law provided $2.069 billion for EERE, which was $654 million below the request, but $145 million above the FY2015 level. Specific program increases included Vehicles ($30 million), Manufacturing ($29 million), Buildings ($29 million), Weatherization Grants ($22 million), Geothermal ($16 million), Water ($9 million), and Solar ($9 million). The Wind program was cut by nearly $12 million.

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Organization and Strategy

The Office of Energy Efficiency and Renewable Energy (EERE) of the Department of Energy (DOE) invests in high-risk, potentially high-value research, development, and deployment (RD&D) in the fields of energy efficiency and renewable energy technologies. EERE also manages a portfolio of grant programs that support state and territorial governments. The office is led by the Assistant Secretary of Energy Efficiency and Renewable Energy,[1] who manages several internal EERE offices and programs. EERE serves as the steward and primary client of the National Renewable Energy Laboratory (NREL), which is located in Golden, CO. NREL is the only national lab dedicated solely to RD&D on efficiency and renewables. In FY2015, the amount of funding that EERE passed through to NREL was nearly double the amount that the office provided to all other national labs combined.

EERE Sectors and Programs

DOE has organized EERE into four functional groups, or sector offices: sustainable transportation, renewable power, energy efficiency, and corporate management.[2] Each sector—and its major component programs—are identified below:

- Sustainable Transportation R&D is made up of three program offices. The Vehicle Technologies office focuses mainly on the development of electric vehicles and on technologies to improve the efficiency and fuel economy of combustion engines of cars and trucks. The Bioenergy office addresses biomass resources and technologies for liquid fuels that can displace petroleum use. The Hydrogen/Fuel Cells office targets the energy efficiency of transportation fuel cells that can use natural gas and/or hydrogen gas as a fuel.
- Renewable Power R&D is made up of four program offices. The Solar Energy office develops electric power systems for buildings and utility-scale installations. The Wind Energy office focuses on hardware for wind farms. The Geothermal Energy office explores technology to generate power from geological resources. Water Power technologies include new hydropower development strategies and hardware for wave, currents (river and ocean), and tidal energy resources.
- Energy Efficiency R&D is made up of three program offices. The Advanced Manufacturing Office (AMO) anchors the Clean Energy Manufacturing Initiative and provides technical assistance for industry. The Building Technologies office addresses building design (codes), component innovation, and equipment standards. The Federal Energy Management Program (FEMP) helps federal agencies with project financing, technical guidance, and planning assistance.
- Corporate Management is made up of three activities. Program Management is the overall administrative arm that manages all EERE programs. Strategic

[1] The Department of Energy Organization Act of 1977 (P.L. 95-91) defined the organizational structure and administrative functions for DOE. Section 203 established eight unspecified assistant secretary positions that report to the Secretary of Energy. The law directs the Secretary to assign a broad range of duties or "functions" to the Assistant Secretaries. Those functions include energy research, development, and applications for renewable energy and energy efficiency.

[2] Details of EERE's organizational structure of offices and programs—as of January 2015—are presented on DOE's website at http://energy.gov/sites/prod/files/2016/01/f29/EERE%20org%20chart%20public%201-29-2016.pdf.

Programs (formerly Program Support) serves an integrative and crosscutting role for EERE. The Facilities and Infrastructure program mainly addresses the development and maintenance of the facilities that make up the National Renewable Energy Laboratory (NREL).

Strategic Plan

EERE's vision aims to promote "clean, affordable, and secure energy." Based on its vision, EERE states that its mission is "... to create and sustain American leadership in the transition to a global clean energy economy."[3] To attain its vision and fulfill its mission, EERE has devised several strategic goals. Some of the goals are sector specific and some are crosscutting:

1. Accelerate development and adoption of sustainable transportation technologies.
2. Increase the generation of electric power from renewable sources.
3. Improve the energy efficiency of homes, buildings, and industries.
4. Stimulate the growth of a thriving domestic clean energy manufacturing industry.
5. Help integrate clean energy into a reliable, resilient, and efficient electricity grid.
6. Lead efforts to improve federal sustainability and use of clean energy solutions.[4]

For each strategic goal, strategic objectives and success indicators were devised as metrics to assess the progress of activities. Further, Multi-Year Program Plans (MYPPs) are developed to provide more detailed strategies for each EERE technology office (e.g., Buildings, Vehicles, Solar Energy). EERE's strategic planning process follows a three-phase innovation model that addresses applied research, development and demonstration, and market barriers.[5]

Administration Perspective and Goals

President Obama has declared energy efficiency and renewable energy to be high priorities, stressing their importance to jobs, economic growth, and U.S. manufacturing competitiveness. The *2013 Economic Report of the President* said that "President Obama has set a goal of once again doubling generation from wind, solar, and geothermal sources by 2020." Other key Administration goals that directly affect the EERE agenda include leading the world in clean energy technologies, doubling energy productivity by 2030 (relative to 2010), making non-residential buildings 20% more efficient by 2020, attaining 80% clean energy power generation by 2035 (includes nuclear and efficient gas), reducing oil imports relative to the 2008 level by one-half by 2020, and cutting greenhouse gases 17% below the 2005 level by 2020.[6]

Sustainable Economic Growth

The *2015 Economic Report of the President* states that the President's strategy for sustainable economic growth addresses three strategic elements: economic growth and job creation,

[3] DOE, EERE, *2016–2020 Strategic Plan and Implementing Framework (EERE Strategic Plan)*, December 2015, p. 4, http://energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf.

[4] *EERE Strategic Plan*, p. 4.

[5] DOE, *EERE Strategic Plan Briefing*, January 2016, http://energy.gov/sites/prod/files/2016/01/f28/01072016%20Strategic%20Plan%20External%20Webinar.pdf.

[6] DOE, *Office of Energy Efficiency and Renewable Energy FY2016 Budget Overview*, March 2015, http://energy.gov/sites/prod/files/2015/03/f20/FY%202016%20Transportation%20Webinar%20%20Presentation.pdf.

improving energy security, and curbing global climate change.[7] Further, it observes that the President's Climate Action Plan "includes a broad range of actions, from providing research, demonstration, and deployment funding for new energy technologies to the direct regulation of carbon emissions under the Clean Air Act."[8]

For "infant" industries, the report finds that, due to difficulties for a private company to capture all the economic benefits of innovation, there tends to be underinvestment in clean energy technologies, such as wind and solar. As a result, "the Administration supports research and early deployment projects aimed at bringing down the ultimate market price of immature renewable energy technologies."[9]

Climate Protection

The 2015 Economic Report of the President concludes that "U.S. leadership is vital to the success of international negotiations to set meaningful [carbon] reduction goals.... Through low-carbon technologies developed and demonstrated in the United States ... this Nation can help the rest of the world reduce its dependence on high-carbon fuels."[10]

Citing authority granted by the Clean Air Act, the Environmental Protection Agency (EPA) has issued a final rule known as the Clean Power Plan (CPP). The CPP aims to reduce carbon emissions from the nation's fleet of electric power plants. The rule directs states to submit implementation plans by September 6, 2016, unless granted an extension to 2018. The state plans must comply with CPP targets set to begin in 2022.[11] Renewable energy is one of EPA's recommended key strategies designed to enable states to comply with the rule's proposed carbon emission goals.[12] Implementation of the CPP could increase the demand for EERE technologies. Such a boost to renewables and efficiency could likely take several forms, including development of renewables capacity and energy storage, transmission infrastructure and grid integration, and implementation of more energy-efficient equipment.

Program Funding History

Spending History in Context

From FY1948 through FY1977 the federal government provided an extensive amount of R&D support for fossil energy and nuclear power technologies. The energy crises of the 1970s spurred the federal government to expand its R&D programs to include renewable energy[13] and energy efficiency technologies. In real (constant dollar) terms, funding support for all four of the main energy technologies skyrocketed during the 1970s to a combined peak in FY1979. Funding then

[7] The White House, Council of Economic Advisers, *2015 Economic Report of the President*, Chapter 6 (The Energy Revolution), p. 242, https://www.whitehouse.gov/administration/eop/cea/economic-report-of-the-President/2015. Natural gas units accounted for most of the remainder.

[8] *2015 Economic Report*, p. 276.

[9] *2015 Economic Report*, p. 284.

[10] *2015 Economic Report*, p. 288.

[11] For more about the background and status of the CPP, see CRS Report R44341, *EPA's Clean Power Plan for Existing Power Plants: Frequently Asked Questions*, by (name redacted) et al.

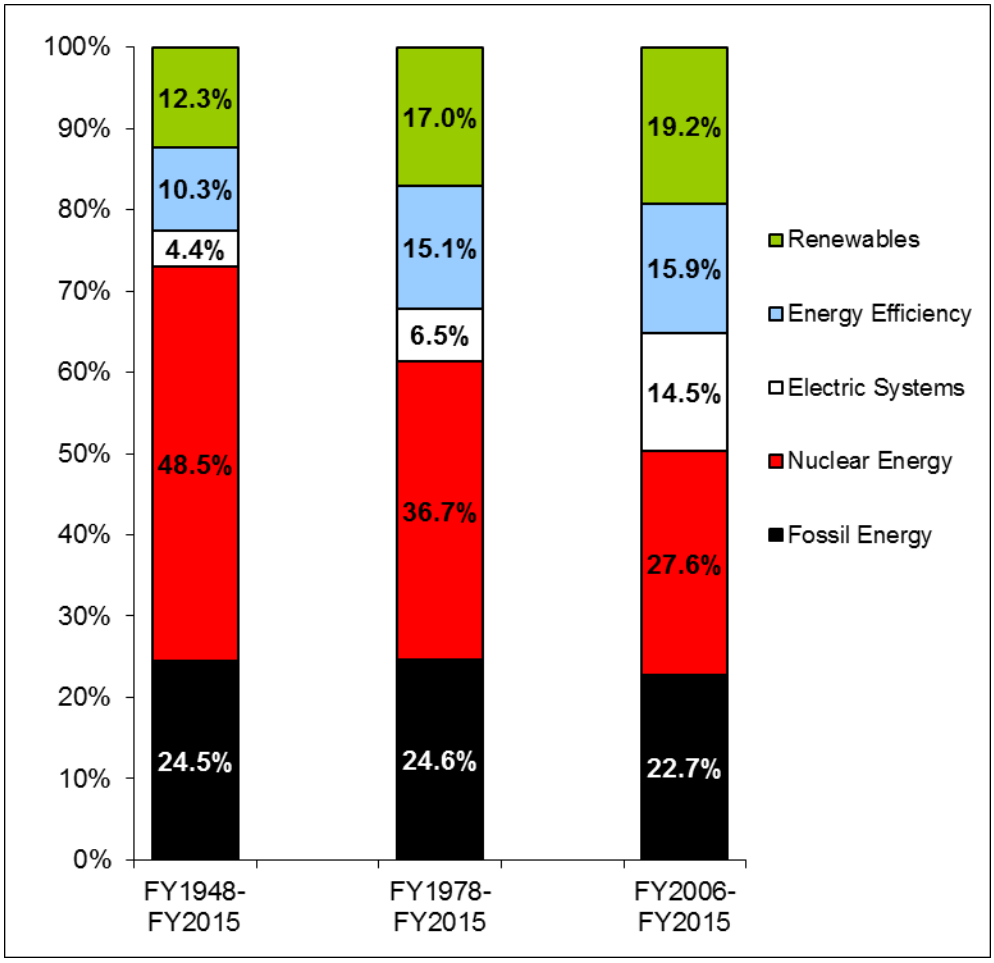
[12] For more about the CPP "building blocks" involving renewables and energy efficiency, see CRS Report R43652, *State CO2 Emission Rate Goals in EPA's Proposed Rule for Existing Power Plants*, by (name redacted) .

[13] Includes wind, solar, biomass, geothermal, and water (hydropower, marine, and hydrokinetic) energy technologies.

dropped steadily, reaching a bottom during the late 1990s. Since then, funding has increased gradually—except that the Recovery Act provided a one-year spike in FY2009.[14] **Figure 1** presents a chart showing the relative shares of funding for the four types of energy technologies over three time periods: 68 years, 38 years, and 10 years. EERE funding is portrayed by the top two portions of each bar in the chart: one for renewables R&D and one for energy efficiency R&D.

Figure 1. DOE Energy Technology Share of Funding, Comparison over Three Periods

(Chart taken from CRS Report RS22858)



Sources: DOE *Budget Authority History Table by Appropriation*, May 2007; DOE Congressional Budget Requests (several years); DOE (Pacific Northwest Laboratory), *An Analysis of Federal Incentives Used to Stimulate Energy Production*, 1980; DOE Conservation and Renewable Energy Base Table. February 1990. Deflator source: *The Budget for Fiscal Year 2016*, Historical Tables, Table 10.1.

Note: The portion shown for Nuclear Energy includes funding for both nuclear fission and nuclear fusion.

[14] More details about DOE—and earlier (pre-1978)—spending for R&D on energy technologies are available in CRS Report RS22858, *Renewable Energy R&D Funding History: A Comparison with Funding for Nuclear Energy, Fossil Energy, and Energy Efficiency R&D*, by (name redacted)

Recent Appropriations History

Since 2005, the annual Energy and Water Development (E&W) appropriations bill[15] has funded all DOE programs, including those operated by the Office of Energy Efficiency and Renewable Energy (EERE).[16] That office conducts two general types of programs: research and development (R&D), often conducted in partnership with private sector firms, and distribution of grant funds to state, territorial, and tribal governments. EERE administers a wide range of R&D programs, each with its own set of goals and objectives.

Since FY2011, DOE has requested sizeable increases in spending each year—but Congress has generally provided funding for EERE programs at less than requested levels. **Table 1**, below, shows the recent pattern of EERE requests and final appropriation levels.

Table 1. EERE Requests and Final Appropriations, FY2011-FY2016

($ billions, current dollars)

Fiscal Year	Request	Final Appropriation
FY2011	$2.4	$1.8
FY2012	$3.2	$1.8
FY2013	$2.3	$1.7
FY2014	$2.8	$1.9
FY2015	$2.3	$1.9
FY2016	$2.7	$2.1

Source: DOE Budget Requests, FY2011 through FY2016.

For FY2015, DOE's request for EERE was $2.3 billion, which would have increased funding relative to the FY2014 level by about $416 million, or nearly 22%.[17] The House approved $1.8 billion, and the Senate Committee on Appropriations Subcommittee on Energy and Water Development recommended $2.1 billion. The enacted FY2015 measure (P.L. 113-235, Division D) provided $1.9 billion for EERE.

FY2016 Highlights

This section presents the key EERE program funding increases requested and describes some highlights for each of those programs. EERE Principal Deputy Assistant Secretary Mike Carr presented a summary of the EERE request at a February 25, 2015, briefing for congressional staff sponsored by the Environmental and Energy Study Institute (EESI).[18]

[15] For an overview of the FY2016 E&W appropriations process, see CRS Report R43966, *Energy and Water Development: FY2016 Appropriations*, by (name redacted)

[16] Prior to 2005, DOE programs were supported partly by the E&W bill and partly by the Interior appropriations bill.

[17] This comparison was calculated on current dollars for the two fiscal years, not constant (inflation-adjusted) dollars.

[18] A video replay of Mike Carr's presentation at the EESI briefing is available at http://www.eesi.org/briefings/view/022515budget.

Summary

DOE presented its FY2016 budget request on February 2, 2015.[19] The request for EERE was about $2.7 billion, which would have been a nearly $809 million, or 42%, increase relative to the FY2015 level. The EERE increase was about one-third of the total requested DOE increase. To balance the requested increase for DOE, the Administration sought a revenue offset derived from a proposal to repeal about $4 billion in fossil fuel tax incentives.[20]

Key Requested Increases

As part of that requested overall increase, DOE sought the largest increases for manufacturing and vehicles, sought significant increases for several other programs, and proposed to create a new local grants program.

- **Manufacturing.** Most of the requested increase, $140 million, would have supported two new Clean Energy Manufacturing Initiatives (CEMIs)—part of the President's National Network for Manufacturing Innovation (NNMI).
- **Vehicles.** The $164 milllion requested increase would have mainly supported the EV Everywhere Grand Challenge—with funds spread over several subprograms.

Five other sizable increases are sought for EERE R&D programs:

- **Solar.** The $104 million increase would have mainly supported the SunShot Initiative goal for utility solar plants to reach 6 cents/kilowatt hour (kwh) by 2020.
- **Buildings.** The largest share of the $92 million increase would have gone to emerging technologies—sensors, grid links, and air conditioning R&D.
- **Geothermal.** The $41 million increase would have supported a production cost goal of 10 cents/kwh by 2030, mainly by adapting sensing, drilling, and fracking technologies for "blind" resources and deep reservoirs.
- **Wind.** The largest share of the $39 million increase would have gone to new technology. Also, a sizable increase would have gone to mitigate wildlife impacts.
- **Bioenergy.** An increase of $21 million would have supported pilot biorefinery projects and efforts to raise algae productivity.

Three notable increases were sought for grant programs.

- **Weatherization.** The $35 million requested increase would have raised the number of retrofits and supported new test models for multifamily buildings.

[19] A video replay of Secretary Moniz's verbal presentation of the DOE request is available at http://energy.gov/articles/energy-department-presents-fy16-budget-request. The portion on energy programs, including EERE, begins at about nine minutes into the video recording. Also, the printed text of the Secretary's verbal presentation is available at http://energy.gov/articles/secretary-monizs-remarks-presenting-department-s-fy-2016-budget-request-delivered.

[20] The Federal Budget Request for FY2016 would repeal $4 billion in FY2016 fossil fuel tax incentives. This repeal is part of a longer-term proposal to eliminate fossil fuel incentives, which President Obama promised at the G20 Summit held in Brisbane, Australia, November 15-16, 2014. For the annual dollar estimates of proposed cuts to fossil energy incentives see U.S. Department of the Treasury, *General Explanations of the Administration's Fiscal Year 2016 Revenue Proposals*, Table 2.

- **State Energy.** Most of the $20 million increase requested would have supported a competitive grant program for innovation and best practices.
- **Local Energy.** A new $20 million program of competitive grants would have promoted best practices.

Main Actions

The House Committee on Appropriations reported (H.R. 2028, H.Rept. 114-91) the Energy and Water Development (E&W) Appropriations Bill, 2016 with a recommendation of about $1.640 billion (includes a $17 million rescission) for EERE. House floor action increased the amount by $11 million to $1.652 billion.[21] The House recommended level drew a veto threat from the Administration. Subsequently, the Senate Committee on Appropriations (S.Rept. 114-54) recommended $1.933 billion (includes a $17 million rescission).[22] Action on H.R. 2028 was suspended, as Congress adopted two omnibus continuing resolutions and pursued lengthy negotiations over final FY2016 appropriations. Ultimately, the E&W bill was incorporated as Division D of the Consolidated Appropriations Act, FY2016 (H.R. 2029). The final enacted version of H.R. 2029 (P.L. 114-113, Division D) provided nearly $2.1 billion for EERE.[23]

Congressional Action

After the Administration issued its FY2016 budget request, Congress held a number of DOE oversight and appropriations hearings. As noted above, further actions were taken in the House and Senate on DOE funding recommendations in the E&W bill, H.R. 2028. Late in the first session, after lengthy negotiations, the E&W bill was incorporated into H.R. 2029.

The various steps of the congressional process for the FY2016 E&W appropriations are outlined in **Table 2**.

Table 2. EERE FY2016 Appropriations Chronology

(Highlights of Committee and Floor Action, with Administration responses.)

Date	Action
February 2, 2015	DOE issued FY2016 budget request.
February 11, 2015	House Energy and Commerce Committee's Subcommittee on Energy and Power held a hearing on the DOE request.
February 12, 2015	Senate Committee on Energy and Natural Resources (SENR) held a hearing on the DOE request.
February 26, 2015	House Appropriations Committee's Subcommittee on Energy and Water Appropriations held a hearing on the DOE request.
March 25, 2015	Senate Appropriations Committee's Subcommittee on Energy and Water Appropriations held a hearing on the DOE request.
April 13, 2015	House Appropriations Committee's Subcommittee on Energy and Water Appropriations released a draft report with recommended funding for FY2016 E&W appropriations bill.

[21] See H.Rept. 114-91, *Energy and Water Development Appropriations Bill, 2016*.

[22] S.Rept. 114-54, *Energy and Water Development Appropriations Bill, 2016*, May 21, 2015.

[23] The text of the enacted bill is available at https://www.congress.gov/114/bills/hr2029/BILLS-114hr2029enr.pdf.

Date	Action
April 15, 2015	House Appropriations Committee's Subcommittee on Energy and Water Appropriations held a subcommittee markup.
April 21, 2015	House Appropriations Committee issued draft report on FY2016 E&W appropriations bill with recommended funding.
April 21, 2015	Office of Management and Budget (OMB) issued a letter to the House Appropriations Committee that expressed the Administration's concerns with the draft E&W appropriations bill.
April 22, 2015	House Appropriations Committee held a full committee markup. Several amendments were adopted, none of which affected the provisions for EERE.
April 24, 2015	House Appropriations Committee issued the E&W appropriations bill (H.R. 2028) and final report (H.Rept. 114-91) with recommended funding for FY2016 E&W appropriations.
April 28, 2015	OMB issued a Statement of Administration Policy that strongly opposed House passage of H.R. 2028.
May 1, 2015	House approved H.R. 2028. Several amendments to EERE programs were adopted, some of which made small changes to program funding.
May 21, 2015	Senate Appropriations Committee reported (S.Rept. 114-54) its recommendations for H.R. 2028.
June 2, 2015	OMB issued a letter to the Senate Appropriations Committee that expressed the Administration's concerns with the Senate version of H.R. 2028.
December 17, 2015	House approved H.R. 2029, Consolidated Appropriations Act, 2016. A modified version of the E&W appropriations bill (H.R. 2028) was included as Division D. The explanatory statement on H.R. 2029 was printed in Congressional Record.
December 17, 2015	Senate approved H.R. 2029.
December 18, 2015	President signed H.R. 2029 into law as P.L. 114-113. The E&W bill was incorporated as Division D.

Source: Multiple sources were used.

Funding Increases

This section presents the key EERE program funding increases enacted and describes some highlights for each of those programs. Several programs received a significant funding increase for FY2016. **Table 3** and **Table 4** show those increases in dollar amounts and percentages, relative to FY2015.

Increases Ranked by Sector

Regarding the changes proposed for FY2016, **Table 3** shows the enacted increases for each of the three functional sectors. The largest dollar and percentage increase was in the energy efficiency sector. The following section provides a further breakdown for the programs under the sectors.

Table 3. EERE Sector Increases, in Rank Order

($ millions, FY2016–FY2015 difference)

Sector	FY2015	FY2016 Final	Increase	Percent Increase
Energy Efficiency	$642	$721	$79	12%
Sustainable Transportation	$602	$636	$34	6%

Sector	FY2015	FY2016 Final	Increase	Percent Increase
Renewable Power	$456	$478	$22	5%
Corporate Management	$237	$238	$1	0.4%

Source: Congressional Record, *Explanatory Statement on Consolidated Appropriations Act, 2016*, December 17, 2015, pp. H10108-H10109, https://www.congress.gov/crec/2015/12/17/CREC-2015-12-17-bk2.pdf.

Note: Figures for Energy Efficiency include both R&D and grants.

Increases Ranked by Program

Table 4 shows that the largest EERE increases are for manufacturing and vehicles.

Table 4. EERE Program Increases, in Rank Order

($ millions, FY2016–FY2015 difference)

Program	Increase	Percent Increase
Research and Development		
Vehicles	$30	11%
Manufacturing	$29	14%
Buildings	$29	17%
Geothermal	$16	29%
Water	$9	15%
Solar	$9	4%
Grant Programs		
Weatherization	$22	9%

Source: Congressional Record, *Explanatory Statement on Consolidated Appropriations Act, 2016*, December 17, 2015, pp. H10108-H10109, https://www.congress.gov/crec/2015/12/17/CREC-2015-12-17-bk2.pdf.

Decrease for Wind Energy

Wind Energy is the only program slated to be cut, by nearly $12 million.

Cross-Cutting Initiatives

The FY2016 request also sought to continue crosscutting programs that coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address national energy, environmental, and national security challenges. The request identified four new broad initiatives that cut across multiple EERE programs—and across programs under other energy (Fossil and Nuclear) offices and the Office of Science:[24]

- **Supercritical Carbon Dioxide (sCO_2).** The aim is to use sCO_2 as the working fluid in power production cycles. Demonstration of feasibility could yield

[24] DOE, *FY2016 Budget Request*, vol. 3, pp. 15-16, http://energy.gov/sites/prod/files/2015/02/f19/FY2016BudgetVolume3_7.pdf. Also, some cross-cutting initiatives involve coordination with the Advanced Research Projects Agency-Energy (ARPA-E) and other federal agencies.

cleaner, more efficient, and less costly power production for fossil, nuclear, concentrating solar, geothermal, and industrial waste heat recovery technologies.[25]

- **Subsurface Engineering (SubTER).** This activity aims to improve technologies for accessing underground fossil and geothermal resources, while exploring ways to store CO_2, fluids, and waste products.[26]
- **Energy-Water Nexus.** This collaboration is focused on technology and analysis to improve the resilience of coupled energy-water systems.[27]
- **Cybersecurity.** This crosscut aims to protect DOE facilities from cyber threats, bolster the federal government's ability to address cyber threats, and improve cybersecurity for the industrial subsectors of electric power, oil, and natural gas.[28]

Also, the request continues a focus on five other key EERE cross-cutting initiatives, established in previous years:

(1) Grid Modernization Initiative. Under this initiative, launched in 2012,[29] EERE's vehicles, solar, and buildings programs would work in coordination with DOE's Grid Tech Team[30] to address electric grid integration barriers and opportunities associated with variable, distributed renewable energy generators, electric vehicle charging, and building efficiency and controls. Thus, EERE would coordinate with DOE's Office of Electricity Delivery and Energy Reliability (OE).

(2) EV Everywhere Grand Challenge. This DOE-wide initiative aims to make technology breakthroughs that would enable the United States, by 2022, to become the first country in the world to invent and produce plug-in electric vehicles that are as affordable and convenient as gasoline-powered vehicles.[31]

(3) SunShot Grand Challenge. This DOE-wide initiative seeks to achieve directly cost-competitive solar power by 2020.[32]

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[25] At high pressure, CO_2 has a higher density than steam, giving it a high power density. This crosscut involves $44 million for a 10-mw demonstration project. For details, see DOE, *Project Profile: 10-Megawatt Supercritical Carbon Dioxide Turbine*, http://energy.gov/eere/sunshot/project-profile-10-megawatt-supercritical-carbon-dioxide-turbine.

[26] For more about SubTER, see DOE, *DOE Crosscutting Subsurface Initiative*, http://www.energy.gov/sites/prod/files/2014/12/f19/DOE-SubTER%20AGU%20town%20hall.pdf.

[27] For more details see DOE, *The Water-Energy Nexus: Challenges and Opportunities*, http://energy.gov/downloads/water-energy-nexus-challenges-and-opportunities.

[28] This crosscut is led by the Office of Electricity Delivery and Energy Reliability (OE). More details at DOE, *Cybersecurity*, http://energy.gov/oe/services/cybersecurity.

[29] The Administration proposed the Grid Modernization Initiative in 2011 (http://www.whitehouse.gov/sites/default/files/microsites/ostp/smart-grid-press-release-6-13-2011.pdf). The Energy Independence and Security Act (EISA, Title 13) made OE the lead DOE office for this initiative (http://energy.gov/oe/services/technology-development/smart-grid). The EERE role is described in a 2014 plan http://www.nrel.gov/esi/pdfs/eere_grid_integration_multi_year_program_plan.pdf.

[30] DOE created the Grid Tech Team to develop a stronger and more extensive network of public-private partnerships to ease the transition to a more modern grid. DOE, EDER, *DOE Grid Tech Team*, http://energy.gov/oe/services/doe-grid-tech-team.

[31] For more details, see *EV Everywhere: Grand Challenge Blueprint*, January 2013, http://energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf.

[32] For more about SunShot, see (1) this report's section on Solar Energy, (2) p. 6 of the budget request for FY2014 at http://energy.gov/sites/prod/files/2013/04/f0/Volume3_1.pdf, and (3) DOE's SunShot program site at http://energy.gov/eere/sunshot/sunshot-initiative.

(4) Clean Energy Manufacturing Initiative. Launched in 2014, this EERE initiative aims to dramatically improve U.S. competitiveness in the manufacture of clean energy products (such as solar modules, LED lights,[33] batteries, and wind blades) and to increase energy productivity as a means to strengthen U.S. competitiveness across multiple manufacturing industries.[34]

(5) Wide Bandgap (WBG) Semiconductors for Clean Energy Initiative. Wide bandgap semiconductor technology—a branch of solid state power electronics—was initially developed for military and solid-state lighting uses. DOE contends it is a key next-generation platform for semiconductor devices with the potential for developing high-power-conversion electronics that are much more compact, more energy efficient, and able to operate at much higher temperatures and voltages than existing commercial technology. DOE says that this "revolutionary" technology could be a platform for the next generation of electric vehicle drivetrains, solar inverters, high-efficiency motors, solid-state transformers for the grid, and many other critical, clean energy applications.[35] WBG semiconductors are one focus of DOE's Next Generation Power Electronics Manufacturing Innovation Institute.[36]

EERE Funding Table

EERE has 13 program offices and three administrative offices. Each program office has a set of goals and funding needs. DOE's FY2016 request groups the 13 program offices under four separate functional themes:

1. Sustainable Transportation, which includes the Vehicles, Bioenergy, and Hydrogen/Fuel Cell programs.
2. Renewable Electricity Generation, which includes Solar, Geothermal, Wind, and Water programs.
3. Energy Efficiency, which includes Manufacturing, Buildings, the Federal Energy Management Program (FEMP), and the grant programs.
4. Corporate Management, which includes the three administrative programs: Facilities, Program Direction, and Strategic Programs.

Table 5, below, gives the EERE breakdown of recent fiscal year appropriations—and the enacted FY2016 appropriation—by program office.

[33] LED is an abbreviation for light-emitting diode, a form of solid state lighting.

[34] For more about CEMI, see (1) this report's section on Advanced Manufacturing, (2) p. 14 of the budget request for FY2015 at http://energy.gov/sites/prod/files/2014/04/f14/Volume%203.pdf, and (3) the EERE program site at http://energy.gov/eere/cemi/clean-energy-manufacturing-initiative.

[35] For more about wide bandgap semiconductors, see (1) p. 14 of the budget request for FY2015 at http://energy.gov/sites/prod/files/2014/04/f14/Volume%203.pdf, (2) p. 6 of the request for FY2014 at http://energy.gov/sites/prod/files/2013/04/f0/Volume3_1.pdf, (3) the EERE program site at http://manufacturing.gov/docs/wide_bandgap_semiconductors.pdf, and (4) the EERE program site at http://energy.gov/articles/factsheet-next-generation-power-electronics-manufacturing-innovation-institute.

[36] For more details, see DOE, *Factsheet: Next Generation Power Electronics Manufacturing Innovation Institute*, 2014, http://energy.gov/articles/factsheet-next-generation-power-electronics-manufacturing-innovation-institute.

Table 5. Energy Efficiency and Renewable Energy Programs

($ millions, current dollars)

Program	FY2014 Approp.	FY2015 Approp.	FY2016 Request	FY2016 Final Approp.	Difference: FY2016 – FY2015	Percent Change
Hydrogen/Fuel Cell Technologies	92.9	97.0	103.0	101.0	4.0	4.1%
Bioenergy	232.3	225.0	246.0	225.0	0.0	0.0%
Vehicle Technologies	289.7	280.0	444.0	310.0	30.0	10.7%
Subtotal, Sustainable Transportation	615.0	602.0	793.0	636.0	34.0	5.6%
Solar Energy	257.1	233.0	336.7	241.6	8.6	3.7%
Wind Energy	88.1	107.0	145.5	95.5	-11.6	-10.8%
Geothermal Technology	45.8	55.0	96.0	71.0	16.0	29.1%
Water Power (Hydro/Ocean)	58.6	61.0	67.0	70.0	9.0	14.8%
Subtotal, Renewable Power	449.5	456.0	645.2	478.1	22.1	4.8%
Building Technologies	177.9	172.0	264.0	200.5	28.5	16.6%
Advanced Manufacturing	180.5	200.0	404.0	228.5	28.5	14.3%
Federal Energy Management	28.2	27.0	43.1	27.0	0.0	0.0%
Subtotal, Efficiency	386.6	399.0	711.1	456.0	57.0	14.3%
Program Direction	162.0	160.0	165.3	155.0	-5.0	-3.1%
Strategic Programs	23.5	21.0	27.9	21.0	0.0	0.0%
Facilities and Infrastructure	46.0	56.0	62.0	62.0	6.0	10.7%
R&D Total[a]	1,451.1	1,457.0	2,149.3	1,570.0	113.0	7.8%
Weatherization Grants	173.9	193.0	228.4	215.0	22.0	11.4%
State Energy Grants	50.0	50.0	70.1	50.0	0.0	0.0%
Other / Local Energy Grants	7.0	—	20.0	0.0	0.0	0.0%
Grants Total[b]	230.9	243.0	318.5	265.0	22.0	9.1%
Use of Prior Year Balances	-2.4	0.0	0.0	0.0	0.0	0.0%
Floor amendments	—	—	—	—	—	—
Rescission	-10.4	-13.1	—	-3.8	—	—
Total EERE Appropriation	1,900.6	1,923.9	2,723.0	2,069.2	145.3	7.6%

Source: P.L. 114-113, FY2015 and FY2016 DOE budget requests.

a. Does not include R&D programs share of Corporate Management (Program Direction, Strategic Programs, Facilities and Infrastructure).

b. Does not include Grants programs share of Corporate Management.

Goals and Funding for Program Offices

Sustainable Transportation

Hydrogen/Fuel Cell Program[37]

This program aims to reduce petroleum use, greenhouse gas emissions, and criteria air pollutants, while contributing to a more diverse and efficient energy infrastructure. The program supports applied research, development, and demonstration (RD&D) of hydrogen and fuel cell technologies, as well as efforts to overcome economic and institutional barriers to commercial deployment. The fuel cell program targets a cost below $40 per kilowatt (kw) and a durability of 5,000 hours (equivalent to 150,000 miles) by 2020. For hydrogen produced from renewable resources, the target is to bring the cost (dispensed and untaxed) below $4.00 per gasoline gallon-equivalent (gge) by 2020.

For FY2016, DOE requested $103 million—a small increase over the FY2015 appropriation. Increases for hydrogen fuel R&D and fuel cell R&D would be offset partially by a reduction for technology validation. The House committee report proposed a $3 million cut from the FY2015 level and recommended cost-shared efforts with states to expand vehicle applications and to address challenges to hydrogen infrastructure. The House-passed Energy and Water Development (E&W) Appropriations bill (H.R. 2028) adopted the committee-recommended level. The Senate committee report recommended level funding with that for FY2015 and a minimum of $35.2 million for R&D. Division D of P.L. 114-113 provided $101 million, an increase of $4 million over the FY2015 level.

Bioenergy Program[38]

This program aims to foster a domestic bioenergy industry that produces renewable biofuels, bioproducts, and biopower. The goals are to curb oil dependence, reduce greenhouse gas emissions, and stimulate economic and job development—especially in farms and forests. While biofuels and industrial bioproducts (plastics, solvents, and alcohols) may soon be price-competitive, swings in oil prices pose an ongoing challenge to achieving cost-competitiveness. The program aims to overcome a feedstock collection barrier by focusing on converting raw biomass to solid pellets or to "green crude" bio-oil that would be easy to transport at large scale.

Recent goals expand the program scope to include the development of biofuels that would contribute to production targets of the Renewable Fuel Standard (RFS). These "drop-in" liquid fuels would be largely compatible with existing infrastructure that delivers, blends, and dispenses fuels. Examples include biomass-based hydrocarbon fuels (renewable gasoline, diesel, and jet fuel), hydrocarbons from algae, and biobutanol. The program aims to help the non-food drop-in biofuels reach a wholesale finished-fuel cost under $3 per gge by 2017 and $3/gge for algae-based fuels by 2020.

For FY2016, DOE requested $246 million for Bioenergy (formerly Biomass and Biorefinery) programs, a $21 million increase (in current dollars) over the FY2015 appropriation.[39] Of that

[37] The Hydrogen/Fuel Cell program is covered in DOE, *FY2016 Budget Request*, pp. 74-100. Note: This page reference is for DOE's PDF file available on the web—the printed version has slightly different pagination.

[38] The Bioenergy program is covered in DOE, *FY2016 Budget Request*, pp. 52-73.

[39] Unless otherwise noted, all comparisons of the FY2016 request with the FY2015 appropriation will employ current (continued...)

total increase, an $8 million (10%) increase would have gone to the Demonstration & Market Transformation subprogram to support three biorefinery pilot projects—or one new demonstration project—to broaden pathways for converting biomass to hydrocarbon fuels. Also, a $7 million increase would have gone to the Feedstocks subprogram, to increase the yield of algal biomass conversion to biofuel intermediate oil. Under the Demonstration subprogram, EERE would also continue to manage commercial biofuel manufacturing facilities—established jointly with the Departments of the Navy and Agriculture—to produce fuels that meet military-specifications.

The House committee report proposed a cut of $60 million below the FY2015 level and recommended no funding for the drop-in biofuels project with the Departments of the Navy and Agriculture. Also, the committee directed DOE to perform an assessment of the potential for existing facilities to produce bio-based products and chemicals. The House-passed E&W bill (H.R. 2028) adopted the committee recommended level. The Senate report recommended level funding with FY2015 and included $45 million for the drop-in biofuels project and $30 million for algae biofuels. Also, DOE is directed to include biopower projects as eligible for technology development funding. The enacted law provided $225 million, the same level as the FY2015 appropriation.

Vehicle Technologies[40]

This program is driven by the 10-year EV-Everywhere Challenge (launched in 2012), which aims to achieve parity for plug-in electric vehicle (EV) affordability and convenience by 2022. The EV Challenge focuses on advanced battery technology, power electronics, and advanced charging technology. A key supporting technology goal is to cut battery production cost from $300/kwh of battery capacity in 2014 to $125/kwh by 2022.[41] Further, the EV program seeks to reduce vehicle materials weight by 30% from 2002 to 2022 and to cut electric drivetrain cost from $16/kw in 2013 to $8/kw by 2022. Other program goals include (1) a cut of 1.8 million barrels per day (16%) in national oil use by 2020, and (2) a hike in fuel economy to 62 miles per gallon (mpg) for cars by 2025. Also, the Vehicle Technologies program participates in the Grid Modernization Crosscut through its Grid Integration Initiative.

To help achieve those goals and support the EV Everywhere initiative, DOE requested $444 million, an increase of $164 million—the second-largest program increase for FY2016. There are four main parts to the $164 million increase. First, funding for batteries and electric drives would increase by $41 million, focused on advanced batteries, power electronics, and charging stations. Second, funding for materials technology would increase by $35 million, emphasizing carbon fiber and other composites, lightweight materials compatible with manufacturing infrastructure, and high temperature materials for valves and turbochargers. Third, funding for outreach and deployment would rise by $28 million to initiate Alternative Fuel Vehicle Community Partner projects. Fourth, funding for fuels and lubricants would rise by $17 million, mainly for Plug-in EV (PEV) vehicle-grid integration, wireless charging, codes and standards, modelling and simulation, and the Supertruck II (idling, HVAC) project.

(...continued)

dollars for each year—not constant (inflation-adjusted) dollars.

[40] The Vehicle Technologies program is covered in DOE, *FY2016 Budget Request*, pp. 19-51.

[41] For example, the production cost for present batteries is about $300 for each kwh of battery capacity. So, a battery capable of generating 25 kwh of motive force energy would cost about $7,500 ($300 multiplied by 25) to produce. DOE's goal for 2022 is to reduce that battery production cost to about $3,125 ($125 multiplied by 25).

The House committee report proposed a cut of $25 million below the FY2015 level. The committee encouraged DOE to address barriers to adoption of lightweight vehicle designs and to work with industry on emissions controls for natural gas vehicles. The House-passed E&W bill adopted the committee recommended level. The Senate report recommended an increase of $12 million over the FY2015 level and included $20 million for the SuperTruck II program. P.L. 114-113 provided $310 million, an increase of $30 million.

Renewable Power

Solar Energy[42]

For this program, DOE requested $337 million, an increase of $104 million over the FY2015 appropriation. The funding would support the SunShot Initiative goal to achieve a cost of solar power of 6 cents/kwh to make utility-scale solar power cost-competitive without incentives by 2020. This effort includes solar photovoltaic R&D; activities that enable a 50% reduction in non-hardware "soft costs"; and development and demonstration of innovative solar energy manufacturing technologies to increase U.S. competitiveness—in support of EERE's Clean Energy Manufacturing Initiative.

The FY2016 funding increase would be spread mainly over four subprograms: a $33 million increase under Systems Integration, for grid integration and dispatchability; a $27 million increase under Photovoltaic R&D, mainly to improve reliability and cell efficiency; a $27 million increase under Balance of Systems, to address barriers and to identify new markets; and a $16 million increase under Manufacturing Innovations, to cover both processes and tool development.

The House committee report proposed a cut of $129 million below the FY2015 level. Further, the committee recommended no funding for the SUNPATH III program. Also, the committee report directed that the program reduce the amount of silicon needed to produce a solar cell. The House-passed bill adopted the committee recommended level. The Senate report recommended an $8.6 million increase over the FY2015 level. P.L. 114-113 provided $242 million, an increase of $9 million.

Wind Energy[43]

There are three key goals for the Wind Program. First, for land-based windfarms, there is a goal for the energy cost of land-based utility-scale turbines to reach levelized cost of energy (LCOE)[44] parity with other power plants.[45] Second, for offshore settings, the goal is to cut energy costs from 21 cents per kilowatt-hour (kwh) in 2010 to 17 cents/kwh (without incentives) by 2020. Third, by

[42] The Solar Energy program is covered in DOE, *FY2016 Budget Request*, pp. 101-124.

[43] The Wind Energy program is covered in DOE, *FY2016 Budget Request*, pp. 125-150.

[44] Levelized cost of electricity (LCOE) is often cited as a convenient summary measure of the overall competiveness of different generating technologies. It represents the per kilowatt-hour cost (in constant dollars) of building and operating a generating plant over an assumed financial life and duty cycle. DOE, Energy Information Administration (EIA), *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014*, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.

[45] In its budget request for FY2014, DOE proposed specific LCOE goals of 5.7 cents/kilowatt-hour (kwh) by 2020 and 4.2 cents/kwh by 2030. That goal for 2020 may have already been reached in some locations.

achieving those cost reduction goals, there is a further overall goal to meet up to 20% of projected electricity demand by 2030. DOE suggests that it may extend this goal to 35% by 2050.[46]

DOE requested $146 million, a $39 million increase over the FY2015 appropriation. The main share of that increase, $24 million, would have gone to the Technology RD&T and Resource Analysis subprogram. It would support new initiatives for rotor design, drivetrain, and the atmosphere-to-electrons (A2e) smart technology demonstration partnerships. Also, a $17 million increase would be used to mitigate market barriers involving transmission access, radar, permitting, and environmental issues. The largest share of that increase would aim to reduce the impacts of windfarms on eagles and other wildlife.

The House committee report proposed a cut of nearly $17 million below the FY2015 level. Also, the committee supported an emphasis on development of offshore technologies that address issues such as high winds, icing, and deep water. The House-passed bill adopted the committee recommended level. The Senate report recommended a cut of $61 million from the FY2015 level—the largest cut it recommended for FY2016. All of the funding would have gone to offshore wind development. P.L. 114-113 provided $96 million, a decrease of nearly $12 million.

Geothermal Technologies[47]

This program aims to lower the risk of resource exploration and cut power production costs to 6 cents/kwh for geothermal power equipment by 2030. The Hydrothermal subprogram has a goal of developing 30 gigawatts[48] (gw) of new resources. It is mainly focused on sensing and drilling technologies designed to target and develop "blind" resource areas. Those resources are mainly in the western United States.

For the enhanced geothermal systems (EGS) subprogram,[49] a 2006 study[50] by the Massachusetts Institute of Technology (MIT) suggested that, at a depth of about six miles, there should be a usable and much larger resource nationwide.[51] The long-term goal is to develop 100 gw of this resource. EGS is focused on adapting specialized resource development technology—which has parallels to oil and gas fracking technology—but it may face even greater technical barriers.

DOE requested $96 million, an increase of $41 million over the FY2015 appropriation. The Hydrothermal subprogram would get $24 million of that increase to complete phase 1 of the play fairway analysis (PFA),[52] launch PFA phase 2 for certain target areas, and support the Subsurface

[46] DOE released an update to its analysis of long-term wind energy development goals in early 2015, see DOE, *WindVision: A New Era for Wind Power in the United States*, March 2015, http://energy.gov/eere/wind/wind-vision.

[47] The Geothermal Technologies program is covered in DOE, *FY2016 Budget Request*, pp. 167-190.

[48] One gigawatt is equal to 1 billion watts, which is the same amount as 1 million kilowatts.

[49] EGS are engineered reservoirs. Pressurized fluid is injected into hot rock to open existing fractures. The increased permeability lets fluid circulate into the production well.

[50] DOE, Idaho National Laboratory, *The Future of Geothermal Energy*, 2006 https://mitei.mit.edu/system/files/geothermal-energy-full.pdf.

[51] Enhanced Geothermal System (EGS) projects can be divided into three categories: Infield, Nearfield, and Greenfield projects. Infield projects are located within an unproductive portion of an operational hydrothermal field. Nearfield EGS projects lie on the margins of an existing hydrothermal field. Greenfield projects are geothermal resources engineered where no geothermal development has occurred previously. DOE estimates that the Greenfield resource has a technical potential of more than 500 gw.

[52] The concept of "play fairway analysis" has been used to identify potential locations of blind hydrothermal systems and to describe geothermal opportunities in rift-zone settings. Borrowed from the petroleum industry, this tool incorporates the regional or basin-wide distribution of known geologic factors besides heat flow that control the occurrence of a particular example of a geothermal system. PFA assesses exploration risk and the probability of finding (continued...)

Engineering crosscutting (SubTER) program. The EGS subprogram would get $13 million of the increase to apply to the first field lab drilling[53] and to further supercritical CO_2 (sCO_2) tests.[54] There is some debate over the fracking aspect of EGS.[55] Concerns include earthquakes, leakages, and spills. DOE's responses to those concerns include the formulation of a seismicity protocol[56] and the development of best management practices.[57]

The House committee report proposed a cut of $9 million below the FY2015 level. The House-passed bill adopted the committee recommended level. The Senate report recommended an increase of $16 million relative to the FY2015 level. P.L. 114-113 provided $71 million, an increase of $16 million.

Water Power[58]

Water power technologies employ conventional hydropower resources—and marine and hydrokinetic (wave, tidal, current, and ocean thermal) resources—to generate electricity. The Hydropower program supports technology development, market acceleration, and grid integration across three resource classes: (1) existing water infrastructure—non-powered dams, (2) undeveloped streams, and (3) pumped-storage hydropower (PSH). Hydropower technology is well established, but the fledgling industry for marine and hydrokinetic (MHK) power facilities is still looking to develop a clear technology theme and viable commercial strategy. Because more than 50% of the nation's population lives within 50 miles of a coastline, MHK technologies have significant potential to provide renewable electricity to consumers in coastal load centers, especially where electricity costs are high. **Table 6** shows the technical production potential and program focus for selected water power technologies. Technical potential is different from economically developable potential, with the latter likely being a much smaller amount.[59] For gauging the magnitude of the technical potentials, the bottom line of the table shows the total U.S. electric power generation during 2013.

(...continued)

new resources on a regional scale, resulting in maps and studies that reduce the industry's drilling and development risks. For more details, see DOE, *Play Fairway Analysis*, http://energy.gov/eere/geothermal/play-fairway-analysis.

[53] This is a site characterization activity for the Frontier Observatory for Research in Geothermal Energy (FORGE). FORGE is a dedicated site that enables testing of new technologies and techniques.

[54] As part of its participation in the supercritical carbon dioxide (sCO_2) crosscutting activity, the increase would support further testing of CO_2 as a geothermal working fluid. This research aims to couple CO_2 sequestration with geothermal energy production.

[55] For one discussion of the debate, see Renewable Energy World, *Is Fracking for Enhanced Geothermal Systems the Same as Fracking for Natural Gas?*, 2013 http://www.renewableenergyworld.com/rea/news/article/2013/07/is-fracking-for-enhanced-geothermal-systems-the-same-as-fracking-for-natural-gas.

[56] The DOE seismicity protocol is available at http://www1.eere.energy.gov/geothermal/pdfs/geothermal_seismicity_protocol_012012.pdf.

[57] DOE, *Best Practices for Geothermal Power Risk Reduction Workshop Follow-Up Manual*, http://geo-energy.org/reports/Geothermal%20Best%20Practices%20Publication%20Final%20CL188154847.pdf. As an example of best practices development, DOE cites current work at its proof-of-concept Newberry project in Oregon.

[58] The Water Power program is covered in DOE, *FY2016 Budget Request*, pp. 151-166.

[59] An estimate of "technical potential" is always larger than the amount of "economically developable" potential. For more explanation of these concepts, see DOE, *Hydropower Resource Assessment and Characterization* http://energy.gov/eere/water/hydropower-resource-assessment-and-characterization and see DOE, *Marine and Hydrokinetic Resource Assessment and Characterization* http://energy.gov/eere/water/marine-and-hydrokinetic-resource-assessment-and-characterization.

Table 6. Water Power Technical Potentials for Sub-Programs

(in trillions of watt-hours, or terawatt-hours)

Sub-Program	Annual Technical Production Potential (in terawatt-hours, twh)	Program Focus
Existing Water Infrastructure (Non-Powered Dams)	31 twh	environmental impact, cost, competing demands for water
Undeveloped Streams	340 twh	environmental impact, endangered species, modular powertrain
Wave Energy	1,170 twh	cost, grid-connected open water test facility
Tidal Energy	250 twh	cost, innovation
Ocean and River Current Energy	283 twh	cost, innovation
Total U.S. Power Generation in 2013	4,066 twh	Not applicable

Sources: DOE, *FY2016 Budget Request*, p. 151; DOE Energy Information Administration, *Electric Power Annual for 2013*, Table 1.1. Total Electric Power Industry Summary Statistics, 2013 and 2012, http://www.eia.gov/electricity/annual/html/epa_01_01.html.

Note: One terawatt-hour (twh) is equal to one trillion watt-hours, or 1 billion kilowatt-hours (kwh).

DOE requested $67 million, an increase of $6 million over the FY2015 appropriation. The entire increase would have gone to the Hydropower subprogram. For non-powered dams, the focus is on modular powertrains and site engineering designs. For undeveloped streams, the focus is on innovation in structural materials and construction methods that reduce costs and environmental disturbance. For FY2016, the Water Power Program supports one DOE crosscut—the Energy-Water Nexus. The crosscut aims to facilitate the transition to more resilient energy and coupled energy-water systems.

The House committee report proposed a cut of about $22 million from the FY2015 level. Also, the committee directed DOE to allocate current (FY2015) funding to MHK based on resource assessments and stakeholder input. The House-passed bill adopted the committee recommended level. The Senate report recommended an increase of $4 million over the FY2015 level. P.L. 114-113 provided $70 million, an increase of $9 million.

Energy Efficiency

Building Technologies[60]

This program develops energy efficiency technologies to curb building-related energy costs, with a goal of reducing energy use by 50% from 2010 to 2030. The program strategy is designed with three linked paths: improve building components (envelope/windows, HVAC,[61] lighting, and sensors/controls), strengthen market pull (through cooperation with private industry), and raise energy efficiency levels for new equipment (via standards) and new buildings (via model codes).

[60] The Building Technologies program is covered in DOE, *FY2016 Budget Request*, pp. 232-262. For a discussion of major long-term barriers to buildings energy efficiency, see CRS Report R40670, *Energy Efficiency in Buildings: Critical Barriers and Congressional Policy*, by (name redacted), (name redacted), and (name redacted)

[61] HVAC is an abbreviation for heating, ventilation, and air conditioning equipment.

DOE requested $264 million for FY2016, an increase of $92 million over the FY2015 appropriation. That overall increase—combined with $6 million in reductions—would be divided into increases for three program areas. First, funding for emerging technologies would increase by $57 million, focused on R&D on sensors, controls, and grid integration, and on new air conditioning and refrigeration technologies. Second, a $25 million increase for residential buildings would support retrofits and building codes for new residential construction. Third, a $16 million increase would aim to accelerate equipment efficiency standards and model building codes.

The House committee report proposed a cut of nearly $22 million from the FY2015 level. Also, the committee directed DOE to initiate a study of the potential benefits of "smart home" electronics. Further, the committee encouraged DOE to (1) continue to consider energy savings from increased energy efficiency of consumer electronics, and (2) support collaborative RD&D with industry on the energy savings potential of adaptive connected equipment and responsive building technologies. The House-passed bill adopted the committee recommended level. The Senate report recommended a boost of $6 million over the FY2015 level. P.L. 114-113 provided $201 million, an increase of $29 million.

Advanced Manufacturing[62]

Domestic manufacturers face increasing challenges in the global marketplace. The Advanced Manufacturing Office (AMO) was designed to focus on national interests—especially concerns about jobs, critical materials, and international competitiveness. AMO anchors DOE's Clean Energy Manufacturing Initiative, which began in 2013. The general goal for AMO programs is to reduce the energy use of manufactured goods across targeted product life-cycles by 50% over 10 years. More specific objectives include (1) attain 50% energy savings through advanced materials and industrial processes, (2) help leading companies cut energy intensity by 25% over 10 years, and (3) facilitate installation of 40 gw of combined heat and power (CHP) equipment by 2020.[63]

To meet these goals and objectives, DOE requested $404 million, a net increase of $204 million over the FY2015 appropriation—the largest EERE program increase requested for FY2016. Most of the requested increase—about $149 million—would be directed to the subprogram on Advanced Manufacturing R&D Facilities. Also, a $49 million increase would be provided for Advanced Manufacturing R&D Projects.

The proposed $149 million increase for Advanced R&D Facilities would have gone mainly to create two new Clean Energy Manufacturing Institutes (CEMIs) at a cost of about $70 million each. The other $9 million would be spread out as support for existing institutes.[64] The two new institutes would address any of several topics, including advanced materials (e.g., nanomaterials), two-dimensional roll-to-roll process, high efficiency modular chemical process, bio-manufacturing, and smart manufacturing, among others. The four existing institutes include Next

[62] The Advanced Manufacturing program is covered in DOE, *FY2016 Budget Request*, pp. 190-206.

[63] DOE, EERE-Advanced Manufacturing Office, *FY14 Budget At-a-Glance*, http://www1.eere.energy.gov/office_eere/pdfs/budget/manufacturing_ataglance_2014.pdf. The 40 gw target would amount to a 50% increase in the total amount that was operating as of 2012. For more details, see DOE, *Combined Heat and Power: A Clean Energy Solution*, 2012 http://energy.gov/sites/prod/files/2013/11/f4/chp_clean_energy_solution.pdf.

[64] The CEMIs are part of the President's National Network for Manufacturing Innovation (NNMI). For more about NNMI see CRS Report R42625, *The Obama Administration's Proposal to Establish a National Network for Manufacturing Innovation*, by (name redacted)

Generation Power Electronics (2013), Advanced Composites (2014), Smart Manufacturing (2014), and one yet to be announced during FY2015.

The CEMIs form part of a larger proposed interagency network aimed at bringing together universities, industry, and the government to jointly invest in solving industry-relevant problems. The institutes focus on technologies applicable to multiple industries and markets. This activity aims to improve U.S. manufacturing competitiveness, in support of DOE's Clean Energy Manufacturing Initiative and the President's initiative for a multi-agency National Network for Manufacturing Innovation (NNMI).[65] A key goal is for each institute to become financially sustainable within five to seven years after it is established.

CEMIs are a relatively new EERE crosscut activity that is anchored by AMO, and each CEMI incorporates activities under many of EERE's other programs.[66] The main goal is to improve U.S. competitiveness in the manufacturing of clean energy products, such as solar photovoltaic modules, LEDs, batteries, and wind turbine blades. The CEMI institutes would provide small- and medium-sized enterprises affordable access to cutting-edge physical and virtual manufacturing capabilities (e.g., 3-D printing equipment) and facilitate technology use in the U.S. manufacturing sector to bolster its global competitiveness. DOE plans to invest about $70 million into each CEMI institute, to be used over a five- to seven-year period.[67]

The final agreement on the FY2015 energy and water development appropriations bill (P.L. 113-235, Division D) included some House and Senate policy directives for new funding to establish additional CEMIs. The House report directed that the request include "a specific research topic" associated with each newly proposed CEMI. The draft Senate report specified that, for the third and each subsequent CEMI there shall be a competitive process, committee notification, development of performance measures, and demonstration of progress toward funding self-sufficiency with prior CEMIs. P.L. 113-235 adopted those House and Senate directives, and required an EERE report that provides performance measures to assess the effectiveness of existing CEMIs.

Another R&D facility, the Critical Materials Hub (led by Ames National Laboratory), was created in FY2012 to focus on technologies that enable manufacturers to make better use of critical materials (e.g., rare earth elements) and to eliminate the need for materials that are vulnerable to supply disruptions. Many rare earth elements are essential to technologies of the clean energy industry.[68] Examples include wind turbines, solar photovoltaic panels, electric vehicles, and energy-efficient lighting. DOE requested $25 million—level funding—to extend the Hub's operation for a fifth—and final—year.

Also, DOE requested $10 million of further support for the Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory. This would be the final year of funding for the MDF.

[65] For the NNMI, there were (at the end of 2014) nine institutes in place, and there is an overall goal to establish a total of 45 institutes over 10 years.

[66] Going forward, DOE expects to establish CEMIs as an alternative to the concept of "manufacturing demonstration facilities" (MDFs), which it implemented in FY2012 with the establishment of the Critical Materials Hub (discussed in the next paragraph). DOE's Oak Ridge National Laboratory is the home for AMO's first MDF focused on additive manufacturing and low-cost carbon fiber. For more on MDFs, see http://www1.eere.energy.gov/manufacturing/rd/m/mdf.html.

[67] For more about CEMIs, see DOE's website at http://energy.gov/eere/cemi/clean-energy-manufacturing-initiative.

[68] The Hub also supports materials needs for defense and other strategic industries.

The proposed $49 million increase for Advanced R&D Projects would provide a total of $133 million in FY2016 for this subprogram. Of that total, $113 million would have gone to new projects that cost $15 million-$20 million each, covering up to six "foundational" areas selected from the following areas:

- Chemical process intensification and smart manufacturing—two likely areas of focus.
- Grid and resource integration—including advanced combined heat and power, waste heat recovery, advanced insulation materials, and integration of energy infrastructure (grid and natural gas).
- Next generation electric machines—including ultraconductive materials.
- Sustainable manufacturing—including water-energy nexus.

Also, the request seeks $20 million for the Advanced Manufacturing Incubator, which is focused on "fundamental" applied R&D projects for small- and medium-sized manufacturing companies.

The House committee report proposed an increase of $5 million above the FY2015 level. The committee recommendation included support for one new CEMI institute in FY2016 and directed that all future budget justifications include a specific research topic associated with each request for a new CEMI Institute. Also, the committee directed DOE to analyze, and report on, the impact federal investment may have in strengthening the availability and usage of lithium, including low-sodium lithium metal. Further, the committee encouraged DOE to (1) continue technical assistance for combined heat and power (CHP) demonstrations for microgrids and grid integration, as well as R&D on next-generation CHP technologies, and (2) consider the need for competitively funded advanced textile manufacturing process research. The House-passed bill adopted the committee recommended level.

The Senate report recommended an increase of $14 million over the FY2015 level. Echoing the House report, the Senate committee recommendation included support for one new CEMI institute in FY2016 and directed that all future budget justifications include a specific research topic associated with each request for a new CEMI Institute. For the fourth—and any future—CEMI, the Senate report further required that DOE conduct an open solicitation and competitive, merit-based review process. Also, both reports recommended $25 million for the Critical Materials Hub. P.L. 114-113 provided $229 million, an increase of $29 million.

Federal Energy Management Program (FEMP)[69]

FEMP provides expertise, training, and other services to help federal agencies achieve congressionally mandated goals for energy efficiency and renewable energy use. Its mission is also driven by presidential executive orders that set energy and environmental goals for federal agencies.[70] FEMP supports key initiatives to better assist federal agencies in meeting aggressive energy, water, greenhouse gas (GHG) and other sustainability goals. It also promotes interagency sharing of solutions—such as best practices, tools, and process improvements.

FEMP helps federal agencies lead by example, by providing assistance to federal agencies through project financing, technical guidance and assistance, planning and evaluation, and federal

[69] The FEMP program is covered in DOE, *FY2016 Budget Request*, pp. 207-231.

[70] For example, see The White House, *Executive Order – Planning for Federal Sustainability in the Next Decade*, March 19, 2015, https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade.

fleet support. By using performance contracts such as energy savings performance contracts (ESPCs) and utility energy service contracts (UESCs), the federal government is able to engage a third party (private sector energy service company) to invest in needed energy projects and pay for the investment through the energy, water, and operations and maintenance (O&M) savings achieved over the life of the contract.[71]

DOE requested $43 million, about $16 million more than the FY2015 appropriation. Most of the increase, about $12 million, would support the Federal Energy Efficiency Fund (FEEF), also known as the Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) program. This subprogram helps agencies invest in priority projects for efficiency and renewables with the greatest impact. Efforts under FEEF/AFFECT would be expanded from about six projects in FY2015 to nearly 30 projects in FY2016. AFFECT awards provide direct funding to support the best available agency projects and to leverage cost sharing at federal agencies for capital improvement projects and for other initiatives to increase energy efficiency, conserve water, and increase renewable energy investments at agency facilities. AFFECT provides a mechanism for FEMP to help ensure the best projects are funded and stay on schedule.[72]

The House committee report proposed a cut of more than $8 million from the FY2015 level. The House-passed bill adopted the committee recommended level. The Senate report recommended funding equal to the FY2015 level. P.L. 114-113 provided $27 million, the same level as the FY2015 appropriation.

Grant Programs

Weatherization Grants[73]

The Weatherization Assistance Program (WAP) aims to increase the energy efficiency of dwellings owned and/or occupied by low-income persons, reduce their total energy costs, and improve their health and safety. Through residential building retrofits, WAP reduces the size of low-income household energy bills. Energy bills of those households require a larger share of total income than the energy bills for higher income households. Since 1976, WAP has performed 6 million retrofits, of which 1 million were supported by the Recovery Act of 2009 (P.L. 111-5). DOE has noted that many states have expended leftover Recovery Act funds and now need new funds to avoid cutting core programs and services.[74]

DOE requested a $35 million increase over the FY2015 appropriation for a total of $224 million. About $19 million of that increase (for a total of $209 million) would raise the number of retrofits in the FY2016 cycle by about 3,000 households (10%).[75] Also, $15 million of the increase would be used to test financial models designed to help expand application of the program to "underserved" multifamily buildings.[76] This action would be accomplished through competitively

[71] DOE, *FY2016 Budget Request*, p. 212.

[72] DOE, *FY2016 Budget Request*, p. 207.

[73] The Weatherization Grants program is covered in DOE, *FY2016 Budget Request*, pp. 267-270.

[74] For more details about the program, see CRS Report R42147, *DOE Weatherization Program: A Review of Funding, Performance, and Cost-Effectiveness Studies*, by (name redacted)

[75] The estimated increment of retrofits that would be attained with the $19 million increase is based on the DOE estimate that each household retrofit costs about $6,000.

[76] More than half of low-income residents live in multi-family buildings.

selected projects to demonstrate the viability of a variety of financing programs for replicability across the country.

The House committee report proposed funding equal to the FY2015 level, and specified no funding of awards for financing models. Also, the committee directed DOE to report on the use of solar and other renewables systems in the Weatherization Assistance Program, and to analyze any requirements of law or regulation that pose a relative cost barrier to the installation of solar energy systems. Further, the committee specified that DOE should not issue any regulations in FY2016 which use the May 2013 estimates for the social cost of carbon until a new working group is convened. The House-passed bill adopted the committee recommended level. The Senate report recommended a boost of $7.4 million over the FY2015 level. P.L. 114-113 provided $215 million, an increase of $22 million.

State Energy Grants[77]

The State Energy Program (SEP) assists states in establishing and implementing clean energy (e.g., energy efficiency and renewable energy) plans, policies, and programs to reduce energy costs, enhance economic competitiveness, improve emergency planning, and improve the environment. SEP provides states with capacity building resources, technical assistance, and best practice sharing networks to facilitate the adoption of plans, policies, and programs that are appropriate for various state and regional circumstances.

DOE requested an increase of $20 million over the FY2015 appropriation. The proposed increase would mainly support a new, $15 million program of competitive grants that promotes regional, sectoral, and national public-private partnerships for innovative scale-up and spread of best practices for efficiency and renewables.

Both the House committee report and Senate report proposed funding equal to the FY2015 level. The House-passed bill adopted the committee recommended level. P.L. 114-113 provided $50 million, the same level as the FY2015 appropriation.

Local Energy Grants[78]

A new program, with funding of $20 million, would be established with a structure parallel to that of the SEP grant program. This new program would aim to enhance local government capacity for energy planning, analysis, and program implementation. Competitive grants would support best practices, technical assistance, and leadership-by-example. DOE expects to support 35 to 40 highly leveraged and replicable projects that would include outdoor lighting, public buildings, and water/wastewater facilities.

Both the House committee report (and House-passed bill) and the Senate report recommended no funding for this DOE-proposed new program. P.L. 114-113 provided no funds for this program.

[77] The State Energy Grants program is covered in DOE, *FY2016 Budget Request*, pp. 271-273.

[78] The proposed Local Energy Grants program is covered in DOE, *FY2016 Budget Request*, pp. 274-276.

Administration

Program Direction[79]

This administrative program funds federal employee salaries, personnel recruitment, and workforce training. It also manages contractor support and operational costs. EERE addresses program cost controls through its Active Project Management (APM) system. DOE requested $165 million, which includes a $5 million increase over the FY2015 level to cover the greater program activity level that would be associated with the overall requested funding increase of $800 million for EERE.

The House committee report proposed a cut of $10 million below the FY2015 level. The House-passed bill adopted the committee recommended level. The Senate report recommended funding equal to the FY2015 level. P.L. 114-113 provided $155 million, a decrease of $5 million.

Strategic Programs[80]

The Office of Strategic Programs (formerly Program Support) serves an integrative and crosscutting mission for EERE. The office has four subprograms: Technology-to-Market, International, Strategic Priorities and Impact Analysis, and Communications and Outreach. The Technology-to-Market subprogram organizes partnerships and projects with industry, universities, DOE's national labs, and others to foster recruitment, investment, innovation, technology transfer, and manufacturing competitiveness. The International subprogram promotes the development of international export markets for U.S. clean energy equipment and promotes U.S.-based standards, test procedures, and certifications. The subprogram for Strategic Priorities and Impact Analysis supports impact assessments and strategic planning for EERE's portfolio. It also leads EERE implementation of the President's Open Data Policy.[81] The Communications and Outreach subprogram handles EERE relations with media and the general public.

For this program, DOE requested an increase of about $7 million relative to the FY2015 appropriation. About $4.8 million of that increase would have gone to the Technology-to-Market subprogram, of which $2.5 million is due to a transfer of the Solar Decathlon activity from EERE's Office of Building Technologies,[82] and $2.3 million would support a new clean energy philanthropy alliance and a clean energy jobs initiative.

The House committee report proposed a cut of about $9 million from the FY2015 level. The Senate report recommended funding equal to the FY2015 level. Also, both committee reports directed that $2 million be applied to the U.S.-Israel energy cooperation agreement. The House-passed bill adopted the committee recommended level. The Senate report directed further that, within six months, DOE report on implementation and coordination plans between EERE and the Office of Fossil Energy to support research and development of natural gas energy technologies as part of the U.S.-Israel cooperative effort. P.L. 114-113 provided $21 million, which is the same as the FY2015 appropriation.

[79] The Program Direction activity is covered in DOE, *FY2016 Budget Request*, pp. 277-281.

[80] Strategic Programs are covered in DOE, *FY2016 Budget Request*, pp. 282-297.

[81] Executive Order M-13-13.

[82] The Decathlon is an annual design/build competition for solar-powered homes that involves student teams from colleges and universities. The transfer is expected to yield better coordination with education and deployment activities.

Facilities and Infrastructure

The Facilities and Infrastructure (F&I) program budget maintains NREL's campus of buildings and facilities. The Facility Management subprogram provides the major support for the Energy Systems Integration Facility (ESIF) at NREL. ESIF is a grid integration research and user facility. As ESIF completes the third year of start-up activities, its high performance computational science center (HPC) is oversubscribed and demand for computer time is increasing. The request seeks an increase of $6 million (20%) to expand the HPC facility, which would nearly double NREL's computer capacity.

The House committee report proposed no change in funding relative to the FY2015 level. The House-passed bill adopted the committee recommended level. The Senate report recommended an increase of $6 million relative to the FY2015 level. P.L. 114-113 provided $62 million, an increase of $6 million.

Additional Reports on EERE Programs, Funding, and Policy

For additional background on selected EERE programs and funding aspects, see

(1) CRS Report R43567, *Energy and Water Development: FY2015 Appropriations*, coordinated by (name redacted)

(2) CRS Report RS22858, *Renewable Energy R&D Funding History: A Comparison with Funding for Nuclear Energy, Fossil Energy, and Energy Efficiency R&D*, by (name redacted)

(3) CRS Report R40670, *Energy Efficiency in Buildings: Critical Barriers and Congressional Policy*, by (name redacted), (name redacted), and (name redacted)

(4) CRS Report R42147, *DOE Weatherization Program: A Review of Funding, Performance, and Cost-Effectiveness Studies*, by (name redacted)

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