



Federal Financial Support for the Development and Production of Fuels and Energy Technologies

The federal government has provided various types of financial support for the development and production of fuels and energy technologies in recent decades. That support, which has taken the form of tax preferences (special provisions of tax law that reduce tax liabilities for certain activities, entities, or groups of people) and spending programs administered by the Department of Energy (DOE), totaled \$24 billion in 2011. (Unless otherwise indicated, all years discussed in this brief are fiscal years, and all dollars are expressed in nominal terms.) That total includes \$20.5 billion in tax preferences and \$3.5 billion in funding for DOE.

Tax preferences for energy were first established in 1916, and until 2005 they were primarily intended to stimulate domestic production of oil and natural gas. Beginning in 2006, the cost of energy-related tax preferences grew substantially, and an increasing share was aimed at encouraging energy efficiency and energy produced from renewable sources, such as wind and the sun, which generally cause less environmental damage than would result from producing and consuming fossil fuels. Provisions aimed at energy efficiency and renewable energy accounted for 78 percent of the budgetary cost of federal energy-related tax preferences in 2011. However, four of those provisions, including the one with the greatest budgetary impact, expired at the end of calendar year 2011. Only four major tax preferences are permanent, three of which are directed toward fossil fuels and one of which is directed toward nuclear energy.

In addition, the Department of Energy supports energy technologies by making direct investments (primarily for research and development) and by providing loans or loan guarantees. That support has varied over time, but, with the exception of the substantial funding provided in the 2009 economic stimulus legislation (the American

Recovery and Reinvestment Act of 2009, or ARRA), it has generally declined in recent years—from \$10 billion (in 2011 dollars) in 1980 to \$3.5 billion in 2011 and \$3.4 billion in 2012. More than half of that support in both 2011 and 2012 was directed toward energy efficiency and renewable energy.

DOE received roughly \$10 billion in funding for its subsidized credit programs in 2009 but has received only limited additional subsidy funding for those programs since then: \$170 million in 2011 and no new funding in either 2010 or 2012. Between 2009 and 2012, DOE provided an estimated \$4.0 billion in subsidies for about \$25 billion in loans, primarily to producers of advanced vehicles, generators of solar power, and manufacturers of solar equipment.

Without government intervention, households and businesses do not have a financial incentive to take into account the environmental damage or other costs to the nation associated with their choices about energy production and consumption. The most direct and cost-effective method for addressing that problem would be to levy a tax on energy sources that reflects the environmental and other costs associated with their production and use. Subsidies (such as tax preferences) for favored technologies can accomplish some of the same goals, but in a less cost-effective way.

Also, unless the government intervenes, the amount of research and development (R&D) that the private sector undertakes is likely to be inefficiently low from society's perspective because firms cannot easily capture the "spillover benefits" that result from it. That is particularly true at the early stages of developing a technology. Such research can create fundamental knowledge that can lead to numerous benefits for society as a whole but not

necessarily for the firms that funded that research; thus government funding can be beneficial. By contrast, DOE's funding of energy technology demonstration projects at later stages in the development process has been far less cost-effective, and the Government Accountability Office, among others, has criticized DOE's management of such projects.

Tax Preferences

The federal government supports the production and use of fossil fuels, nuclear power, and renewable energy and encourages increased energy efficiency through provisions of law that reduce the amount of taxes paid by producers and consumers of energy from those fuels or technologies. Those tax preferences include special deductions, special tax rates, tax credits, and grants in lieu of tax credits. In 2011, the combined cost of reduced revenues and increased outlays from those tax preferences amounted to an estimated \$20.5 billion. (See Table 1, which reports provisions that were estimated to cost at least \$50 million. Major provisions, costing at least \$500 million, are listed individually; those costing less than \$500 million are included in the "other" category.) Energy producers also benefit from general tax preferences that are available to all firms, but those provisions are not included in the \$20.5 billion. Energy-related tax preferences account for a small percentage of the cost of all federal tax preferences, which totals hundreds of billions of dollars per year.

Historical Trends

From 1916 to the 1970s, federal energy-related tax policy focused almost exclusively on increasing the production of domestic oil and natural gas; there were no tax incentives for promoting renewable energy or increasing energy efficiency.¹ Beginning in the 1970s, lawmakers began adding tax preferences for new sources of fossil fuel, alternatives to fossil fuel, and energy efficiency. Disruptions in the supply of oil in the 1970s heightened interest in encouraging the production of alternative transportation fuels, such as ethanol and "unconventional fuels" (for example, oil produced from shale and tar sands, or synthetic fuel produced from coal). Furthermore, growing awareness of environmental damage caused by producing energy from fossil fuels—such as the

harmful effects of the carbon dioxide (CO₂) emissions from burning coal—led to tax preferences for improvements in energy efficiency and for the production of electricity from renewable sources.

Nevertheless, tax preferences for fossil fuels continued to make up the bulk of all energy-related tax incentives through 2007, typically accounting for more than two-thirds of the total cost. The Energy Policy Act of 2005 changed the focus of energy-related tax policy—adding a number of provisions aimed at increasing energy efficiency and the use of alternative motor vehicles, such as fuel-cell and hybrid vehicles—and substantially increased the number of energy-related tax preferences and their total cost. By 2008, fossil fuels accounted for only 33 percent of the total cost of energy-related tax incentives. The Emergency Economic Stabilization Act of 2008 expanded and extended provisions related to energy efficiency and renewable energy. ARRA further expanded tax preferences for energy efficiency, renewable energy, and alternative vehicles. In addition, it created the Section 1603 grant program, which allowed producers of renewable energy to collect one-time cash payments in lieu of future tax credits.²

The value of tax preferences related to energy and the composition of that financial support have changed over time. Those changes stem from a combination of factors, including changes in the number of energy-related tax preferences; changes in the prices of oil and natural gas, which affect investment in those industries; and increases or decreases in overall tax rates, which make existing tax preferences more or less valuable. In some cases, an existing tax credit was applied for a new purpose. For example, an income tax credit for alternative fuel mixtures was initially intended as an incentive for firms to produce liquid motor fuels from biomass (organic materials used to produce energy). In 2009, however, pulp and paper producers claimed the credit for blending "black liquor"—a by-product of the pulping process that is used to make paper—with liquid petroleum-based fuels to power their paper-making operations. That use greatly expanded the cost of the credit, which was allowed to

1. This discussion of historical trends largely draws from Molly E. Sherlock, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures*, CRS Report for Congress R41227 (Congressional Research Service, May 2, 2011).

2. Before the availability of Section 1603 grants, qualifying renewable-energy projects were federally supported primarily through production or investment tax credits. The Section 1603 grant program allowed companies to receive up-front cash grants in lieu of those tax credits, which, in many cases, the companies would be able to use only in future years in which they had sufficient tax liability.

Table 1.**Energy-Related Tax Preferences in Fiscal Year 2011**

Primary Target of Support	Tax Preference	Total Cost (Billions of dollars)	Expiration Date
Energy-Related Tax Preferences Affecting Income Taxes			
Energy Efficiency	Credit for energy-efficiency improvements to existing homes	1.5	12/31/2011
Renewable Energy	Credits for electricity production from renewable resources ^a	1.4	12/31/2012 for wind; 12/31/2013 for other renewable resources
	Credit for investment in advanced energy property, such as property used in producing energy from wind, the sun, or geothermal sources	0.7	Fixed \$2.3 billion in credit; expires when depleted
Fossil Fuels	Expensing of exploration and development costs for oil and natural gas	0.8	None
	Option to expense 50 percent of qualified property used to refine liquid fuels	0.8	None
	Option to expense investment costs on the basis of gross income rather than on production	0.9	None
Nuclear Energy	Nuclear energy (special tax rate for nuclear decommissioning reserve funds)	0.9	None
Various	Other ^b	2.7	n.a.
	Subtotal, Tax Preferences Affecting Income Taxes	9.7	n.a.
Energy-Related Tax Preferences Affecting Excise Taxes^c			
Renewable Energy	Excise tax credit for alcohol fuels	6.1	12/31/2011
	Excise tax credit for biodiesel	0.8	12/31/2011 ^d
	Subtotal, Tax Preferences Affecting Excise Taxes	6.9	n.a.
Grants in Lieu of Tax Credits			
Renewable Energy	Section 1603 grants	3.9	12/31/2011
	Total, Energy-Related Tax Preferences	20.5	n.a.

Sources: Congressional Budget Office based on data from Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2011–2015*, JCS-1-12 (January 17, 2012), pp. 33–35, and *List of Expiring Tax Provisions 2010–2020*, JCX-2-11 (January 21, 2011); and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2013: Appendix* (February 2012), p. 1068.

Notes: Provisions listed individually are those that were estimated to cost at least \$500 million in 2010.

Estimates do not reflect the amount of revenues that would be raised if those provisions of the tax code were eliminated and taxpayers adjusted their activities in response to those changes.

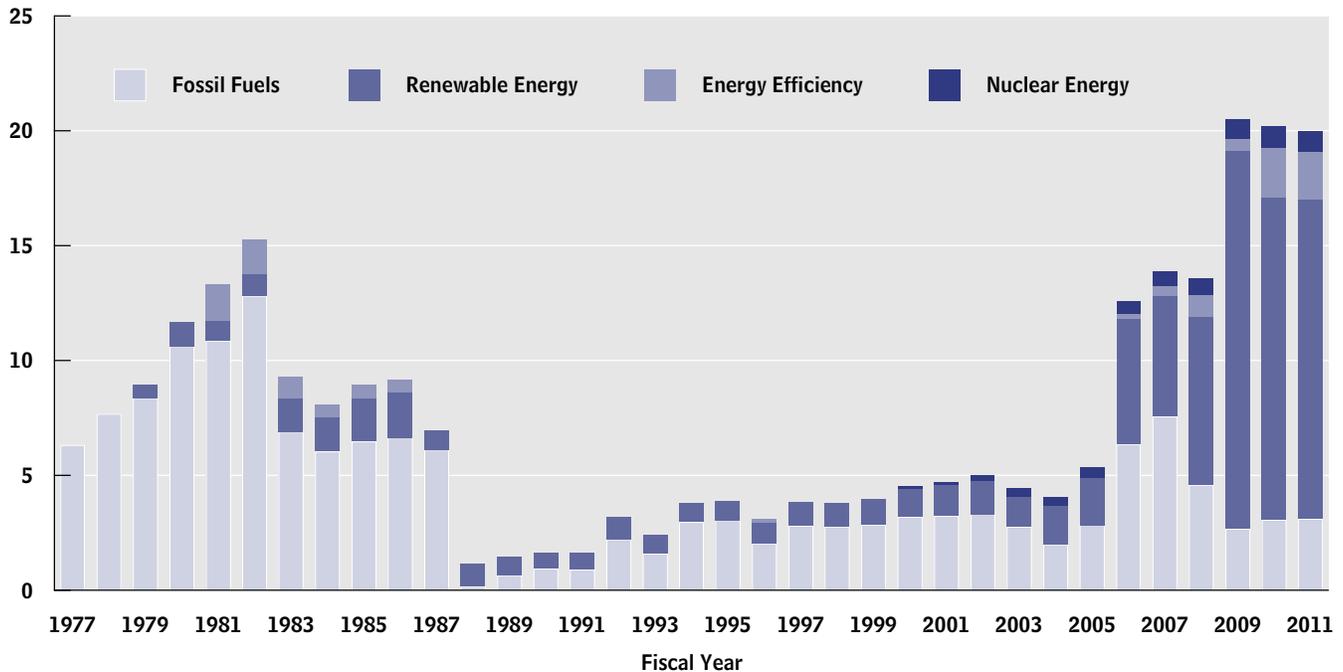
The totals do not incorporate any potential interactions among preferences.

n.a. = not applicable.

- Credits provided for 5 to 10 years after a facility is placed in service; the placed-in-service date must be by December 31, 2012, for wind and by December 31, 2013, for other renewable sources of energy.
- “Other” includes individual provisions that were estimated to cost between \$50 million and \$500 million. It does not include income tax preferences that would cost less than \$50 million, because the Joint Committee on Taxation does not estimate those costs.
- The Joint Committee on Taxation and the Administration do not generally estimate tax expenditures in the excise tax system. They do, however, provide information on revenue reductions from excise tax credits for alcohol and biodiesel.
- With the exception of the credit for cellulosic biodiesel, which expires at the end of 2012.

Figure 1.**Energy-Related Tax Preferences, by Type of Fuel or Technology**

(Billions of 2011 dollars)



Source: Congressional Budget Office based on data from Molly F. Sherlock, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures*, CRS Report for Congress R41227 (Congressional Research Service, May 2, 2011), p. 26; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2011–2015*, JCS-1-12 (January 17, 2012), pp. 33–35; and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2013: Appendix* (February 2012), p. 1068.

Notes: The estimates do not account for any potential interactions among preferences and do not include tax provisions estimated to cost less than \$50 million.

Estimates do not reflect the amount of revenues that would be raised if those provisions of the tax code were eliminated and taxpayers adjusted their activities in response to those changes.

The figure does not include tax preferences that could not be allocated to a particular fuel or technology.

expire at the end of 2009. The Internal Revenue Service subsequently ruled that black liquor would qualify for a different credit—the cellulosic biofuel producer tax credit; however, lawmakers later amended the law in a manner that prevented that unintended use.

Measured in 2011 dollars, the cost of energy-related tax preferences more than doubled between 1977 and 1982 and then fell dramatically between 1982 and 1988, in part because of declines in tax rates and fuel prices (see Figure 1). The cost of energy-related tax preferences grew gradually between 1988 and 2005 and averaged about \$4 billion a year from 2000 to 2005. That cost (including outlays for grants in lieu of tax preferences) has risen sharply since then, to an average of \$20 billion a year from 2009 through 2011.

Financial Support in 2011

The tax preferences that explicitly target energy use and production take three forms: preferences in the income tax system, such as special deductions, special tax rates, and credits; preferences in excise taxes, such as excise tax credits; and Section 1603 grants (in lieu of future tax reductions). In 2011, those preferences provided financial support as follows:

- \$9.7 billion for energy-related preferences in the income tax code.³ The most costly preferences were credits for energy-efficiency improvements to existing homes and credits for producing electricity from renewable sources.

3. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2011–2015*, JCS-1-12 (January 17, 2012).

- \$6.9 billion for two major energy-related tax preferences in the excise tax system—excise tax credits for alcohol fuels and for biodiesel.⁴ The bulk of that support resulted from the excise tax credit for alcohol fuels. Use of the credit was boosted by the renewable-fuel standard, which required that 13.95 billion gallons of renewable fuels be used in the national transportation fuel supply.⁵
- \$3.9 billion for grants under the Section 1603 program. Those grants were primarily used by producers of wind-generated electricity.

In 2011, a total of \$13.9 billion, or 68 percent of the energy-related tax preferences, was directed toward renewable energy, and \$2.1 billion, or 10 percent, was directed toward energy efficiency (see Figure 2).⁶

Expired Provisions

The tax preferences available in calendar year 2012 are very different from those that were in effect in 2011. Four provisions among those shown in Table 1—which together accounted for 60 percent of the budgetary cost of the energy-related tax preferences—expired at the end of calendar year 2011. One was the only major preference that provided support for energy efficiency. The other three supported the production of renewable energy, and their expiration leaves in effect only two major preferences devoted to renewable-energy production. Moreover, the credits offered under one of those preferences will expire by the end of calendar year 2013. Only four of the major tax preferences are permanent; of those, three are directed toward fossil fuels and one is directed toward nuclear energy.

4. Estimates provided by staff of the Joint Committee on Taxation. For a discussion of the effects of biofuel tax credits, see Congressional Budget Office, *Using Biofuel Tax Credits to Achieve Energy and Environmental Goals* (July 2010).

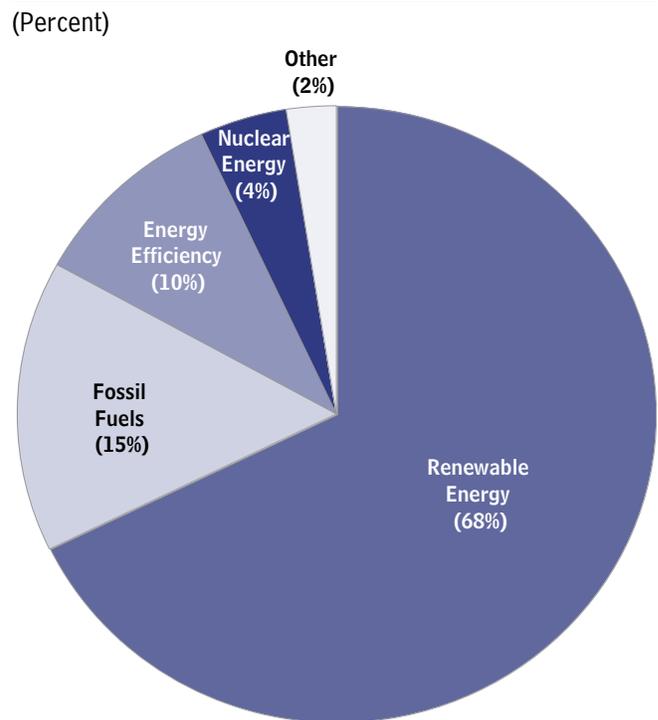
5. Lawmakers first established the renewable-fuel standard in the Energy Policy Act of 2005 and expanded it in the Energy Independence and Security Act of 2007. Current law requires the quantity of renewable fuel used by passenger vehicles and heavy trucks to gradually increase to 36 billion gallons by 2022.

6. For a more detailed discussion of energy-related tax preferences, see Joint Committee on Taxation, *Present Law and Analysis of Energy-Related Tax Expenditures and Description of the Revenue Provisions Contained in H.R. 1380, the New Alternative Transportation to Give Americans Solutions Act of 2011*, JCX-47-11 (September 20, 2011).

Department of Energy Programs

In 2012, funding for the Department of Energy’s financial support for fossil-fuel R&D, nuclear energy, energy efficiency, and renewable energy (all of which are referred to in this analysis as energy technologies) totals \$3.4 billion. (Although comprehensive tax estimates are available only through 2011, the data regarding DOE’s funding are available for 2012. Consequently, the discussion of DOE’s spending programs focuses on that year.) Virtually all of that funding is for direct investments by

Figure 2.
Allocation of Energy-Related Tax Preferences in Fiscal Year 2011, by Type of Fuel or Technology



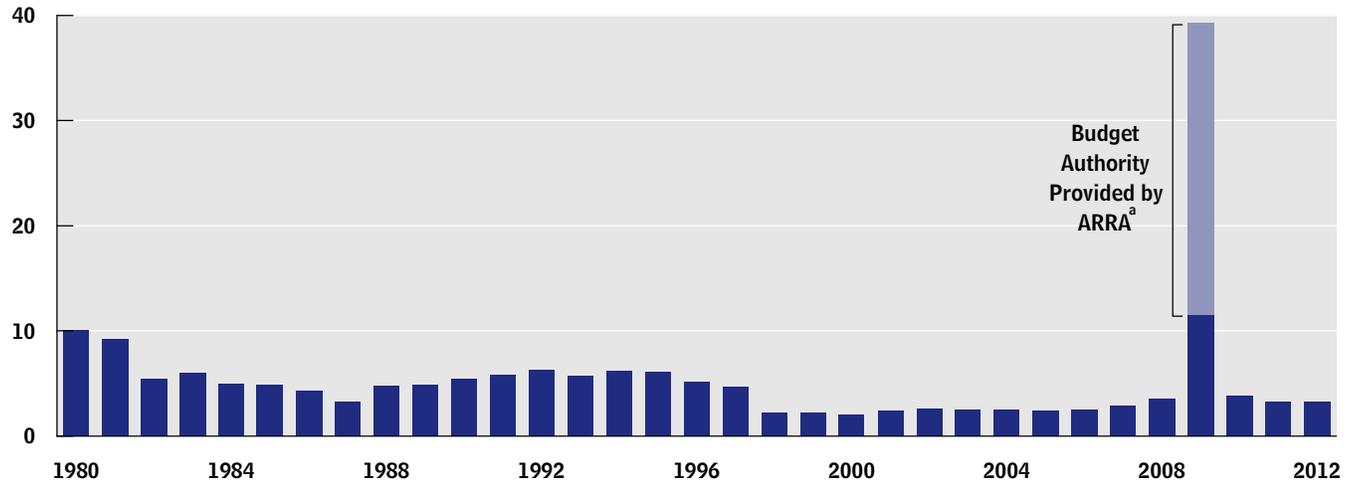
Source: Congressional Budget Office based on data from Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2011–2015* (January 17, 2012); and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2013: Appendix* (February 2012), p. 1068.

Notes: This figure encompasses all of the tax preferences listed in Table 1, including those listed as “other.” The cost of those other income tax preferences included \$1 billion for renewable energy, \$600 million for energy efficiency, \$600 million for fossil fuels, and \$500 million that was unallocated.

Numbers do not add up to 100 percent because of rounding.

Figure 3.**DOE's Financial Support for Energy Technologies and Energy Efficiency**

(Budget authority in billions of 2011 dollars)



Source: Congressional Budget Office based on data from the Department of Energy, Office of the Chief Financial Officer.

Note: DOE = Department of Energy; ARRA = American Recovery and Reinvestment Act of 2009.

a. Reflects transfers and rescissions of budget authority for Section 1705 loan guarantees made after ARRA was enacted.

DOE; the department did not receive any new funding in 2012 for making loans or loan guarantees, partly because 2009 funding provided for those programs had not been exhausted. The \$3.4 billion accounts for only about 13 percent of DOE's 2012 appropriations; much of that agency's funding is for maintaining the U.S. nuclear weapons stockpile and the environmental cleanup of old nuclear facilities. Other agencies also spend money in ways that affect the demand for and supply of energy. This brief focuses only on expenditures that promote the development of specific fuels or energy technologies.⁷

Historical Trends

The Department of Energy was established in the late 1970s in response to a dramatic increase in oil prices. Throughout most of its history, DOE has supported energy technologies primarily by funding R&D and demonstration projects. DOE's initial funding for energy

technologies was aimed at creating new domestic sources of energy. Budget authority—authority provided by law to incur financial obligations that will result in outlays of government funds—for DOE's technology programs has varied significantly over the past three decades. In 1980, such programs received appropriations of budget authority totaling about \$10 billion (measured in 2011 dollars; see Figure 3). After 1980, however, the federal government's interest in funding the development of new energy sources waned. By 2000, appropriations for DOE's energy technology programs had fallen to about \$2 billion (in 2011 dollars). DOE's funding for that purpose began to rise again in the 2000s, driven at least in part by concern about CO₂ emissions from the generation of electricity.

In 2009, DOE received \$39 billion for support of energy technologies (after accounting for rescissions and transfers)—roughly 17 times the average annual appropriation for the preceding decade. That funding included \$27.6 billion in budget authority provided under ARRA and \$11.4 billion in regular 2009 appropriations. Forty percent of the ARRA funding was for weatherization and for implementing other energy conservation measures, a much higher percentage than in most annual appropriations for DOE. Through loan guarantees or grants, ARRA also funded the manufacture

7. Those amounts do not include, and this brief does not address, the cost of energy-related activities of other agencies, which include leasing and resource-management programs of the Department of the Interior and programs supporting rural electricity production and transmission operated by the Department of Agriculture. This brief also does not address the government's role in the production of electricity through such entities as the Tennessee Valley Authority and the Bonneville Power Administration.

of advanced batteries and other innovative energy technologies. The regular 2009 appropriation included \$7.5 billion for loans for manufacturing advanced technology vehicles.

Although ARRA funds have generally been spent more rapidly than funds that DOE has received through the normal appropriation process, large amounts remain unspent. For example, as of the end of fiscal year 2011, only \$9.6 billion of the \$16.8 billion of the ARRA funds dedicated to DOE's energy-efficiency and renewable-energy programs had been spent, and only \$365 million of the \$3.4 billion appropriated for the fossil-fuel programs had been spent. Several of the demonstration projects in the fossil energy program (mainly projects that would capture and sequester CO₂ emissions from coal-fired electricity generators) have been canceled by the private partners. What will happen to the funds that had been allocated for those projects is unclear.

Financial Support for Energy Technologies in 2012

The \$3.4 billion available to the Department of Energy in 2012 for the development and production of fuels and energy technologies has two components: direct investments (\$3.3 billion) and credit programs (\$6 million).

Direct Investments. Most of DOE's direct investments in support of specific energy technologies are currently divided into four general areas: energy efficiency and renewable energy, nuclear energy, fossil-fuel R&D, and electrical delivery and energy reliability. In addition, funding was provided for the Advanced Research Projects Agency-Energy, which funds high-risk, high-payoff research for all four technologies. The \$3.3 billion is allocated as follows:

- 54 percent for energy efficiency and renewable energy, divided roughly equally between energy-efficiency programs (which focus on improving the efficiency of buildings and automobiles and provide grants for weatherization and conservation) and renewable-energy programs (which emphasize the development of solar, biomass, wind, and other such energy sources);
- 23 percent for nuclear energy programs, which focus on making reactors safer and cheaper, developing a sustainable nuclear fuel cycle, and maintaining federal nuclear energy research facilities;

- 10 percent for fossil-fuel R&D programs, primarily for reducing emissions, particularly of CO₂, from coal-fired electricity generation;
- 4 percent for electricity delivery and energy reliability programs, which support improvements in the electricity grid that increase energy efficiency and the use of renewable-energy technologies; and
- 8 percent for the Advanced Research Projects Agency-Energy.

Credit Programs. DOE directs resources to promote the deployment of new energy technologies by providing loans and loan guarantees to private firms that bring them to market. In recent years, DOE has extended credit through three major programs:

- The Advanced Technology Vehicle Manufacturing (ATVM) program—a permanent loan program that aims to improve the energy efficiency of automobiles;
- The Section 1705 program—a temporary loan guarantee program that supports loans for some renewable-energy systems, electric power transmission, and innovative biofuel projects; and
- The Section 1703 loan guarantee program—a permanent program that aims to increase investment in nuclear facilities or other innovative clean-energy facilities.⁸

DOE's credit programs operate under the rules established by the Federal Credit Reform Act of 1990 for calculating the budgetary cost of direct loans and loan guarantees issued by the federal government.⁹ In general, before DOE (or any agency) can make loans or loan guarantees, lawmakers must provide funding sufficient to cover the government's cost of the loan, referred to as the subsidy cost. Funding for subsidy costs may be derived from an appropriation from the Treasury, and those costs can be reduced by fees paid by borrowers. Lawmakers control the amount of federal credit assis-

8. Together, the Section 1705 and Section 1703 programs are often referred to as the Title 17 program.

9. Estimates prepared pursuant to the Federal Credit Reform Act do not, however, provide a comprehensive measure of what federal credit programs actually cost the government. See Congressional Budget Office, *Fair-Value Accounting for Federal Credit Programs* (March 2012).

tance either by appropriating the amount needed for the subsidies or, in cases in which subsidy costs are covered by fees, by setting limits on the volume of loans or loan guarantees.

The subsidy costs for DOE's loans and loan guarantees are the estimated lifetime costs of the credit assistance, which include losses from defaults—such as the loss that will result from the loan guarantee DOE provided for Solyndra, a manufacturer of photovoltaic systems that declared bankruptcy in 2011—net of any recoveries on the loan. Estimates of the risks of default, and the consequent budgetary costs, change as government agencies gain more experience with each loan or loan guarantee. As a result, the estimated subsidy cost of federal loans and loan guarantees is frequently revised over the life of a credit program.

Lawmakers initially provided subsidy funding for the ATVM program and for Section 1705 loan guarantees (primarily for renewable energy) but not for Section 1703 loan guarantees (primarily for nuclear power). In total, the ATVM program and the Section 1705 loan guarantees have received \$10 billion in budget authority for subsidies (after accounting for rescissions and transfers). Initially, the Section 1703 loan guarantees were intended to be self-supporting, with recipients paying a fee that covered the government's cost of providing the guarantee; however, DOE's 2011 appropriation included \$170 million in subsidies for those loan guarantees. None of the credit programs received a subsidy appropriation for 2012, but DOE received \$6 million for administrative expenses.

The estimated subsidy cost of the ATVM program and Section 1705 loan guarantees for fiscal years 2009 to 2012 totals \$4.0 billion on about \$25 billion in loans. DOE made loans totaling \$9.1 billion to six manufacturers of advanced technology vehicles, with an estimated subsidy cost of \$1.6 billion.¹⁰ Guarantee authority for the Section 1705 program expired on September 30, 2011, at which point DOE had made commitments for

10. The ATVM program has obligated \$3.5 billion of its \$7.5 billion in subsidy funds; DOE has subsequently revised the estimated subsidy costs for those loans downward by \$1.9 billion. In the case of the 1705 loan guarantees, DOE initially estimated that the subsidy costs would total \$1.9 billion but has since raised those estimates by \$0.5 billion.

\$16.1 billion in loan guarantees, with an estimated subsidy cost of \$2.4 billion. Eighty percent of those loan guarantees went either to generators of solar power or to manufacturers of solar equipment. As of the end of 2011, DOE had not finalized any Section 1703 loan guarantees, although it is authorized to guarantee debt totaling \$34 billion under that program (provided that recipients pay a fee covering the projected subsidy cost of those loans).

Cost-Effectiveness of Government Actions

The federal government's intervention in energy markets can be beneficial if it leads to a more efficient use of resources than would occur in a purely private market. It is most likely to be beneficial in cases in which private choices about the production or use of energy create external costs or spillover benefits—costs or benefits that are experienced by society as a whole rather than falling on firms or households in proportion to their production and consumption.¹¹

Reducing External Costs Through the Tax System

Environmental costs are examples of external costs. The production and consumption of energy causes environmental damage that is not borne directly by households and firms in proportion to their production or use of energy. For example, coal combustion emits carbon dioxide as well as sulfur dioxide, which causes damage to downwind lakes and contains particulates that increase the incidence of asthma. Similarly, gasoline combustion releases CO₂ and smog-causing emissions that increase the incidence of respiratory-related illnesses and death. Without government intervention, environmental costs are not reflected in the prices charged for various fuels and energy services, so firms and households lack an incentive to take them into account when deciding what types and quantity of energy to produce and consume.

Some policymakers and analysts view the United States' dependence on oil as another source of external costs. Because many sectors of the U.S. economy—especially transportation—use oil, the United States is economically

11. For a more comprehensive discussion of these two types of market failures, see Congressional Budget Office, *Evaluating the Role of Pricing and R&D in Reducing Carbon Emissions* (September 2006).

vulnerable to a disruption in the supply of oil. Reducing exposure to that disruption would require a large decrease in the total amount of oil consumed in the United States. To the extent that such vulnerability exists and does not affect consumers in direct proportion to their oil consumption, households and businesses will tend to use more oil than would be best from a societal perspective.

The most cost-effective way to reduce the external costs associated with energy would be to enact policies, such as taxes, that would increase the prices of various types of energy to reflect the external costs that their production and use entail. That approach would provide a financial incentive for businesses and households to consider those external costs when deciding on the types and amounts of energy to use.

In the absence of such price increases, the government could directly subsidize the investment in (or use of) technologies that lead to lower external costs, such as improvements in energy efficiency or the use of renewable energy. Subsidies, such as tax preferences or direct payments, are typically less cost-effective than incorporating external costs into energy prices, for at least three reasons:

- They may cause the government to pay firms or households to make choices about investment, production, or consumption that they would have made anyway, in the absence of the subsidies;
- They typically support particular technologies, which may not be the least expensive method of reducing external costs; and
- They increase government expenditures or reduce revenues, which adds to the deficit or requires that the government pay for those subsidies by reducing other spending or by increasing other taxes, possibly those that discourage the productive use of labor and capital. (For example, taxes on labor income tend to reduce the amount of time that individuals choose to work.)¹²

Many of the tax preferences provided in 2011 were directed toward technologies that have the potential to lower the external costs of energy production and use. Of those preferences, 78 percent were for energy efficiency or renewable energy: Energy efficiency lowers

external costs by reducing the total consumption of energy; renewable energy can lower external costs because, in most cases, it produces lower emissions than do fossil-fuel alternatives.¹³ Historically, however, tax preferences have been targeted toward encouraging, not discouraging, the use of fossil fuels, particularly oil. Under current law, most of the tax preferences for energy efficiency and renewable energy will expire, but preferences for fossil fuels are permanent.

Increasing Spillover Benefits Through Support for R&D

Knowledge created by investments in R&D—for energy technologies as well as for many other types of technologies—may yield spillover benefits for society that do not translate into profits for the innovating firm. Legal arrangements, such as patents, help innovators capture some of the benefits that result from innovation (although they also tend to reduce the total benefits from those same innovations by limiting their spread). Spillover benefits are typically largest from basic research, which can create general scientific knowledge that cannot be subject to patents, and diminish as technologies approach commercial production. Although the inability of innovators to fully capture the benefits of their work is not a circumstance unique to energy R&D, that inability leads to an inefficiently low level of R&D on technologies that might reduce pollution or lead to less consumption of oil.

A large share of DOE's spending on energy has been directed toward R&D. One comprehensive review of research indicates that government funding of energy R&D has often yielded benefits greater than its costs.¹⁴

12. Taxes that reflect external costs can also indirectly reduce incentives to work and invest by lowering inflation-adjusted returns to labor and capital (if prices rise and wages and returns to capital do not). That indirect effect, referred to as the tax interaction effect, can be at least partially offset by using the revenue generated by the tax that reflects external costs to reduce taxes that discourage the productive use of labor and capital.

13. For a more detailed discussion of whether renewable fuels, such as ethanol, might lead to decreases in greenhouse gas emissions, see Congressional Budget Office, *The Impact of Ethanol Use on Food Prices and Greenhouse Gas Emissions* (April 2009).

14. National Research Council, *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000* (Washington, D.C.: National Academy Press, 2001).

Different types of energy R&D have produced very different returns. In general, funding aimed at the early stages of developing a technology, such as basic research, has been more likely to yield benefits in excess of costs than has funding for demonstration projects.¹⁵ Moreover, DOE's handling of demonstration projects has long been criticized by the Government Accountability Office and others because of inadequacies in DOE's project management.¹⁶

One review of the literature on DOE's efforts to develop renewable energy concluded that a large proportion of government-sponsored R&D focused on renewable sources of energy—wind and solar thermal energy, for example—has been technically successful.¹⁶ However, such sources constitute just a small share of today's market, in part because the prices of conventional sources of energy do not reflect the external costs of their production and consumption. That review also concluded that the forecasts of cost reduction for those sources of energy were generally achieved but that the forecasts of market penetration and sales were generally overstated. The authors of the study also concluded that one of the major factors contributing to the lack of commercial success of the renewable-energy technologies was the decline in the

inflation-adjusted price of oil during the forecast period. Other factors included changes in the structure of the markets for electricity generation and changes in the regulation of railroads that decreased the delivered price of coal. In sum, although the price of renewable energy fell, so did the price of fossil energy. Because consumers did not pay for the external costs of their consumption of fossil fuels, those energy sources retained a commercial advantage.

15. For a more comprehensive discussion, see Congressional Budget Office, *Federal Climate Change Programs: Funding History and Policy Issues* (March 2010).

16. See, for example, Government Accountability Office, *Department of Energy: Consistent Application of Requirements Needed to Improve Project Management*, GAO-07-518 (May 2007).

16. See James McVeigh and others, *Winner, Loser, or Innocent Victim? Has Renewable Energy Performed as Expected?* Discussion Paper 99-28 (Washington, D.C.: Resources for the Future, 1999).

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