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Federal Support for the Development, Production, and Use of Fuels and Energy Technologies

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Summary

The federal government provides financial support for the development, production, and use of fuels and energy technologies both through tax preferences and through spending programs administered by the Department of Energy (DOE). Policymakers have provided that support with several goals in mind, including increasing domestic energy production, reducing greenhouse gas emissions, and encouraging research that might benefit society but that would not be profitable for private firms to undertake without government funding.

In fiscal year 2015, tax preferences provided the bulk of federal support for energy development, production, and use. Whereas tax preferences are estimated to have resulted in $15.8 billion in forgone revenues, lawmakers appropriated funds equal to about one-third of that amount—$5.4 billion—for DOE to fund the relevant spending programs.

How Does the Federal Government Support the Development, Production, and Use of Fuels and Energy Technologies?

One way in which federal support is provided is through tax preferences—special provisions of tax law that reduce tax liabilities for certain activities, entities, or groups of people—for both producers and users of certain fuels and energy technologies.

Notes: Unless otherwise noted, years referred to in this report are federal fiscal years, which run from October 1 through September 30 and are designated by the calendar year in which they end.

Numbers in the text and tables may not add up to totals because of rounding.

All dollar amounts are expressed in fiscal year 2015 dollars unless otherwise noted. Nominal (current-year) amounts were adjusted to remove the effects of inflation using the gross domestic product deflator.

On June 29, 2016, CBO released an updated version of this report. A tax preference that was originally categorized as a preference related to renewable energy is now correctly categorized as a preference related to fossil fuels. That change affects Figures 1 and 2, Table 2, and related numbers in the text on pages 5 and 6.

Preferences aimed at producers increase the profitability of investing in a particular technology (tax credits for generators that produce electricity from wind, for example) or lower the cost of producing certain fuels (depletion allowances for producing oil and natural gas, for example). Preferences aimed at users lower their after-tax cost of purchasing certain products; for instance, tax credits subsidize homeowners' investments in energy-efficient windows.

Federal assistance is also provided through DOE in the form of funding for basic research and technology development. In particular, DOE funds research that furthers the understanding of the basic science underlying energy or that supports the development of new energy technologies. It provides funding for universities and government laboratories, demonstration projects, and loans or loan guarantees for energy technologies. Other federal programs (both within and outside DOE) affect energy markets and the supply of energy resources; for example, the government's leasing of federal lands for oil production boosts the supply of oil. This report, however, examines only federal spending that encourages either basic research or the development of new energy technologies.

How Has Federal Support Changed Over Time?

From the introduction of tax preferences for oil producers in the Revenue Act of 1916 until 2005, the largest share of energy-related tax preferences went to domestic producers of oil and natural gas. Beginning in 2005, the composition of those preferences changed: An increasing share of them was aimed at encouraging the use of energy-efficient technologies and of energy generated from wind, the sun, and other renewable sources. Along with those changes came a fivefold increase in the inflation-adjusted cost of tax preferences, from $4.9 billion in 2004 to a peak of $25.4 billion in 2012. Since then, the value of tax preferences has fallen by almost 40 percent, to an estimated total of $15.8 billion in 2015.

DOE's funding has also changed over time, but with the exception of the substantial amounts provided in 2009 by the American Recovery and Reinvestment Act (ARRA), it has generally been less, adjusted for inflation, since 1998 than it was between 1985 (the first year included in this analysis) and 1998. Whereas such funding (measured in 2015 dollars) averaged $7.6 billion each year in the early 1990s, it has averaged $4.7 billion a year since 2010.

DOE's funding includes appropriations to cover the subsidy costs of loans and loan guarantees for the development of new energy technologies. In recent years, DOE has extended credit through three major programs, although the authority to make new loan guarantees for one of those programs expired on September 30, 2011. Of the $9.5 billion in funding for credit subsidies that lawmakers have provided since 2009, DOE has obligated $4.7 billion thus far. The department's funding for 2015 included only small amounts for the administrative expenses of its credit programs; no new funds were provided for loans or loan guarantees.

How Effective Has That Support Been at Increasing Domestic Production, Reducing Greenhouse Gas Emissions, and Spurring Research and Development?

Increasing the domestic production of oil and gas has long been a goal of federal policy, and following the disruptions in the global supply of oil in the 1970s, the emphasis on boosting domestic oil production only intensified. Although U.S. production of crude oil has increased over the past 10 years, by CBO's estimates only a small share of that increase resulted from tax preferences, which cost between $90 and $200 per additional barrel of oil produced. That cost was in addition to the market price of oil, which averaged $80 per barrel over the past decade.

In the mid-2000s, the share of energy subsidies aimed at reducing greenhouse gas emissions, particularly carbon dioxide (CO_2) emissions, began to grow. The most efficient method for reducing emissions would be to set a price on fossil fuels that equaled the damage caused by the production and use of the fuel. Tax preferences and other subsidies for the development and use of favored technologies can also reduce emissions, but they are less cost-effective. Although some studies have found that certain technologies, including those for generating electricity from wind, have been responsive to subsidies, a review by the National Academy of Sciences (NAS) concluded that the tax credit for the generation of electricity from renewable sources reduced CO_2 emissions at an average cost of $250 per ton. By comparison, federal agencies recently estimated that the value of the benefits of reducing CO_2 emissions is between $40 and $60 per ton.

Promoting research and development (R&D) has long been another motivation behind federal energy subsidies. Government funding is most likely to be cost-effective when it supports research that would benefit society but that would not be profitable for firms to undertake on their own, such as research on the basic science of energy or research aimed at the very early stages of technology development. Estimating the returns on investments in basic science research is difficult; however, such research can lead to knowledge that can be used in unforeseen ways, sometimes long after the research is completed, and some evidence suggests that, taken as a whole, the returns from basic science research have been substantial. Estimating returns on investments in applied research is somewhat easier, and evidence suggests that DOE's funding of such research has had mixed results. Funding work in the early stages of developing new energy technologies has generally been more cost-effective than supporting large demonstration projects for new technologies. Despite those mixed results, federal funding of energy research has led to a significant amount of technology transfer to private firms.

Tax Preferences

The federal government supports the production and use of fossil fuels, nuclear power, and renewable energy and encourages energy efficiency through provisions of law that reduce the tax liability of producers and consumers. Those tax preferences include special deductions, lower tax rates, tax credits, and grants in lieu of tax credits. On the basis of projections prepared by the staff of the Joint Committee on Taxation, CBO estimates that energy-related tax preferences totaled $15.8 billion in 2015.

In addition to benefiting from tax preferences that support the production of fuels or improvements in energy efficiency, energy producers benefit from tax preferences that are available to all businesses, such as the one that allows companies to defer tax payments on overseas earnings. Because those preferences support industry generally—not just energy-related activities—they are not included in the above estimate. Energy-related tax preferences account for only a small percentage of the cost of all federal tax preferences, which total hundreds of billions of dollars each year.[1]

Historical Trends

The value of tax preferences related to energy and the composition of that financial support have changed over time.[2] Those changes stem from a combination of factors, including the addition and expiration of specific energy-related tax preferences; fluctuations 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.

For much of the 20th century, federal energy-related tax preferences were used to spur the domestic production of oil and natural gas. Beginning in the 1970s, disruptions in the supply of oil heightened interest in encouraging the domestic production of oil and other fossil fuels as well as renewable fuels. More recently, growing awareness of the environmental damage caused by burning fossil fuels to produce energy—the harmful effects of the carbon dioxide emissions, for example—has led to tax preferences for the production of electricity from renewable sources and for improvements in energy efficiency.

Tax preferences to encourage the production of fossil fuels made up the bulk of all energy-related tax incentives from the passage of the Revenue Act of 1916 through the mid-2000s; tax preferences for oil and natural gas producers accounted for more than two-thirds of the total cost of all preferences in most years. Those tax preferences are permanently in place, but since the mid-2000s, new legislation has expanded the scope of federal energy policy, and the share of total financial support provided through energy-related tax incentives that goes toward the production of fossil fuels has decreased.

1. For a recent estimate of such costs, see Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018,* JCX-97-14 (August 5, 2014), http://go.usa.gov/3zHY5.

2. For more information, see Joint Committee on Taxation, *Present Law and Analysis of Energy-Related Tax Expenditures*, JCX-100-14 (September 16, 2014) http://go.usa.gov/3emC9.

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 promoting the use of alternative-fuel motor vehicles, such as fuel-cell and hybrid vehicles. As a result, it substantially increased the number of energy-related tax preferences and their total cost. By 2008, fossil fuels accounted for only about one-third of the total cost of energy-related tax incentives.

Subsequent legislation has further increased the amount of federal resources devoted to energy-related tax preferences and decreased the share of those preferences that go to producers of fossil fuels. The Emergency Economic Stabilization Act of 2008 extended and expanded tax preferences related to renewable energy and energy efficiency. Shortly thereafter, ARRA temporarily expanded tax preferences for promoting energy efficiency, renewable energy, and alternative vehicles. It also created the Section 1603 grant program, which allowed producers of renewable energy to collect one-time cash payments in lieu of future tax credits.[3]

The estimated cost of energy-related tax preferences fell dramatically between 1985 and 1988, in part because tax rates and fuel prices declined in those years (see Figure 1). From 1988 to 2004, the cost of such tax preferences grew gradually, averaging about $5 billion per year in 2015 dollars. After the Energy Policy Act of 2005 was enacted, tax expenditures rose sharply. Support was especially great from 2009 to 2013—peaking at $25.4 billion in 2012—partly as a result of stimulus provisions intended to reduce the effects of the recession that the United States faced from 2007 to 2009.[4] Tax support has fallen over the past few years: In 2015, the preferences totaled roughly 60 percent of those that were provided in 2012.

Tax Preferences in 2015

Roughly two-thirds of the projected cost of tax preferences for energy in 2015 was for renewable energy and energy efficiency (see Figure 2). An estimated $7.8 billion, or 49 percent of the energy-related tax preferences, was directed toward renewable energy, and $2.7 billion, or 17 percent, went to energy efficiency. Fossil fuels accounted for most of the remaining cost of energy-related tax preferences—an estimated $4.8 billion, or 30 percent.

3. 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. With such grants, recipients no longer needed to enter into specialized financing arrangements (which ultimately reduce the value of the incentive that goes to the producers of renewable energy) to monetize tax credits.

4. Those provisions of ARRA caused revenue losses to increase significantly in 2009 and 2010. See Margot L. Crandall-Hollick and Molly F. Sherlock, *Residential Energy Tax Credits: Overview and Analysis*, Report for Congress R42089 (Congressional Research Service, March 18, 2014).

The tax preferences that explicitly target energy use and production are provided through three mechanisms: preferences in the income tax system, such as special deductions, lower tax rates, and tax credits; preferences in excise taxes, such as excise tax credits; and Section 1603 grants in lieu of tax credits (see Table 1).[5] In 2015, total energy-related support included the following amounts:

- $12.1 billion for energy-related preferences in the income tax code. Of that amount, preferences for renewable energy ($4.1 billion) accounted for the largest share, and those for fossil fuels ($4.8 billion), the second largest. The two most costly preferences were the credit for electricity production from renewable sources ($2.9 billion) and the credit for percentage depletion, which provides the option to recover the cost of investments in fossil-fuel mining over time on the basis of gross income rather than on the basis of production ($1.7 billion).

- $1.7 billion for excise tax credits and other incentives for biodiesel and alternative fuels.

- $2.0 billion for grants under the Section 1603 program. Section 1603 grants allow producers of renewable energy to take a cash grant in lieu of a tax credit; the grant is provided once the qualifying facility is put into service. Although those provisions expired on December 31, 2011—the last date on which projects could become eligible for the benefit—facilities that were under construction as of that date qualified for the option. Thus, some grants were disbursed in 2015.

Whereas most tax preferences related to fossil fuels are permanent features of the tax code, most of the preferences for renewable energy sources and energy efficiency are temporary and will continue to be available only if they are extended. (About $6 billion of the revenue forgone in 2015 stems from tax preferences that expired in December 2014.) Although temporary preferences have often been extended, their lack of permanence creates uncertainty about the extent to which they will lower future production costs (or, if the credits are provided to consumers, increase future demand). The temporary nature of preferences for renewable energy sources and energy efficiency creates less incentive to invest in those technologies than there would be if those preferences were permanent; however, the magnitude of the reduction in investment due to that uncertainty is unknown.[6]

5. CBO includes the Section 1603 grants among tax preferences because the federal support for projects provided under that program originates through the tax system, and eligibility for such support is determined by the eligibility of a project to receive tax support.

6. Testimony of Gilbert E. Metcalf, Professor of Economics, Tufts University, before the Senate Committee on Finance, *Reforming America's Outdated Energy Tax Code* (September 17, 2014), http://go.usa.gov/3eEM5 (PDF, 91 KB).

In December 2014, lawmakers retroactively extended through the end of that month many tax preferences—including several energy-related preferences—that had expired on December 31, 2013. That retroactive extension allowed firms to claim a tax credit for expenditures made at any time during calendar year 2014, resulting in an estimated $3.4 billion in additional revenue losses associated with energy-related preferences in fiscal year 2015.[7] (Those costs are included in the amounts listed above.) The most costly preference of that group, the extension of the biodiesel and renewable diesel credits, accounted for $1.3 billion in forgone revenues.[8]

Spending for Department of Energy Programs

In 2015, DOE's funding for basic energy science, energy technologies (including R&D for fossil fuels, nuclear energy, renewable energy, and electricity delivery and reliability), and energy efficiency totaled $5.4 billion. That total accounts for roughly 20 percent of DOE's 2015 appropriations, the largest shares of which were for maintaining the U.S. nuclear weapons stockpile and cleaning up former nuclear facilities.

Although other agencies also fund energy-related programs—for example, the Department of the Interior's leasing and resource-management programs and the Department of Agriculture's programs supporting rural electricity production and transmission—the costs of those activities are not included in this report.[9] This report focuses on expenditures that promote the development of specific fuels or energy technologies or that further the scientific knowledge on which those new technologies rely. Specifically, this report includes the funding for basic energy sciences research that is administered through DOE's Office of Science as well as the funding provided through the department's programs for energy technology R&D. Previous versions of this report did not include funding for basic research; here, the historical data have been revised to include those amounts.

7. Calculated using data from staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF. Pending updates to estimates by the staff of the Joint Committee on Taxation of the tax expenditure resulting from the preferences, CBO has used the estimate of the revenue loss instead. Because estimates of tax expenditures are based on people's behavior with the tax expenditures in place, the 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 the changes.

8. That total includes the effects on both income and excise taxes.

9. This report also excludes government spending for the production of electricity through the Tennessee Valley Authority, the Bonneville Power Administration, and other federal power entities; spending for the Low Income Home Energy Assistance Program; and spending by the Energy Information Administration.

Historical Trends

Since it was established in 1977, DOE has supported the development of energy technologies primarily by funding R&D and technology demonstration projects aimed at creating new domestic sources of energy. Budget authority—authority provided by appropriation laws 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 1985, such programs received budget authority totaling $6.2 billion, in 2015 dollars (see Figure 3). Following a period of substantial investment in the early 1990s, however, the federal government's interest in funding the development of new energy sources waned. By 2000, constant-dollar budget authority for DOE's energy technology and sciences programs had fallen to $3.3 billion.

In 2009, DOE received $46.2 billion for support of energy technologies (measured in 2015 dollars and adjusted to account for rescissions and transfers)—roughly 11 times the average annual budget authority for the preceding decade. That funding included $31.5 billion in budget authority provided by ARRA (the dark portion of the total depicted in Figure 3) and $14.7 billion in regular appropriations.

Those ARRA funds have been spent more rapidly than the funds that DOE receives through the normal appropriation process are typically spent; nearly half of the total outlays were made within three years of the appropriation. Nevertheless, at the end of 2015, nearly 15 percent of the ARRA funds—particularly those designated for fossil-fuel programs—remained unspent. As of October 2015, $1.5 billion of the $3.4 billion of budget authority provided by ARRA for demonstration projects, mostly to fund partnerships with private electric utilities that would capture and sequester CO_2 emissions from coal-fired electricity generators, remained unspent, and some projects were canceled by the private partners. ARRA specified a deadline of September 30, 2015, for DOE to expend the funds provided.

Financial Support for Energy Technologies in 2015

The $5.4 billion appropriated to the Department of Energy in 2015 for the development and production of fuels and energy technologies includes both direct investments and credit programs. The direct investments included investments in applied energy research totaling $3.6 billion and investments in basic energy sciences totaling $1.7 billion (see Table 2). The credit programs received less than $50 million each in 2015 to cover the administrative costs of overseeing DOE's loan portfolio; no funding was provided for subsidies for new loans.

Direct Investments. DOE directly invests in two broad areas of research: Funding for applied energy research is offered through the offices devoted to the different types of energy, such as nuclear or fossil fuels, and funding for basic energy research is provided through DOE's Office of Science.

The $5.4 billion appropriated for direct investments in 2015 was allocated as follows (see Figure 4):

- 36 percent (or $1.9 billion) was for renewable energy and energy efficiency. Renewable-energy programs, which promote the development of solar, biomass, wind, and other renewable energy sources, account for about half of all such funding. Energy-efficiency programs, which support R&D to improve the energy efficiency of buildings and automobiles and also provide grants for weatherization to improve the energy efficiency of some low-income housing units, account for almost 40 percent. The remaining 10 percent goes toward program administration, facilities, and overhead.

- 32 percent (or $1.7 billion) was for the Basic Energy Sciences program. That funding supports research to provide the scientific foundation or impetus for many of the advances made in each of the applied fields of energy technology. To accomplish that mission, the research is devoted to understanding, predicting, and ultimately controlling matter and energy at the atomic and molecular levels.

- 14 percent (or $0.7 billion) was for nuclear energy. The nuclear energy program focuses on making reactors safer and cheaper, developing a sustainable nuclear fuel cycle, and maintaining federal nuclear energy research facilities.

- 10 percent (or $0.6 billion) was for fossil energy R&D programs. DOE's funding for those programs goes primarily to research for technologies aimed at reducing emissions—particularly of CO_2—from coal-fired electricity generation.

- 8 percent ($0.4 billion) was for other purposes, including the Advanced Research Projects Agency–Energy ($0.3 billion), which funds high-risk research that has the potential for a large payoff in any of the above technological areas, and for electricity delivery and energy reliability programs ($0.1 billion), which support improvements in the electricity grid that allow for increased energy efficiency and additional use of renewable-energy technologies.

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

- The Section 1703 loan guarantee program—a permanent program aimed at increasing investment in nuclear facilities or other innovative clean-energy facilities;

- The Section 1705 loan guarantee program—a now-expired program that guaranteed loans to support projects developing renewable-energy systems and electric power transmission as well as some innovative biofuel projects; and

- The Advanced Technology Vehicles Manufacturing (ATVM) loan program—a permanent program intended to improve the energy efficiency of automobiles.[10]

DOE's credit programs provide both subsidized and unsubsidized loans and guarantees. Most of the guarantees authorized under the Section 1703 program (primarily guarantees for loans to nuclear facilities) are intended to be self-supporting; recipients pay a fee designed to cover the government's cost of providing the guarantee, as estimated under the Federal Credit Reform Act of 1990.[11] In contrast, lawmakers have provided a total of $9.5 billion in budget authority to subsidize loan guarantees made under the Section 1705 program (primarily those for renewable energy) and loans made through the ATVM program. All of that budget authority was granted in previous years; no subsidy appropriations were provided for the credit programs in 2015 (although DOE received $46 million for administrative expenses). DOE has obligated $4.7 billion of the $9.5 billion that had been appropriated for subsidy costs.[12] The ATVM loan program continues to accept applications on a rolling basis and has the authority to make more than $16 billion in new loans as of the end of fiscal year 2015. Also as of then, DOE had about $28.7 billion in remaining authority with which to issue loan guarantees under the Section 1703 program.[13]

Between 2009 and 2014, DOE's credit programs provided 35 loans and loan guarantees in support of 30 projects (see Table 3).[14] As of the close of 2015, 5 of those 35 loans and guarantees were in default. Most of the defaulted loans and guarantees (which were largely for the manufacturing of solar or automotive products) were considered risky at the time they were issued: Loans and guarantees for 3 of the 5 projects that ultimately resulted in defaults had credit ratings below investment

10. The Section 1703 and Section 1705 programs are often referred to collectively as the Title 17 program.

11. Lawmakers set limits on both the value of loans or loan guarantees that each program can provide and on the government's cost of making those loans, which is referred to as the subsidy cost. Under the Federal Credit Reform Act of 1990, before an agency can make a loan or loan guarantee, lawmakers must provide funding sufficient to cover the subsidy cost minus fees paid by borrowers. The subsidy costs for DOE's loans and loan guarantees are the estimated lifetime costs of the credit assistance, which include losses from defaults net of any recoveries on the loans. Government agencies change their estimates of the risks of default and the consequent budgetary costs of their loans and loan guarantees as they gain more experience with them. As a result, the estimated subsidy costs of federal loans and loan guarantees made under a particular credit program are frequently revised over the life of the program. To reduce the effects of those costs on the federal budget, the federal credit programs that support innovation often require the recipients of loans and guarantees to pay for the expected lifetime costs of the credit.

12. Estimates of the cost of some obligated subsidies have been subsequently reduced, but those savings are not available for use by the agency.

13. Government Accountability Office, *DOE Loan Programs: Current Estimated Net Costs Include $2.2 Billion in Credit Subsidy, Plus Administrative Expenses,* GAO-15-438 (April 2015), pp. 6–7, www.gao.gov/products/GAO-15-438.

14. Ibid., pp. 14–17.

grade. Moreover, none of the projects with loans in default had revenue streams that were guaranteed by long-term contracts. In contrast, none of the 21 loans and loan guarantees that did have long-term contracts have defaulted to date. Those loans and guarantees were for projects undertaken to generate or transmit energy from solar or other renewable sources. Such projects were low risk because they involved contracts—usually with regulated utilities—that guaranteed a market for much of the power produced.

Cost-Effectiveness of Federal Support

Federal support aimed at promoting the development and use of fuels and energy technologies has been motivated by several goals. Initially, such support was intended to increase domestic production of oil and natural gas. More recently, a growing number of energy subsidies have been aimed at reducing pollution, particularly greenhouse gas emissions. For decades, lawmakers have also sought to promote energy-related R&D that would potentially benefit society as a whole but that the private sector would not undertake without federal support.

Lawmakers have had multiple tools at their disposal to accomplish those goals. This report focuses on tax preferences and spending programs, but lawmakers have also used regulations to obtain the desired outcomes. For example, fuel efficiency standards for vehicles and regulations that require that a specific share of transportation fuels be renewable are aimed at both minimizing U.S. consumers' vulnerability to spikes in oil prices and reducing greenhouse gas emissions.

The existence of multiple goals and policy tools complicates any effort to determine the effectiveness of federal funding. Achieving the goals of one policy may undermine the objectives of another. For example, one solution to U.S. dependence on imported oil in the 1970s was to increase the use of fossil fuels that were plentiful in the United States—namely coal and natural gas—in the production of electricity. But the substitution of coal for oil in electricity generation raised the emissions of carbon dioxide, a greenhouse gas that contributes to climate change. Furthermore, the existence of multiple policies can make it difficult to measure the incremental effects of a single policy. For example, not only were automotive fuel blenders mandated to use renewable fuels, a mandate that they met primarily by using corn ethanol, but they also benefited from a tax credit (now expired) for doing so. Attributing a precise share of the subsequent rise in the use of ethanol to either one of those policies is difficult because they worked in conjunction with each other.[15]

15. For more information, see testimony of Terry Dinan, Senior Advisor, Congressional Budget Office, before the Subcommittee on Environment and the Subcommittee on Oversight of the House Committee on Science, Space, and Technology, *The Renewable Fuel Standard: Issues for 2015 and Beyond* (November 3, 2015), www.cbo.gov/publication/50944; and Congressional Budget Office, *The Renewable Fuel Standard: Issues for 2014 and Beyond* (June 2014), www.cbo.gov/publication/45477.

The following discussion—organized according to the three goals described above: boosting domestic production, reducing greenhouse gas emissions, and encouraging R&D—does not provide a comprehensive assessment of the cost-effectiveness of energy tax preferences or of DOE's funding. It does, however, provide examples of types of funding that have and have not been cost-effective.

Boosting Domestic Production

U.S. policymakers have long expressed concern about the vulnerability of the United States to disruptions in the supply of oil. That concern has motivated them to institute policies, including several tax preferences, aimed at increasing the domestic production of oil.[16]

Over the past decade, the amount of oil produced in the United States has increased dramatically because of technological developments related to hydraulic fracturing.[17] However, CBO finds that the per-unit cost of the *additional* domestic production of oil spurred by tax preferences over that period has been high. Tax preferences for domestic production (including the option to expense investment costs on the basis of gross income rather than production, as well as the other preferences listed in Table 1) have had a minimal effect on the amount of domestic oil produced; as a result, measured on the basis of each additional barrel of oil produced, the cost of the tax preferences has been substantial.

Estimates of the cost-effectiveness of tax credits themselves depend on estimates of how responsive domestic oil producers are to changes in prices. Using three estimates of that responsiveness drawn from the research literature, CBO has calculated the following ranges of estimates for the 2005–2014 period:

- Domestic oil production was between 0.4 percent and 0.8 percent greater with the tax preferences than it would have been without them, and

- The cost of the tax preferences was between $90 and $200 per additional barrel of domestic oil produced. That cost to the government is in addition to the market price of the oil, which averaged roughly $80 per barrel during the period.

Those numbers are only rough estimates. Effects could vary among different types of producers (integrated oil companies, which both drill for oil and sell refined products, versus nonintegrated companies, whose revenues are primarily derived from drilling, for example) and under different market conditions. (See the Appendix for information on the methods and data used to produce those estimates.)

16. For a discussion about the effects of increasing domestic oil production on energy security, see Congressional Budget Office, *Energy Security in the United States* (May 2012), www.cbo.gov/publication/43012.

17. See Congressional Budget Office, *The Economic and Budgetary Effects of Producing Oil and Natural Gas From Shale* (December 2014), www.cbo.gov/publication/49815.

Other studies have generally reached similar conclusions about the limited response of oil producers to tax policies that support the domestic production of oil. For example, a study by the National Academy of Sciences concluded that eliminating the depletion allowance (one of the tax preferences included in CBO's analysis) would have virtually no effect on the quantity of oil produced domestically.[18] In addition, two studies conducted in 2009 examined the effect of eliminating more than $30 billion (in 2009 dollars) of tax preferences that oil and natural gas producers would receive between 2010 and 2019. Those analyses used a set of tax preferences that was more expansive than the set that CBO examined. For example, those studies included the effect of eliminating oil producers' ability to claim the domestic manufacturing tax deduction—which CBO did not include in its analysis because the deduction is not specifically related to energy—against income derived from the production of oil and gas. Both of the studies concluded that eliminating the preferences would reduce domestic oil production by less than one-half of one percent and would have virtually no effect on the domestic price of gasoline.[19]

Oil producers themselves say that eliminating preferences would have a greater effect on production. An industry-sponsored survey of independent producers (who account for roughly half of all oil production) found that nearly half of respondents indicated that they would reduce their production from marginal wells by at least 20 percent if the percentage depletion allowance was eliminated.[20] Even so, estimates of such effects that are based on historical data about the relationship between oil prices and crude oil production, like those described in the studies above, tend to be better indicators

18. National Research Council, Board on Science, Technology, and Economic Policy, Committee on the Effects of Provisions in the Internal Revenue Code on Greenhouse Gas Emissions, *Effects of U.S. Tax Policy on Greenhouse Gas Emissions* (National Academies Press, 2013), p. 4, www.nap.edu/catalog/18299.

19. Testimony of Alan B. Krueger, Assistant Secretary for Economic Policy and Chief Economist, Department of the Treasury, before the Subcommittee on Energy, Natural Resources, and Infrastructure of the Senate Committee on Finance (September 10, 2009), http://go.usa.gov/3emve (PDF, 87 KB); and testimony of Stephen P. A. Brown, Nonresident Fellow, Resources for the Future, before the Subcommittee on Energy, Natural Resources, and Infrastructure of the Senate Committee on Finance, *An Economic Assessment of Eliminating Oil and Gas Company Tax Preferences* (September 10, 2009), http://go.usa.gov/3emGW (PDF, 171 KB).

20. Independent Petroleum Association of America, *Profile of Independent Producers, 2012–2013* (2014) p. 14, http://tinyurl.com/phq3xwa (PDF, 2.27 MB). Marginal well production accounts for roughly 15 percent of total U.S. oil production, but only independent producers are eligible for the depletion allowance; integrated oil companies are not. Thus, much of the marginal well production is not eligible for the tax preference discussed in the survey. It is difficult, however, to determine the amount of such production that would be eligible because the marginal well production of independent oil producers is not reported separately from that of integrated oil companies. See Independent Petroleum Association of America, *United States Petroleum Statistics, 2014 Data* (June 2015), Tables 4 and 7, http://tinyurl.com/of89mq9 (PDF, 1.24 MB). For eligibility regarding tax preferences, see Senate Committee on the Budget, *Tax Expenditures: Compendium of Background Material on Individual Provisions* (December 2012), p. 129, http://go.usa.gov/3emu9.

than surveys of how total domestic production would change if the preferences were eliminated.

Because of the limited production response by oil producers to tax preferences, the amount of revenues forgone per barrel of additional oil produced as a result of those preferences is likely to be high. That cost is also high because it includes the revenues forgone by subsidizing the production of oil that would have occurred even without the tax preferences.

Reducing Greenhouse Gas Emissions

Beginning in the mid-2000s, lawmakers increased the share of federal funding for energy aimed at reducing the negative effects of energy production and consumption on the environment. In particular, they have provided tax preferences to reduce emissions of greenhouse gases.

The costs associated with greenhouse gas emissions and other forms of pollution are external costs—costs that are borne by society as a whole rather than falling on businesses or households in proportion to their production or consumption.[21] For example, consumption of gasoline or electricity generated from fossil fuels results in the release of carbon dioxide; without government intervention, however, the prices charged for electricity and gasoline do not reflect the damage caused by the CO_2 that is released. As a result, businesses and households lack sufficient incentives to take greenhouse gas emissions into account when deciding what types and quantity of energy to produce and consume.

Taxing Greenhouse Gas Emissions Versus Subsidizing Alternatives. The most efficient way to reduce the external costs associated with energy—including the damage caused by greenhouse gas emissions—would be to enact policies, such as taxes, that increased the prices of various types of energy to reflect the external costs that their production and use entail. Such policies would be efficient in that they would motivate emission reductions up to the point at which the additional costs of achieving those reductions equaled the benefit (the external costs prevented from being incurred) of achieving them. For example, policymakers could choose to tax fossil fuels on the basis of the CO_2 that is released into the atmosphere when the fuels are burned. 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. Alternatively, policymakers could enact a cap-and-trade program under which the government would set a cap on CO_2 emissions and allow firms (such as oil producers, natural gas refiners, and large electricity generators) to buy and sell rights to those emissions. Such trading would establish a price on emissions. Compared with a tax, a cap-and-trade

21. For a more comprehensive discussion of external costs and other types of market failures, see Congressional Budget Office, *Federal Climate Change Programs: Funding History and Policy Issues* (March 2010), www.cbo.gov/publication/21196.

program would provide more certainty about the quantity of domestic CO_2 emissions but would provide less certainty about the price of those emissions.

In the absence of policies that incorporate the cost of environmental damage into the price of fuels, the government could directly subsidize investment in or use of technologies or fuels with lower external costs; it might help fund improvements in energy efficiency or subsidize the use of renewable energy, for example. However, such subsidies are typically less cost-effective than incorporating external costs into energy prices because they have some combination of the following undesirable effects:

- Subsidies increase government expenditures or reduce revenues, thereby either adding to the deficit or requiring the government to reduce other spending or increase other taxes—possibly some that discourage the productive use of labor and capital—to pay for the subsidies. (For example, the government might choose to raise taxes on labor income; increases in those taxes tend to reduce the amount of time that individuals choose to work.)[22]

- The government may end up paying firms or households to make choices about investment, production, or consumption that they would have made without the subsidies. For example, tax credits for energy-efficient windows might go to homeowners who would have purchased them anyway.

- Subsidies may boost the demand for services that energy is used to provide. For example, by reducing the cost of maintaining a home at a given temperature, subsidies for energy-efficient windows may cause people to set their thermostats higher in the winter, offsetting at least part of the energy savings that would otherwise have been achieved.[23]

- Typically, subsidies support particular technologies, but those technologies may not necessarily provide the least expensive means of reducing external costs. For example, subsidies could motivate electricity producers to install wind turbines when it would have been more cost-effective for them to achieve reductions in greenhouse gas emissions by making efficiency improvements.

22. 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 portion of the revenues generated by the tax that reflects external costs to reduce taxes that discourage the productive use of labor and capital.

23. That reaction is commonly called the rebound effect. See David Austin, *Addressing Market Barriers to Energy Efficiency in Buildings*, Working Paper 2012-10 (Congressional Budget Office, August 2012), www.cbo.gov/publication/43476. See also Lorna A. Greening, David L. Greene, and Carmen Difiglio, "Energy Efficiency and Consumption—the Rebound Effect—a Survey," *Energy Policy*, vol. 28, nos. 6–7 (June 2000), pp. 389–401, http://dx.doi.org/10.1016/S0301-4215(00)00021-5.

Studies of the Cost-Effectiveness of Tax Preferences Aimed at Reducing Greenhouse Gas Emissions. Determining the cost-effectiveness of tax preferences aimed at reducing greenhouse gas emissions is complicated. Researchers must determine how the tax preferences affect the use of various fuels and energy technologies, including how those preferences interact with other existing policies, such as renewable fuel requirements. They must also determine the emissions consequences of changes in the use of various fuels or energy technologies; that determination is in turn complicated by the necessity of accounting for unintended increases in emissions—either in the United States or overseas—that might occur because of price changes resulting from the preferences.

The National Academy of Sciences study mentioned above assessed the effectiveness of tax credits in reducing greenhouse gas emissions. That assessment included a review of the existing literature as well as original analysis based on the authors' own model. The model, which reflected the assumption that all tax policies and relevant regulations would remain in place throughout the analysis period, examined the effect of tax preferences that were in place in 2011 and projected their effects through 2035.

On the basis of that approach, the NAS study concluded that reducing greenhouse gas emissions through tax preferences was costly. Moreover, it found that some preferences can have the unintended effect of increasing greenhouse gas emissions. Specifically, the NAS study found that production and investment tax credits for renewable electricity generation reduced CO_2 emissions at an average cost of $250 per ton.[24] By comparison, the Environmental Protection Agency (EPA) and other federal agencies recently estimated that the value of damage avoided by a one-ton reduction in CO_2 emissions is $40 to $60.[25]

The high cost of reducing emissions through tax preferences has two causes. First, production and investment tax credits have been substantial, amounting to roughly 20 percent of the price of electricity or 30 percent of the initial investment in the generation facility. Second, although some investments in generation from renewable sources have responded to tax credits, the NAS study concluded that a substantial share of the increase in renewable power generation would have occurred even without the tax

24. National Research Council, Board on Science, Technology, and Economic Policy, Committee on the Effects of Provisions in the Internal Revenue Code on Greenhouse Gas Emissions, *Effects of U.S. Tax Policy on Greenhouse Gas Emissions* (National Academies Press, 2013), p. 70, www.nap.edu/catalog/18299; and Brian C. Murray and others, "How Effective Are US Renewable Energy Subsidies in Cutting Greenhouse Gases?" *American Economic Review*, vol. 104, no. 5 (May 2014), p. 572, http://dx.doi.org/10.1257/aer.104.5.569.

25. Other estimates, representing the extremes of the possible distribution of costs, are higher. See Environmental Protection Agency, "The Social Cost of Carbon" (accessed October 9, 2015), http://go.usa.gov/3emd3.

credits because states have set requirements for such production.[26] Investments in renewable power generation to meet states' requirements, in turn, boost the per-ton cost of tax credits even though the credits did not provide the motivation for the investments to be made.

The NAS study also examined the effects of tax credits for renewable transportation fuels. In that case, it found that the credits actually *increased* greenhouse gas emissions. It attributed that counterintuitive result to the fact that the tax credits for renewable fuels reduced the price—and thus increased the consumption—of motor fuels. That increase in turn outweighed any beneficial emission effects of blending renewable fuels in with gasoline or diesel fuel.[27]

In making that calculation, the NAS study panel assumed that each gallon of biofuel reduced greenhouse gas emissions by the amount necessary to meet the minimum requirements of EPA's Renewable Fuel Standard (RFS) program, which requires that a certain quantity of renewable fuels be blended into the transportation fuel supply each year.[28] For example, to qualify for use in meeting the RFS, each gallon of corn ethanol produced at facilities constructed after December 20, 2007, must reduce emissions by at least 20 percent when used instead of gasoline. However, the actual effect on emissions of substituting biofuels for fossil fuels is unclear. Estimating those effects is complicated by the difficulty of determining the emission consequences of changes in land use and fertilizer use that might have been triggered by increases in the production of renewable fuels.[29] Researchers who have sought to measure those effects have reached different conclusions: Some have found that the production and use of biofuels led to higher emissions than the fossil fuels that they replaced, and others have concluded that biofuels reduced emissions by more than the EPA thresholds.

Promoting R&D

Promoting energy-related research and development through federal subsidies has long been a goal of lawmakers. Knowledge created by investments in R&D—whether for energy sciences or energy technologies—may yield benefits for society that often do

26. One area in particular that has been found to be responsive to tax preferences is wind generation. See Gilbert E. Metcalf, "Investment in Energy Infrastructure and the Tax Code," in Jeffrey R. Brown, ed., *Tax Policy and the Economy*, vol. 24 (University of Chicago Press, 2010), pp.1–33, www.nber.org/chapters/c11968.

27. National Research Council, Board on Science, Technology, and Economic Policy, Committee on the Effects of Provisions in the Internal Revenue Code on Greenhouse Gas Emissions, *Effects of U.S. Tax Policy on Greenhouse Gas Emissions* (National Academies Press, 2013), p. 6, www.nap.edu/catalog/18299.

28. Ibid., p. 96. The NAS study panel conducted sensitivity analysis using a range of estimates about the effects of biofuel use on emissions, but that analysis did not separate the effects of the tax credits from the effects of the Renewable Fuel Standard program.

29. See Congressional Budget Office, *The Renewable Fuel Standard: Issues for 2014 and Beyond* (June 2014), www.cbo.gov/publication/45477.

not translate into profits for the innovating firm. Therefore, without government support, the amount of such research undertaken by the private sector is likely to be inefficiently low. Such benefits are typically largest from basic research, which can lead to general scientific knowledge that cannot be patented, and they tend to diminish as technologies approach commercial production, when individual firms can largely appropriate the benefit.

The extent to which private investment in energy-related R&D falls below what would be considered the ideal amount if benefits to society were taken into account is difficult to determine. Recent estimates indicate that private firms have made more substantial investments in energy technologies than previously thought. Specifically, U.S. companies spent $21.3 billion of their own funds on energy-related R&D in 2012, mainly to increase energy efficiency (see Box 1). By way of comparison, DOE's R&D programs received $4.6 billion in appropriations for that year.

Although a comprehensive review of the effectiveness of federal funding of energy-related R&D is beyond the scope of this report, CBO has concluded that energy-related R&D funded by DOE has had mixed results; nevertheless, technologies created by DOE-funded projects have transferred to private firms at a relatively high rate compared with R&D funded by other federal agencies.

The Effect of DOE's Funding on Innovation. Assessing the benefits of basic science research is difficult because the knowledge can be used in a wide variety of often unforeseen ways and because there can be significant lags in time between when the research is conducted and when the knowledge is used. Nevertheless, one early study suggests that the benefits of federally funded basic research have been substantial.[30]

Assessing the returns from more applied research is somewhat less challenging. One comprehensive review finds that the returns from DOE's funding of research for technology development have been uneven.[31] That pattern of uneven economic returns is common in the R&D process and is the consequence of the many risks involved: Most R&D projects, large or small, provide only small benefits to society, if any at all, but a few projects yield very large benefits. Investing in a wide portfolio of many projects may mitigate the risks of R&D more than investing in a few large projects.[32]

30. See Edwin Mansfield, "Academic Research and Industrial Innovation," *Research Policy*, vol. 20, no. 1 (February 1991), http://dx.doi.org/doi:10.1016/0048-7333(91)90080-A. The Mansfield study addressed the benefits of academic research in general rather than just energy-specific research. See Congressional Budget Office, *A Review of Edwin Mansfield's Estimate of the Rate of Return From Academic Research and Its Relevance to the Federal Budget Process* (April 1993), www.cbo.gov/publication/16596.

31. National Research Council, Board on Energy and Environmental Systems, Committee on Benefits of DOE R&D on Energy Efficiency and Fossil Energy, *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000* (National Academies Press, 2001), www.nap.edu/catalog/10165.

32. For a broader discussion of the role of federal R&D in innovation, see Congressional Budget Office, *Federal Policies and Innovation* (November 2014), pp. 9–16, www.cbo.gov/publication/49487.

In general, funding for the early stages of developing new technologies, such as research that provides a better understanding of materials or underlying physical processes, has been more likely to yield benefits in excess of costs than has funding for the commercial demonstration of large integrated systems, such as projects demonstrating technological innovations in the generation of electrical power. Early-stage technology development programs, often in energy efficiency, regularly returned economic benefits that exceeded their costs by substantial amounts. Specifically, DOE-funded R&D on refrigeration, electronic ballasts for lights, compact fluorescent lights, low-emission windows, and improvements in oil field technology have yielded positive net benefits.[33] Not only can federal agencies play a pivotal role in increasing the understanding of physical phenomena that are critical to the development of new technology, they can also serve as the repositories of technical expertise and specialized instruments.

In contrast, many large energy technology demonstration projects undertaken in the 1970s and 1980s produced returns that fell short of their costs. DOE has generally been unsuccessful at lowering costs by funding large demonstration projects, for two reasons. First, federal agencies, including DOE, typically do not have an advantage in lowering production costs.[34] In most cases, industrial costs decline only when industries begin producing in substantial volumes, and such costs might even rise with the first few projects. Second, DOE's handling of large demonstration projects has been questionable in the past; the Government Accountability Office and others have long criticized DOE for poor management of such projects.[35]

The potential for technology demonstration projects funded by DOE to lower production costs of new electricity-generating technologies in future years could also be curtailed by the limited demand for new capacity in the industry. The Energy Information Administration forecasts that additions to capacity for electricity generation in the United States are expected to be lower in the coming decades than in the recent past.[36]

The Effect of DOE's Funding on Technology Transfer to Private Firms. To leverage federal investments in R&D and to ensure that technology developed using federal funds

33. National Research Council, Board on Energy and Environmental Systems, Committee on Benefits of DOE R&D on Energy Efficiency and Fossil Energy, *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000* (National Academies Press, 2001), www.nap.edu/catalog/10165.

34. Congressional Budget Office, *Federal Efforts to Reduce the Cost of Capturing and Storing Carbon Dioxide* (June 2012), www.cbo.gov/publication/43357.

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

36. Energy Information Administration, "Projected Electric Capacity Additions are Below Recent Historical Levels," *Today in Energy* (May 11, 2015), www.eia.gov/todayinenergy/detail.cfm?id=21172.

reaches the wider public, federal R&D agencies are encouraged to partner with other agencies, universities, and private firms. Aggregate statistics from DOE suggest that some of the technology developed by the department (including all of its programs, not just the offices responsible for applied research into each specific energy type) is of particular use to private-sector entities.

Although there are many metrics by which to evaluate the transfer of technology from federal agencies to private firms, DOE accounts for a disproportionately large share in at least two categories. In 2012, DOE accounted for 40 percent of all active licenses for government technology.[37] It also accounted for a disproportionate share—24 percent—of federal income from all active licenses, despite the fact that it accounted for only 7 percent of federal obligations for R&D in 2012.[38]

The department's other metrics of technology transfer are not as exceptional. DOE's share of collaborative relationships with nonfederal entities is not particularly large; it accounted for only 8 percent of cooperative research and development agreements between federal laboratories and nonfederal entities.

37. National Institute of Standards and Technology, *Federal Laboratory Technology Transfer, Fiscal Year 2012: Summary Report to the President and the Congress*, pp. 100–104 (December 2014), www.nist.gov/tpo/transfer-031715.cfm. The statistics presented are for DOE as a whole. DOE has not published technology transfer data that would allow CBO to distinguish between DOE's activities in energy, science, and nuclear programs.

38. By comparison, the Department of Defense and the National Institutes of Health accounted for almost 80 percent of federal R&D obligations in 2012. See National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 2011–13*, Detailed Statistical Tables NSF 14-312 (July 2014), www.nsf.gov/statistics/nsf14312/.

Appendix: Methods and Data Used to Estimate the Effects of Tax Preferences on Oil Production

The Congressional Budget Office estimates that from 2005 to 2014, domestic production of oil was, on average, between 0.4 percent and 0.8 percent greater with the tax preferences for fossil fuels than it would have been without those preferences. The cost of those tax preferences was, CBO estimates, between roughly $90 and $200 for each additional barrel of domestic production.

This appendix explains the methods and data that CBO used to make those estimates.

Estimating the Increase in Domestic Production

To estimate how much more oil was produced domestically with the tax preferences than would have been produced without them, CBO took the following steps:

- First, the agency calculated the percentage change in the after-tax price that oil producers received as a result of the tax preferences, and
- Second, it applied estimates of producers' responsiveness to those price changes.[39]

Percentage Change in the After-Tax Price of Oil

The tax preferences for oil represent an increase in the after-tax price received by producers for each barrel of oil they sell. To measure the percentage change in the after-tax price of oil, CBO calculated the value of the tax preference for oil production between 2005 and 2014 as a share of the value of oil production during that same period.[40]

In a few cases, the tax preferences apply only to oil producers. In most cases, however, the preferences also apply to producers of natural gas, and the costs of those preferences are not broken down by the type of fuel produced (see Table 1). In those cases, CBO allocated the value of the tax preference between the two fuels in proportion to the value of the production of each fuel.

The value of oil production was determined by multiplying the number of barrels of oil produced by its price per barrel. For natural gas, CBO summed the value of natural gas production plus the value of natural gas liquids production. Those calculations indicated that oil accounted for 49 percent of the combined value of oil and natural

39. For an example of another study that used a similar approach, see Gilbert E. Metcalf, "Federal Tax Policy Towards Energy," in James M. Poterba, ed., *Tax Policy and the Economy*, vol. 21 (MIT Press, May 2007), pp. 145–184, www.nber.org/chapters/c0049.

40. CBO used the 10 most recent fiscal years for which complete data are available (2005 to 2014) to account for periods of both high and low oil prices.

gas production during the 2005–2014 period. Consequently, for those tax preferences for which only the combined value of preferences for oil and natural gas were reported, CBO allocated 49 percent of the total value to oil producers. One tax preference—the election to expense 50 percent of qualifying property used to refine liquid fuels—applied only to oil and the natural gas liquids subset of the natural gas category. In that case, CBO attributed 75 percent of the tax preference to oil, which was oil's share of the combined production value of oil and natural gas liquids during the 2005–2014 period.

CBO used price and production data from the Energy Information Administration (EIA) in its calculations. Production data included oil production, U.S. natural gas marketed production, and U.S. gas plant production of natural gas liquids and liquid refinery gases.[41] For prices, CBO used first purchase prices for domestic oil and natural gas wellhead prices.[42] CBO assumed that natural gas liquids sold at the same prices as oil.

Between 2005 and 2014, tax preferences specifically for oil and natural gas cost taxpayers roughly $29 billion.[43] Adding up the value of the tax preferences that apply only to oil and the value of oil's share of tax preferences that apply to both oil and natural gas, CBO estimated that during those years, oil producers received $15.1 billion. Over that same time period, the value of domestic oil production was $1.7 trillion, so the value of the tax preferences accounted for 0.9 percent of total production value (see Table A-1). Thus, the tax preference can be said to be a 0.9 percent increase in the after-tax price that oil producers' receive for the oil they sell. The total oil production presented in Table A-1 includes both the additional oil that firms produced in response to the tax incentives and the oil that they would have produced even without such incentives.

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41. EIA releases updated data monthly. For production data on oil, see Energy Information Administration, "U.S. Field Production of Crude Oil," http://go.usa.gov/3eyuR; for natural gas, see "U.S. Natural Gas Marketed Production," http://go.usa.gov/3eVCk; and for natural gas liquids, see "U.S. Gas Plant Production of Natural Gas Liquids and Liquid Refinery Gases," http://go.usa.gov/3eVCz.

42. For price data on oil, see Energy Information Administration, "Domestic Crude Oil First Purchase Prices by Area," www.eia.gov/dnav/pet/pet_pri_dfp1_k_m.htm; and for natural gas, see "U.S. Natural Gas Wellhead Price," www.eia.gov/dnav/ng/hist/n9190us3M.htm. EIA did not report wellhead natural gas prices for 2013 and 2014. CBO used Henry Hub prices (natural gas futures prices on the New York Mercantile Exchange, which are used as a benchmark for the North American natural gas market) for those years. See Energy Information Administration, "Henry Hub Natural Gas Spot Price," www.eia.gov/dnav/ng/hist/rngwhhdm.htm.

43. CBO calculated the costs of those preferences using the following sources: Molly F. Sherlock, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures*, Report for Congress R41227 (Congressional Research Service, May 2, 2011), p. 26; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018*, JCX-97-14 (August 5, 2014), pp. 23–25, http://go.usa.gov/3zHY5; and staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF.

Producers' Responsiveness to Price Changes

Because the tax preferences represent an after-tax increase in prices that producers receive, those preferences encourage domestic firms to produce more oil than they would have produced without the preferences. The magnitude of that increase, however, is uncertain. Traditionally, economists have concluded that U.S. oil production does not shift in equal proportion to changes in oil prices; rather, production changes by much smaller percentages than do prices.

The sensitivity of supply to changes in price can be expressed as the elasticity of supply, which is defined as the percentage change in quantity produced for every 1 percent change in price. Until recently, observers have generally estimated that the elasticity of supply for oil fell in the range of 0.3 to 0.5, meaning that the quantity of oil produced would rise by 0.3 percent to 0.5 percent for every 1 percent rise in the price.[44] However, some analysts have concluded that the development of hydraulic fracturing (or fracking) and other modern drilling technologies has made some oil production much more responsive to oil prices; they have suggested that the elasticity of supply is now as high as 0.9 and that it will continue to rise.[45]

For the purpose of this analysis, CBO examined two cases—one based on a supply elasticity of 0.4, which is the middle of the range from the older literature, and one based on a supply elasticity of 0.9 to reflect the recent estimates. CBO used the elasticities to estimate the share of the $1.7 trillion in total production that occurred as a result of the tax preferences. If U.S. oil producers responded as they had historically (that is, if the supply elasticity was 0.4), then the tax preferences increased domestic oil production by 0.4 percent (or by 76 million barrels) over the 2005–2014 period. If the recent estimates are correct in indicating that oil production has responded more favorably than it has in the past (that is, if the supply elasticity was 0.9), tax preferences increased domestic production by 0.8 percent (or by 171 million barrels) over the period.

Estimating the Cost of Tax Preferences per Barrel of Additional Production

To calculate the cost of the tax preferences per barrel of additional production, the total value of the tax preferences is divided by the additional oil production that is estimated

44. For the low estimate, see Noureddine Krichene, *A Simultaneous Equation Model for World Crude Oil and Natural Gas Markets*, IMF Working Paper WP/05/32 (International Monetary Fund, February 2005), http://tinyurl.com/p3y9sye. The higher estimate comes from Stephen P. A. Brown and Hillard G. Huntington, "Terms of Trade and OECD Policies to Mitigate Global Climate Change," *Economic and Financial Policy Review*, Federal Reserve Bank of Dallas, vol. 2, no. 1 (2003), http://dallasfed.org/research/efpr/. Because most of the tax preferences for fossil fuels are permanent, the use of long-run elasticities of supply is appropriate; estimates of short-run elasticities are an order of magnitude smaller.

45. National Economic Research Associates (NERA) Economic Consulting, *Economic Benefits of Lifting the Crude Oil Export Ban* (September 9, 2014), p. 120, http://tinyurl.com/o2rdara. NERA forecasts that by 2020, the elasticity of supply for oil will rise to about 1.0.

to have resulted from those tax preferences. That cost represents the taxpayer's cost of obtaining one additional barrel of domestic oil. Because of the uncertainty about the responsiveness of producers to changes in oil prices, the cost to taxpayers is also very uncertain.

- If 76 million additional barrels were produced over the 2005–2014 period because of the tax preferences (corresponding to an elasticity of 0.4), then the average cost of the tax preference was roughly $200 per barrel ($15.1 billion divided by 76 million barrels).
- If 171 million additional barrels were produced over the period (corresponding to an elasticity of 0.9), then the average cost of the tax preferences was roughly $90 per barrel ($15.1 billion divided by 171 million barrels).

Those costs to the government are in addition to the private costs of purchasing the oil. The average market price of oil between 2005 and 2014 was about $80 per barrel.[46]

46. Energy Information Administration, "Refiner Acquisition Cost of Crude Oil" (November 2, 2015), www.eia.gov/dnav/pet/pet_pri_rac2_dcu_nus_m.htm.

About This Document

This Congressional Budget Office report was prepared at the request of the Ranking Member of the Senate Finance Committee. It updates the testimony of Terry Dinan, Senior Advisor, Congressional Budget Office, before the Subcommittee on Energy of the House Committee on Science, Space, and Technology, *Federal Financial Support for Fuels and Energy Technologies* (March 13, 2013), www.cbo.gov/publication/43993. In keeping with CBO's mandate to provide objective, impartial analysis, this report makes no recommendations.

Philip Webre and Terry Dinan prepared this report in collaboration with Mark Booth and with guidance from Joseph Kile and Chad Shirley. Paul Burnham, Megan Carroll, Wendy Edelberg, Nathaniel Frentz, Ronald Gecan, Kathleen Gramp, and Tristan Hanon provided helpful comments, as did the staff of the Joint Committee on Taxation. Jason Bordoff of Columbia University, Aparna Mathur of the American Enterprise Institute, and Molly Sherlock of the Congressional Research Service provided useful comments. The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.

Jeffrey Kling, John Skeen, and Robert Sunshine reviewed the report, and Bo Peery edited it. Maureen Costantino designed the cover, and Jeanine Rees prepared the report for publication. The report is available on CBO's website (www.cbo.gov/publication/50980).

Keith Hall
Director

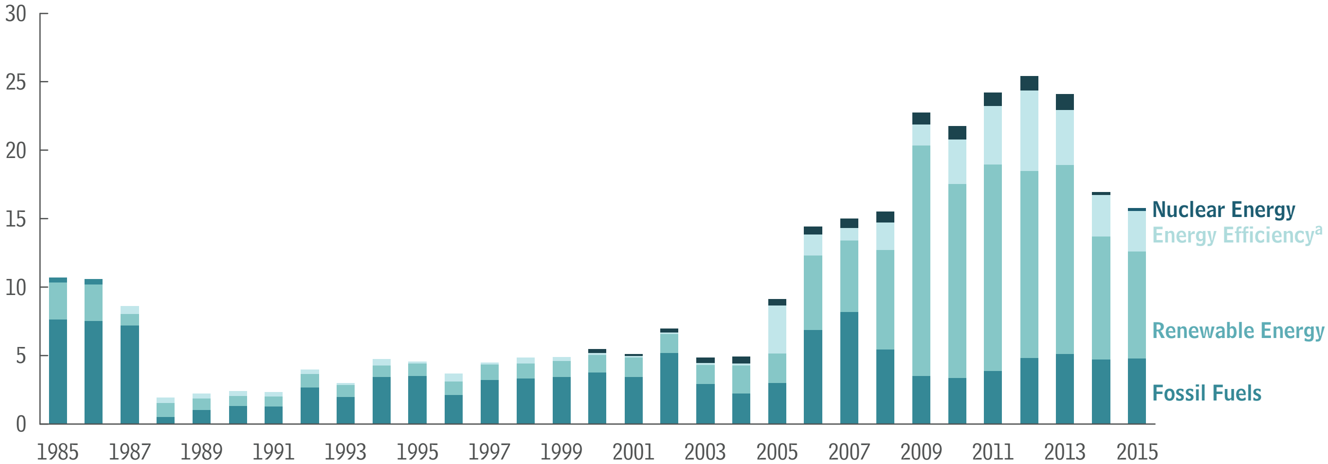
November 2015

Figure 1.

Return to Reference

Costs of Energy-Related Tax Preferences, by Type of Fuel or Technology, 1985 to 2015

Billions of 2015 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*, Report for Congress R41227 (Congressional Research Service, May 2, 2011), p. 26, and updated data from the Congressional Research Service; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018*, JCX-97-14 (August 5, 2014), pp. 23–25, http://go.usa.gov/3zHY5; staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF; and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2016: Appendix* (February 2015), p. 1010, www.whitehouse.gov/omb/budget/Appendix.

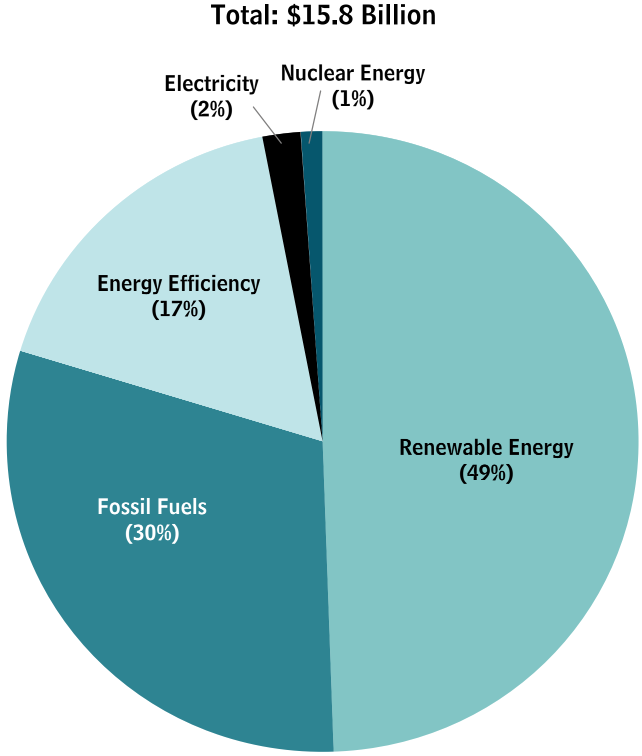
Notes: The estimates of the costs of individual tax preferences do not account for any potential interactions between preferences or include the costs of those tax provisions estimated to result in less than $50 million in forgone revenues. Nor do they reflect the amount of revenues that would be raised if those preferences were eliminated and taxpayers adjusted their activities in response to those changes.

a. Includes the costs of tax preferences related to the transmission of electricity, which are typically small.

Figure 2.

Return to Reference

Estimated Allocation of Energy-Related Tax Preferences, by Type of Fuel or Technology, 2015



Source: Congressional Budget Office based on data from Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018*, JCX-97-14 (August 5, 2014), pp. 23–25, http://go.usa.gov/3zHY5, and *List of Expiring Federal Tax Provisions 2014–2025*, JCX-1-15 (January 9, 2015), http://go.usa.gov/3zFSm; staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF; and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2016: Appendix* (February 2015), p. 1010, www.whitehouse.gov/omb/budget/Appendix.

Note: This figure includes all of the tax preferences listed in Table 1.

Table 1.

Return to Reference 1, 2, 3, 4

Energy-Related Tax Preferences, 2015

Type of Fuel or Technology Supported	Tax Preference	Estimated Total Cost (Billions of dollars)	Expiration Date
	Tax Preferences Affecting Income Taxes		
Renewable Energy	Credit for the production of electricity from renewable resources	2.9 [a]	12/31/2014[b]
	Credit for investments in solar and geothermal equipment, fuel cells, and microturbines	0.6	12/31/2016
	Credit for investment in advanced energy property, including property used in producing energy from wind, the sun, or geothermal sources	0.3	Fixed $2.3 billion in credit; available until used
	Five-year depreciation for certain renewable energy equipment	0.3	None
Fossil Fuels	Option to expense depletion costs on the basis of gross income rather than actual costs	1.7	None
	Exceptions for publicly traded partnerships with qualifying income derived from certain energy-related activities[c]	1.1	None
	Expensing of exploration and development costs for oil and natural gas	1.1	None
	Amortization of costs of air pollution control facilities	0.4	None
	Credit for investment in clean coal facilities	0.2	Fixed dollar amount of credit; available until used
	15-year depreciation for natural gas distribution lines	0.2	12/31/2010[d]
	Amortization of geological and geophysical expenditures associated with oil and gas exploration	0.1	None
Energy Efficiency	Residential efficiency property credit	1.2	12/31/2016
	Credit for energy-efficiency improvements to existing homes	0.8 [a]	12/31/2014
	Credit for plug-in electric vehicles	0.2	Expires for each manufacturer when the number of vehicles it sells reaches the limit set by the federal government
	10-year depreciation for smart meters or other devices for monitoring and managing energy use	0.2	None
	Credit for new energy-efficient homes	0.2 [a]	12/31/2014
	Deduction for energy-efficient commercial buildings	0.1 [a]	12/31/2014

Continued

Table 1. **Continued**

Energy-Related Tax Preferences, 2015

Type of Fuel or Technology Supported	Tax Preference	Estimated Total Cost (Billions of dollars)	Expiration Date
Electricity	Dispositions of property related to electricity transmission[e]	0.3	12/31/2014
	15-year depreciation of certain property related to electricity transmission	0.2	None
	Special rule to implement restructuring of the electricity transmission infrastructure	-0.2	12/31/2014[d]
Nuclear Energy	Special tax rate for reserve funds for nuclear decommissioning	0.2	None
	Subtotal, Tax Preferences Affecting Income Taxes	12.1	n.a.
	Tax Preferences Affecting Energy-Related Excise Taxes[f]		
Renewable Energy	Biodiesel and renewable diesel credits[g]	1.3 [a]	12/31/2014
	Tax incentives for alternative fuels	0.4 [a]	12/31/2014
	Subtotal, Tax Preferences Affecting Excise Taxes	1.7	n.a.
	Grants in Lieu of Tax Credits Affecting Energy-Related Excise Taxes		
Renewable Energy	Section 1603 grants	2.0	12/31/2011[h]
	All Energy-Related Tax Preferences		
Total		**15.8**	**n.a.**

Source: Congressional Budget Office based on data from Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018*, JCX-97-14 (August 5, 2014), pp. 23–25, http://go.usa.gov/3zHY5, and *List of Expiring Federal Tax Provisions 2014–2025*, JCX-1-15 (January 9, 2015), http://go.usa.gov/3zFSm; staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF; and Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2016: Appendix* (February 2015), p. 1010, www.whitehouse.gov/omb/budget/Appendix.

Notes: The estimates of the costs of individual tax preferences do not account for any potential interactions between preferences or include the costs of those tax provisions estimated to result in less than $50 million in forgone revenues. Nor do they reflect the amount of revenues that would be raised if those preferences were eliminated and taxpayers adjusted their activities in response to those changes.

n.a. = not applicable.

a. This tax preference was extended through calendar year 2014 by the Tax Increase Prevention Act of 2014, which was enacted in December 2014. In this table, pending updated estimates by the staff of the Joint Committee on Taxation (JCT) of the cost of the tax preference, CBO used JCT's estimate of the revenue loss due to the one-year extension.

b. The production tax credit is generally available for 10 years beginning on the date that the facility is put into service. The Tax Increase Prevention Act of 2014 defined eligible facilities as those whose construction began by December 31, 2014.

c. This tax preference may be claimed for a variety of activities associated with the production of energy and natural resources; however, on the basis of industry estimates of the size of the industries in which the firms that would qualify for the tax preference operate, CBO expects that most of the $1.1 billion accrues to firms in the fossil fuel industry.

d. Effects of the tax preference extend beyond the expiration date.

e. After 2015, the changes in revenues become positive.

f. Neither JCT nor the Administration generally estimates revenues forgone in the excise tax system. They do, however, provide information on revenue reductions from excise tax credits for alcohol and biodiesel.

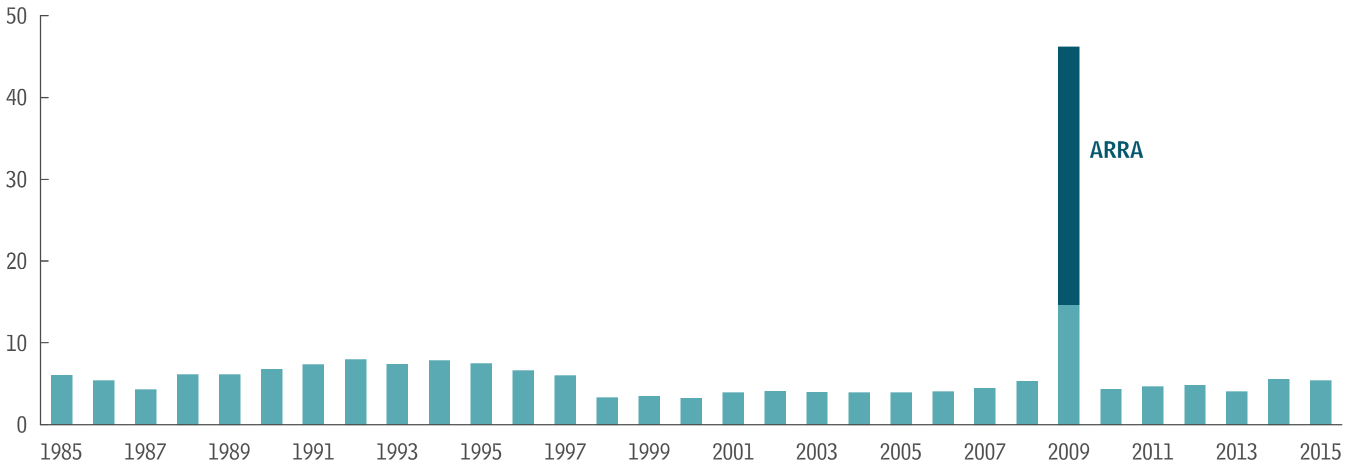
g. Estimate includes effects on both income and excise taxes.

h. Companies that began constructing a facility and applied for the benefit by December 31, 2011, are eligible. Grants are not paid until facilities are placed into service; they are therefore still being disbursed.

Figure 3. Return to Reference 1, 2

DOE's Financial Support for Energy Technologies and Energy Efficiency, 1985 to 2015

Budget Authority, in Billions of 2015 Dollars



Source: Congressional Budget Office.

Notes: The amount indicated for funding provided by the American Recovery and Reinvestment Act of 2009 (ARRA) reflects transfers and rescissions of budget authority for Section 1705 loan guarantees that were made after ARRA was enacted.

DOE = Department of Energy.

Table 2. Return to Reference

DOE's Support for Energy Technologies and Energy Efficiency, 2015

	Budget Authority (Billions of dollars)
Direct Investment Programs	
Applied Energy	
Renewable energy and energy efficiency	1.9
Nuclear energy	0.7
Fossil energy research and development	0.6
Electricity delivery and energy reliability	0.1
Advanced Research Projects Agency–Energy	0.3
Subtotal	3.6
Science	
Basic Energy Sciences program	1.7
Subtotal, Direct Investments	5.4
Energy Credit Programs	
Title 17 Innovative Technology Loan Guarantee Program	*
Advanced Technology Vehicles Manufacturing Loan Program	*
Total	**5.4**

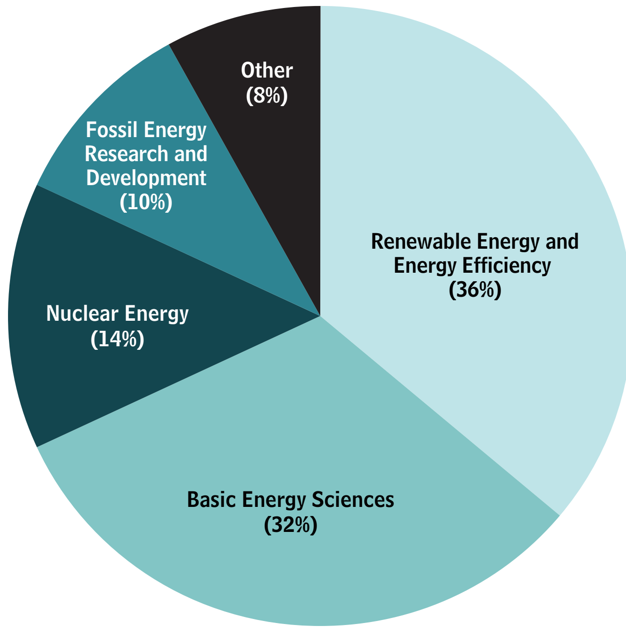
Source: Congressional Budget Office.

Note: DOE = Department of Energy; * = between zero and $50 million.

Figure 4. Return to Reference

Allocation of DOE's Direct Investments in Energy Technologies and Energy Efficiency, 2015

Total: $5.4 Billion



Source: Congressional Budget Office.

Notes: "Other" includes funding for the Advanced Research Projects Agency–Energy and for electricity delivery and energy reliability programs.

DOE = Department of Energy.

Table 3. Return to Reference

DOE's Loan and Loan Guarantee Amounts and Subsidy Rates, 2009 to 2014

	Section 1703 Loan Guarantee Program for Nuclear and Other Clean-Energy Facilities[a]	Section 1705 Loan Guarantee Program for Renewable Energy and Electricity Transmission	Advanced Technology Vehicles Manufacturing Loan Program
Number of Loans or Loan Guarantees	2	28	5
Total Loan or Loan Guarantee Amount (Billions of dollars)	6.2	14.0	8.4
Disbursements Through 2014 (Billions of dollars)	1.7	12.6	6.8
Original Weighted-Average Subsidy Rate (Percent)	-4.2	11.0	45.3
2014 Reestimated Weighted-Average Subsidy Rate (Percent)	-4.0	13.7	4.1

Source: Congressional Budget Office based on data from Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2016: Federal Credit Supplement* (February 2015), pp. 46 and 66, www.whitehouse.gov/omb/budget/Supplemental; and Department of Energy, Loan Programs Office, "Portfolio Projects" (accessed October 13, 2015), www.energy.gov/lpo/portfolio-projects.

Notes: Negative subsidies occur when the present value of cash inflows to the government exceeds the present value of cash outflows.

DOE = Department of Energy.

a. The amounts indicated for the Section 1703 program are for the two loan guarantees that the Department of Energy approved in 2014 for the Alvin W. Vogtle Electric Generating Plant, a nuclear power plant in Georgia. In 2015, DOE guaranteed three more loans for that project totaling $1.8 billion. On the basis of public information from the Treasury Department, CBO estimates that DOE disbursed about $1.1 billion for the new guarantees in June 2015, with a subsidy rate of roughly negative 2 percent.

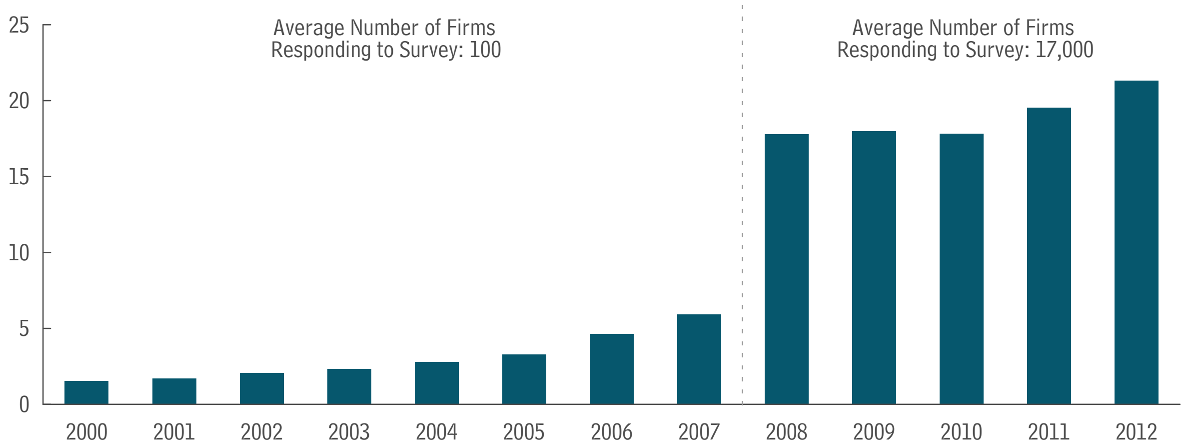
Box 1.

Return to Reference

Private-Sector Investment in Energy-Related Research and Development

Spending by the Private Sector on Energy-Related Research and Development

Billions of 2015 Dollars



Source: Congressional Budget Office based on National Science Foundation, National Center for Science and Engineering Statistics, *Business Research and Development and Innovation*, Detailed Statistical Tables (various years), http://go.usa.gov/3JAt5.

Note: In 2008, the National Science Foundation began requiring firms in all industries to answer survey questions about their spending on energy-related research and development.

In 2008, the National Science Foundation (NSF) revised its survey of energy-related research and development (R&D) funded by the private sector and substantially increased its estimate of the amounts that private firms invest in such R&D.[47] The NSF required firms in all industries to answer questions about R&D related to energy (answering those questions had previously been voluntary) and followed up with them to ensure that they complied. The result of those changes was an increase in the number of responses each year from an average of 100 from 2000 to 2007 to an average of more than 17,000 from 2008 to 2012. Measured in 2015 dollars, NSF's estimate of the amount spent by the private sector to conduct energy-related R&D rose from $5.9 billion in 2007 to $17.8 billion in 2008. The increase in the amounts of reported private-sector spending on energy-related R&D presented in the revised NSF survey suggests that the role of the private sector in developing new energy-related technologies is more significant than was previously thought—several times the size of the Department of Energy's effort.

Reported spending on energy-related R&D by the private sector has grown rapidly since 2008. By 2012, the most recent year for which the NSF has tabulated its data, private-sector spending on energy-related R&D had risen by 20 percent, to $21.3 billion (see the figure). However, that growth

47. The NSF increased the sample size and changed both its survey instrument and collection method. For annual tabulations of the surveys of private sector R&D, see National Science Foundation, National Center for Science and Engineering Statistics, *Business Research and Development and Innovation*, Detailed Statistical Tables (various years), http://go.usa.gov/3JAt5. The NSF stated in pre-2008 publications of its survey results that its estimates of private-sector spending for energy R&D were not meant to be comprehensive.

might be overstated: The number of firms responding to the survey grew substantially between 2008 and 2012, so what appears to be growth in spending is at least partially caused by an increase in the number of firms that responded to the survey.

Like aggregate private-sector spending for R&D, private-sector spending for R&D specifically related to energy is concentrated in a few industries. About three-quarters of energy-related spending for R&D in 2012 was concentrated in the manufacturing sector, whereas one-quarter was in nonmanufacturing industries such as mining, utilities, and engineering services. In the manufacturing sector, the automobile industry, semiconductor manufacturing, and the machinery industry accounted for one-half of private spending for energy-related R&D. In the nonmanufacturing sector, the industries that spent the most money for energy-related R&D were the mining and support industries; the professional, scientific, and technical services industries; and the information industries, which together accounted for 90 percent of nonmanufacturing spending on R&D specifically for energy.

Most of the private-sector spending on energy-related R&D was devoted to increasing energy efficiency rather than developing new energy supplies. At least three-fourths of private spending on energy-related R&D went to energy efficiency projects. The manufacturing sector—except for the makers of turbines, engines, and power transmission equipment, which accounted for about 6 percent ($1.2 billion) of energy-related R&D in 2012—appears to have largely pursued energy efficiency. Spending in the nonmanufacturing sector is more difficult to categorize: R&D in the mining and utilities industries might be categorized as spending for new energy supplies, but it is unclear how spending by the professional, scientific, and technical services industries should be allocated. The information industries are unlikely to be involved in developing new energy supplies.

Table A-1.

Return to Reference 1, 2

Oil Production Attributable to Tax Preferences, 2005 to 2014

Total U.S. Production (Billions of barrels)	21.4
Purchase Price, Weighted Average (Dollars per barrel)	79
Value of Total Production (Billions of dollars)	1,686
Value of Preferences (Billions of dollars)	15.1
Preferences' Share of Total Production Value (Percent)	0.9

Source: Congressional Budget Office based on data from the Energy Information Administration; Molly F. Sherlock, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures,* Report for Congress R41227 (Congressional Research Service, May 2, 2011), p. 26; Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2014–2018*, JCX-97-14 (August 5, 2014), pp. 23–25, http://go.usa.gov/3zHY5; and staff of the Joint Committee on Taxation, "Estimated Revenue Effects of H.R. 5771, The 'Tax Increase Prevention Act of 2014,' Scheduled for Consideration by the House of Representatives on December 3, 2014," JCX-107-14R (December 3, 2014), http://go.usa.gov/3zHDF.