



Report to the Ranking Member,
Subcommittee on Energy, Committee on
Energy and Natural Resources, U.S.
Senate

September 2018

ADVANCED FOSSIL ENERGY

Information on DOE-
Provided Funding for
Research and
Development Projects
Started from
Fiscal Years
2010 through 2017

Accessible Version

GAO Highlights

Highlights of GAO-18-619, a report to the Ranking Member, Subcommittee on Energy, Committee on Energy and Natural Resources, U.S. Senate

Why GAO Did This Study

One aspect of DOE's mission is to secure U.S. leadership in energy technologies. To that end, DOE funds R&D for energy projects, including for advanced fossil energy (innovative technologies for coal, natural gas, and oil). DOE provides funding for R&D projects, including large projects designed to demonstrate the commercial viability of technologies. Also, DOE is authorized to make loan guarantees to support certain energy projects through its Loan Guarantee Program, which is administered by its Loan Programs Office.

GAO was asked to review DOE's funding for advanced fossil energy projects. This report describes DOE's funding for advanced fossil energy R&D projects started from fiscal years 2010 through 2017 and the types of projects and recipients that received funding, among other objectives. For purposes of this report, GAO used the term funding to mean obligations.

GAO analyzed relevant laws, regulations, and guidance; DOE data on R&D funding for fiscal years 2010 through 2017; and DOE documents. GAO also interviewed DOE officials in the Office of Fossil Energy, the National Energy Technology Laboratory, and the Loan Programs Office.

What GAO Recommends

GAO is not making any recommendations.

View [GAO-18-619](#). For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov.

September 2018

ADVANCED FOSSIL ENERGY

Information on DOE-Provided Funding for Research and Development Projects Started from Fiscal Years 2010 through 2017

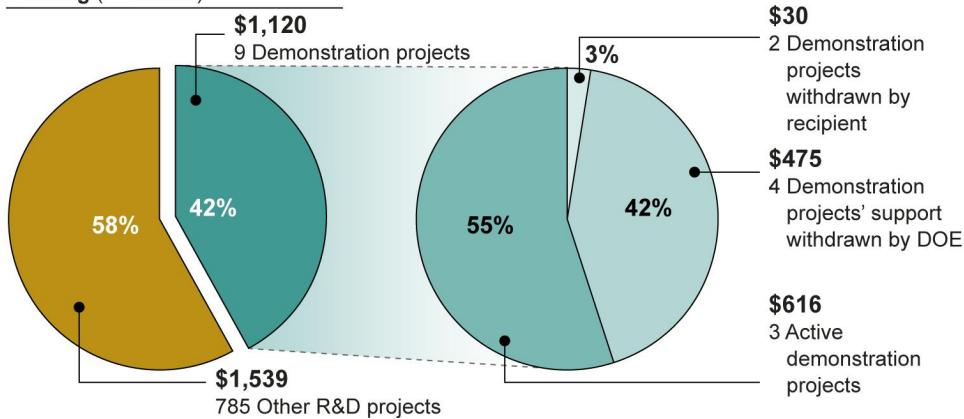
What GAO Found

The Department of Energy (DOE) provided \$2.66 billion in funding, or obligations, for 794 research and development (R&D) projects started from fiscal years 2010 through 2017 to develop advanced fossil energy technologies. Such technologies include processes for converting coal into synthesis gas composed primarily of carbon monoxide and hydrogen, and recovering methane from gas hydrates. Of the \$2.66 billion, DOE provided \$1.12 billion in funding for 9 later-stage, large demonstration projects, which were to assess the readiness for commercial viability of carbon capture and storage (CCS) technologies. CCS involves capturing man-made carbon dioxide at its source and storing it permanently underground. DOE provided the remaining \$1.54 billion in funding for 785 other projects in amounts that were relatively small—over half were for less than \$1 million.

Six demonstration projects researched CCS technologies using coal, while three used other fuels. The nine demonstration projects received funding ranging from \$13 million to \$284 million. As shown in the figure, three projects implementing CCS technologies were active as of the end of fiscal year 2017. Also, DOE withdrew its support for four projects, and two projects were withdrawn by the recipients—all before completion. These projects did not reach completion due to several factors, such as a lack of technical progress, or changes in the relative prices of coal and natural gas that made the projects economically unviable.

Distribution of Department of Energy (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects that Started from Fiscal Years 2010 through 2017

Funding (in millions)



Source: GAO analysis of Department of Energy (DOE) data. | GAO-18-619

Note: Of the 794 R&D projects, 9 large demonstration projects supported carbon capture and storage technologies to assess their readiness for commercial viability. Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of this report, GAO used the term funding to mean obligations. Funding amounts may not sum due to rounding.

Of the 785 other projects, about 89 percent involved R&D of coal technologies, such as coal gasification—the conversion of carbon-containing material into synthesis gas. The other 11 percent of the 785 projects involved R&D of oil and gas technologies, such as the development of technologies to find, characterize, and recover methane from gas hydrates.

Contents

Letter	1
Background	5
DOE Provided \$2.66 Billion in Funding for 794 Advanced Fossil Energy R&D Projects Started from Fiscal Years 2010 through 2017	8
DOE Made No Loan Guarantees for Advanced Fossil Energy from Fiscal Year 2006 through August 2018	24
Agency Comments	25
Appendix I: Objectives, Scope, and Methodology	27
Appendix II: GAO Contact and Staff Acknowledgments	31
Appendix III: Accessible Data	32
Data Tables	32
Tables	
Table 1: Department of Energy's (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017 by Fuel Type ¹⁷	
Table 2: Recipient Types for the Department of Energy's (DOE) Advanced Fossil Energy Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017 ²¹	
Table 3: Department of Energy's (DOE) Advanced Fossil Energy Research and Development (R&D) Projects and Funding by Recipient Type for Projects Started during Fiscal Years 2010 through 2017	22
Data Table for Figure 2: Department of Energy's (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects Other than Large Demonstration Projects Started from Fiscal Years 2010 through 2017, by Fiscal Year Started	32
Data Table for Figure 3: Department of Energy's (DOE) Advanced Fossil Energy Funding for Research and Development	

(R&D) Projects Started from Fiscal Years 2010 through
2017 by Recipient Location

32

Figures

Figure 1: Distribution of Department of Energy (DOE) Funding for Advanced Fossil Energy Research and Development Projects that Started from Fiscal Years 2010 through 2017

10

Figure 2: Department of Energy's (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects Other than Large Demonstration Projects Started from Fiscal Years 2010 through 2017, by Fiscal Year Started

16

Figure 3: Department of Energy's (DOE) Advanced Fossil Energy Funding for Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017 by Recipient Location

23

Abbreviations

CCS	carbon capture and storage
CCUS	carbon capture, utilization, and storage
CO ₂	carbon dioxide
DOE	Department of Energy
EPAct	Energy Policy Act of 2005
FE	Office of Fossil Energy
IGCC	integrated gasification combined cycle
LGP	Loan Guarantee Program
NETL	National Energy Technology Laboratory
R&D	research and development
Recovery Act	American Recovery and Reinvestment Act of 2009

This is a work of the U.S. government and is not subject to copyright protection in the United States. The published product may be reproduced and distributed in its entirety without further permission from GAO. However, because this work may contain copyrighted images or other material, permission from the copyright holder may be necessary if you wish to reproduce this material separately.



U.S. GOVERNMENT ACCOUNTABILITY OFFICE

441 G St. N.W.
Washington, DC 20548

September 21, 2018

The Honorable Joe Manchin III
Ranking Member
Subcommittee on Energy
Committee on Energy and Natural Resources
United States Senate
Dear Senator Manchin:

For more than 100 years, three fossil fuel sources—coal, oil, and natural gas—have made up at least 80 percent of total U.S. energy consumption, according to the Department of Energy's (DOE) Energy Information Administration.¹ Furthermore, in 2017, about 63 percent of U.S. electricity generation was from fossil fuels—including coal, oil, and natural gas—and fossil fuels made up about 95 percent of transportation fuels in the United States.² While fossil fuels are associated with some negative environmental impacts—such as carbon dioxide (CO₂) emissions—the predominance of coal, oil, and natural gas is likely to continue into the future, according to the Energy Information Administration.

Since 1979, DOE has provided technical and financial assistance for research and development (R&D) for advanced fossil energy projects. Advanced fossil energy projects include processes for capturing man-made CO₂ at its source and storing it underground, converting carbon-containing material (i.e., coal) into synthesis gas composed primarily of carbon monoxide and hydrogen, and recovering methane from gas hydrates.³ Within DOE, the Office of Fossil Energy (FE) carries out federal R&D programs on advanced fossil energy technologies, among other things. FE's primary mission is to ensure reliable fossil energy

¹The Energy Information Administration is the statistical and analytical agency within DOE that collects, analyzes, and disseminates independent and impartial energy information.

²For transportation fuels, 92 percent were petroleum products—including gasoline, distillate fuels (mostly diesel fuel), and jet fuel—while 3 percent were from natural gas pipeline compressors.

³Synthesis gas is composed primarily of carbon monoxide and hydrogen, and can be used as a fuel to generate electricity or steam; as a basic chemical building block for a large number of uses in the petrochemical and refining industries; and for the production of hydrogen. Gas hydrates are naturally-occurring combinations of methane gas and water that form under specific conditions of low temperature and high pressure.

resources for clean, secure, and affordable energy while enhancing environmental protection. In addition, the National Energy Technology Laboratory (NETL)—overseen by FE—implements a broad spectrum of energy and environmental R&D programs; has expertise in coal, oil, and natural gas; and performs contract and project management, among other things. In addition, the laboratory coordinates and oversees R&D projects for FE.

In addition to its R&D programs, DOE administers the Title XVII Loan Guarantee Program (LGP) for innovative energy technologies through its Loan Programs Office. One of the goals of the LGP is to encourage commercial use in the United States of new or significantly improved energy-related technologies. Title XVII of the Energy Policy Act of 2005 (EPAct), as amended, authorizes DOE to provide loan guarantees for certain energy projects in several categories, including advanced fossil energy technology.⁴ Under the LGP, to encourage such innovative energy projects, the federal government agrees to reimburse lenders for the guaranteed amount of loans if the borrowers default. If borrowers default on the loans, the federal government can be exposed to substantial financial risks.

You asked us to review DOE's funding for advanced fossil energy projects. This report describes 1) DOE's funding for advanced fossil energy R&D projects that started from fiscal years 2010 through 2017 and the types of projects and recipients that received funding, and 2) DOE's loan guarantees, if any, for advanced fossil energy projects from fiscal year 2006 through August 2018. For the purposes of this report, we use the term funding to mean obligations.⁵

To address the first objective, we reviewed relevant laws, regulations, and DOE guidance. We analyzed DOE advanced fossil energy R&D project

⁴Pub. L. No. 109-58, Title XVII, 119 Stat. 594, 1117 (2005) (codified as amended at 42 U.S.C. §§ 16511-16516).

⁵An obligation is a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received, or a legal duty on the part of the United States that could mature into a legal liability by virtue of actions on the part of the other party beyond the control of the United States. Payment may be made immediately or in the future. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another. GAO, *A Glossary of Terms Used in the Federal Budget Process*, GAO-05-734SP (Washington, D.C.: Sept. 2005).

data for fiscal years 2010 through 2017. We focused our review on 794 advanced fossil energy R&D projects that received funding through NETL because the 794 projects represent all of the advanced fossil energy R&D projects in our scope started from fiscal years 2010 through 2017. We used fiscal year 2010 as the start date because DOE officials told us that DOE's current data management system came into use for the R&D projects that started in fiscal year 2010. We used fiscal year 2017 as the end date because that was the most recent complete year for which data were available. DOE provided us with a spreadsheet that included key project information—such as the name of the recipient of the R&D funding and the project start date—as well as obligations data for each project started during the period of our review by summing the obligations for the project from each year. We reported on DOE's funding for these R&D projects; DOE generally provided financial assistance for these projects through grants or cooperative agreements.⁶ Because advanced fossil energy R&D financial assistance for the Small Business Innovation Research and Small Business Technology Transfer programs, as well as for the DOE national laboratories, are not obligated through NETL, we excluded these projects from our scope.⁷ To assess the reliability of the funding data, as well as the specific project information for the 794 R&D projects, we interviewed data specialists at DOE Headquarters, FE, and NETL and reviewed DOE internal guidance for the maintenance of agency data. We found the data to be sufficiently reliable for our purposes. We also reviewed DOE websites and documentation, including fact sheets, and interviewed officials from FE and NETL. To characterize

⁶Federal financial assistance means assistance that non-federal entities receive or administer in the form of grants, property, cooperative agreements, food commodities, direct appropriations, or other assistance, and can also include loans, loan guarantees, interest subsidies, and insurance, depending on the context, but does not include amounts received as reimbursement for services rendered to individuals in accordance with OMB-issued guidance. 2 C.F.R. § 200.40. See also 31 U.S.C. § 7501(5). A grant agreement is generally defined as a legal instrument of financial assistance between a federal awarding agency and a non-federal entity that is used to enter into a relationship the principal purpose of which is to transfer anything of value from the federal awarding agency to the non-federal entity to carry out a public purpose authorized by law, and not to acquire property or services for the federal awarding agency's direct benefit or use. 2 C.F.R. § 200.51. A cooperative agreement is distinguished from a grant in that it provides for substantial involvement between the federal awarding agency and the non-federal entity in carrying out the activity contemplated by the federal award. 2 C.F.R. § 200.24. For purposes of our report, we use the term awards to refer to both grants and cooperative agreements.

⁷We also did not include tax expenditures administered by the Department of the Treasury, such as the tax credits for industrial carbon dioxide capture and sequestration and investment in clean coal facilities.

the recipients of advanced fossil energy R&D funding, we coded each recipient into one of three categories: university, industry or other.⁸ We developed definitions for making the coding determination for each recipient; more information on this process, including the full definitions, is in appendix I.

To describe the status of DOE's advanced fossil energy loan guarantees, we reviewed relevant laws, regulations, and guidance, as well as past GAO reports describing DOE's administration of the loan program. We analyzed information that DOE provided on applications for loan guarantees for advanced fossil energy projects under the LGP and other related information for fiscal year 2006 through August 2018. We used fiscal year 2006 as the start date because it was the first year that DOE issued an advanced fossil energy project solicitation—an announcement of opportunities for loan guarantees for advanced fossil energy projects—and we used August 2018 as the end date in order to provide the most up-to-date information possible. We also reviewed the advanced fossil energy project solicitations issued by DOE during this timeframe. To assess the reliability of the summary information, we interviewed LGP staff who maintain the information for advanced fossil energy applications, and reviewed DOE documentation. We found the data to be sufficiently reliable for our purposes. In addition, we interviewed officials from the Loan Programs Office who work on the LGP. For further details on our scope and methodology, see appendix I.

We conducted this performance audit from March 2017 to September 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

⁸For purposes of our report, we use the term recipient to include all entities (e.g., universities, industry) that received financial assistance for advanced fossil energy R&D projects regardless of the instrument used (e.g., by grant or cooperative agreement). We use university to include any institution of higher education, such as a public or non-profit private college, junior college, or university. We defined industry as any private sector organization that is not an institution of higher education, such as a consulting group or business. For more information on our methodology, see appendix I.

Background

This section provides an overview of 1) DOE's administration of its advanced fossil energy R&D program, and 2) DOE's Loan Guarantee Program (LGP).

DOE's Administration of Its Advanced Fossil Energy R&D Projects

Within DOE, FE carries out DOE's program for fossil energy R&D, which includes federal research, development, and demonstration efforts on advanced power generation; power plant efficiency; water management; and carbon capture and storage (CCS) technologies. CCS is a process that involves capturing man-made CO₂ at its source and storing it permanently underground.⁹ The program for fossil energy R&D also includes the development of technological solutions for the development of U.S. unconventional oil and gas domestic resources, such as from shale formations. FE also oversees the operations, infrastructure, and R&D at NETL, among other things. NETL officials told us that NETL has dual roles: it serves as project manager for advanced fossil energy R&D projects that receive federal assistance, and, as a DOE national laboratory, it also conducts applied research.¹⁰ FE and NETL collaborate on the selection and administration of the awards for advanced fossil energy R&D projects, according to DOE officials.

DOE's efforts to administer its program for advanced fossil energy R&D take place across a spectrum of activities, including providing financial assistance for large demonstration projects.¹¹ In the 1980s and early 1990s, DOE's fossil energy R&D program primarily focused on reducing emissions of harmful pollutants from coal-fired power plants, particularly

⁹CCS is sometimes referred to as CCUS—carbon capture, utilization, and storage. In addition, CCS is also sometimes referred to as carbon capture and sequestration. CCS is also applicable to non-coal industrial processes such as corn ethanol plants and oil refineries.

¹⁰NETL is the only DOE national laboratory operated by the government rather than a contractor. NETL's in-house R&D work was outside of the scope of our review.

¹¹Demonstration projects operate new or improved technologies to collect information on their performance and assess readiness for commercialization and deployment for widespread use.

sulfur dioxide and nitrogen oxide. For example, DOE began its large demonstration projects of advanced coal technologies in the mid-1980s; this work focused on R&D to mitigate acid rain and to reduce the pollutants released from coal combustion. More recently, DOE has provided funding for advanced fossil energy R&D to reduce CO₂ emissions by developing beneficial uses for CO₂ from coal-fired power plants, and to improve methods for CCS, among other things. As we have previously reported, CCS is a key technology that shows potential for reducing CO₂ emissions from coal plants.¹² Specifically, CCS technologies separate and capture CO₂ from other gases produced when combusting or gasifying coal, compress it, then transport it to underground geologic formations such as saline aquifers—porous rock filled with brine—or oil and natural gas reservoirs, where the captured CO₂ is injected for long-term storage.

Globally, two power plants currently generate electricity from fossil fuel while capturing CO₂ in large quantities: the Boundary Dam plant in Canada and the Petra Nova plant in Texas. Both plants retrofitted CCS technology to existing plants. A third fossil-fueled, electricity-generating operation, the Kemper County Energy Facility in Mississippi, was scheduled to begin CCS operations in 2016, but cost overruns and delays in construction and operations led to the suspension of the plant's CCS component in June 2017. Each of these power plants using CCS systems may be described as a first-of-its-kind venture, using technologies developed at a pilot scale ramped up to commercial scale. It is not unusual for projects in the demonstration phase of the R&D process to experience higher-than-anticipated costs, delays, and other challenges, according to a 2017 Congressional Research Service report.¹³

DOE generally uses announcements of opportunities for federal financial assistance to competitively solicit potential applicants of advanced fossil energy R&D projects. According to DOE officials, the department sets priorities for its advanced fossil energy R&D funding each year based in part on the amount appropriated for FE R&D and on FE's R&D plans, as well as any direction that Congress may have specified for certain types

¹²GAO, *Coal Power Plants: Opportunities Exist for DOE to Provide Better Information on the Maturity of Key Technologies to Reduce Carbon Dioxide Emissions*, GAO-10-675. (Washington, D.C.: June 16, 2010).

¹³Congressional Research Service, *Carbon Capture and Sequestration (CCS) in the United States*. (Washington D.C.: November 14, 2017).

of technology R&D. DOE's advanced fossil energy R&D projects typically lasted for multiple years.

DOE sets milestones for technical progress for each year of a project to ensure that funding recipients accomplish a specific R&D objective or set of objectives, according to DOE officials. The recipient may submit some form of report on its progress on the R&D as well as accomplishments to DOE for review and approval to continue. DOE officials told us they review the progress of the recipient at each phase and the project continuation is subject to the recipient's technical progress, the recipient's compliance with all of the other terms—including any financial terms—of the agreement, and the availability of DOE's funds, based on congressional appropriations.

DOE's Loan Guarantee Program

The LGP was originally designed to address a fundamental impediment to innovative and advanced energy projects: securing enough affordable financing to survive the period between developing innovative technologies and commercializing them. As we have previously reported, these projects have risks, such as technology risk—the risk that the new technology will not perform as expected—and execution risk—the risk that the borrower or project will not perform as expected.¹⁴ Because the risks that commercial lenders must assume to support new technologies can put the cost of private financing out of reach, companies may not be able to commercialize innovative technologies without the federal government's financial support.

Federal loan guarantee programs such as the LGP can help companies obtain financing because the federal government agrees to reimburse the lender for the guaranteed amount if a borrower defaults. Section 1703 of EPAct authorizes DOE to provide loan guarantees for projects that avoid, reduce, or sequester air pollutants or man-made emissions of greenhouse gases and employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued.¹⁵ EPAct describes several categories

¹⁴GAO, *DOE Loan Programs: Current Estimated Net Costs Include \$2.2 Billion in Credit Subsidy, Plus Administrative Expenses*, GAO-15-438 (Washington, D.C.: April 27, 2015).

¹⁵Pub. L. No. 109-58, § 1703, 119 Stat. 594, 1120 (2005) (codified as amended at 42 U.S.C. § 16513).

of projects that are eligible for guarantees under the program, including, among others, renewable energy systems, efficient end-use energy technologies, advanced nuclear facilities, advanced fossil energy technology, and CCS technologies. DOE's Loan Programs Office, which administers the LGP, had issued three loan guarantees under Section 1703 supporting nuclear technologies as of August 2018, but none supporting advanced fossil energy or any other technologies.

DOE Provided \$2.66 Billion in Funding for 794 Advanced Fossil Energy R&D Projects Started from Fiscal Years 2010 through 2017

DOE provided \$2.66 billion in funding for 794 advanced fossil energy R&D projects started from fiscal years 2010 through 2017. These 794 projects included 9 later-stage large demonstration projects and 785 other advanced fossil energy R&D projects.¹⁶ DOE provided \$1.12 billion in funding to nine large projects aimed at demonstrating the commercial viability of CCS technologies. DOE provided \$1.54 billion in funding to 785 other R&D projects for both coal and oil and gas technologies, mostly to universities and industry, located in 46 states and the District of Columbia.

DOE Provided \$1.12 Billion in Funding for Nine Large Demonstration Projects Started from Fiscal Years 2010 through 2017

For nine large demonstration projects started from fiscal years 2010 through 2017, DOE provided \$1.12 billion in funding. These projects received that funding from appropriations from the American Recovery and Reinvestment Act of 2009 (Recovery Act)¹⁷ and supported efforts to reduce the financial and technical risks of commercial CCS, according to

¹⁶The 785 R&D projects include all the advanced fossil energy R&D projects except for the 9 large demonstration projects in our scope.

¹⁷The Recovery Act was enacted in 2009 to preserve and create jobs, promote economic recovery, and to provide investments needed to increase economic efficiency by spurring technological advances in science and health, among other things. Pub. L. No. 111-5, 123 Stat. 115 (2009).

a 2017 report by the Congressional Research Service.¹⁸ Six demonstration projects researched CCS technologies using coal, while three used other fuels, namely methane, ethanol, and petcoke.¹⁹ Recipients were generally required to provide a certain percentage of the cost of each R&D project, called cost share.²⁰ Specifically, to receive funding, recipients of funding for the nine large demonstration projects agreed to pay at least \$610 million in cost share for the demonstration projects. Three of those demonstration projects remained active at the end of fiscal year 2017. Four projects had their support withdrawn by DOE, and two were withdrawn by the recipient. These projects ended due to several factors such as a lack of technical progress, the closure of the Recovery Act appropriations account on September 30, 2015, and changing economic conditions—such as decreased natural gas prices which resulted in changes in the relative prices of coal and natural gas.

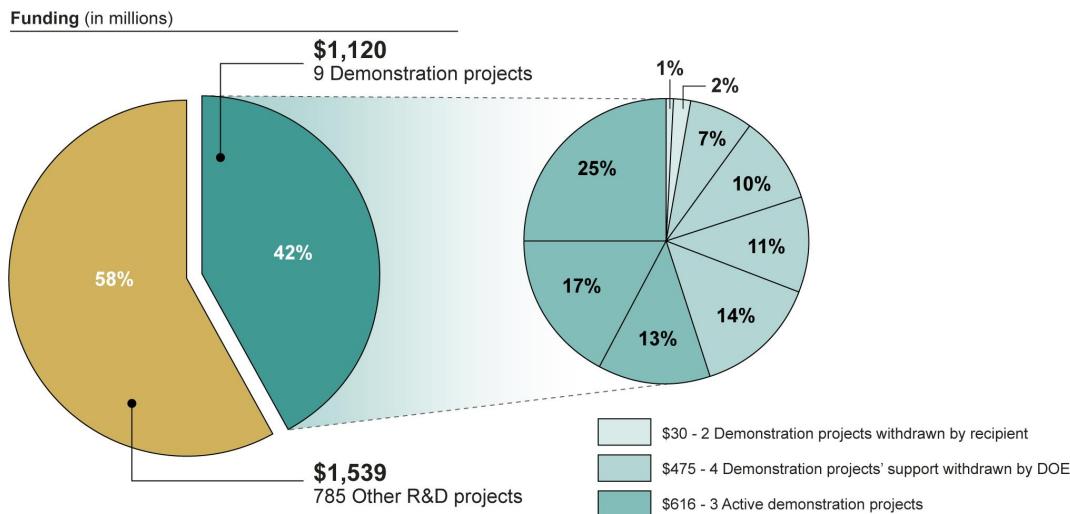
The nine large demonstration projects represented over 40 percent of the \$2.66 billion in advanced fossil energy R&D funding for the 794 projects (see fig. 1).

¹⁸Congressional Research Service, *Carbon Capture and Sequestration: Research, Development, and Demonstration at the U.S. Department of Energy*. Washington D.C.: April 24, 2015.

¹⁹Petcoke—petroleum coke—is a waste byproduct of oil refining with an appearance and texture similar to coal.

²⁰In general, once a project begins, the recipient is responsible for cost overruns, plus all the unallowable project costs (i.e. project costs in which the government is not permitted to share), according to DOE officials.

Figure 1: Distribution of Department of Energy (DOE) Funding for Advanced Fossil Energy Research and Development Projects that Started from Fiscal Years 2010 through 2017



Source: GAO analysis of Department of Energy (DOE) data. | GAO-18-619

Note: Of the 794 research and development projects, 9 later-stage large demonstration projects supported carbon capture and storage technologies to assess their readiness for commercial viability. Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of our report, we use the term funding to mean obligations. Funding amounts may not sum exactly due to rounding.

Three Large Demonstration Projects Remained Active as of the End of Fiscal Year 2017

Of the \$1.12 billion in funding for the advanced fossil energy demonstration projects, DOE provided \$616 million in funding for three large demonstration projects that started in fiscal year 2010 and that remained active as of the end of fiscal year 2017.

- Petra Nova Parish Holdings of Texas has a demonstration project underway that has retrofitted an existing coal-fired power plant in Texas with post-combustion carbon capture technology, according to DOE documentation.²¹ The objective of this project is to demonstrate the ability to capture 90 percent of the CO₂ emitted from a flue gas stream—gas created from burning coal. DOE

²¹Post-combustion carbon capture is a process in which the CO₂ is captured from flue gases (gases that are emitted as exhaust) after the fossil fuel has been burned. It is used mainly for conventional coal-fired power generation, but the term can also apply to combustion turbines and other combustion systems fired by natural gas.

provided \$190 million in funding for the project from fiscal years 2010 through 2017.²² According to DOE documentation, DOE's involvement with the project is scheduled to conclude in December 2019. The Petra Nova project captured and stored its first 1 million metric tons of CO₂ in November 2017, according to DOE officials.

- Archer Daniel Midlands of Illinois had a demonstration project underway to capture CO₂ produced as a by-product of the production of fuel-grade ethanol for its demonstration project in Illinois, according to DOE documentation. The objective of this project is to capture approximately 1 million tons of CO₂ per year using dehydration and compression processes and sequester it in the Mt. Simon Sandstone formation (a saline reservoir) in Illinois.²³ DOE provided \$141 million in funding for the project from fiscal years 2010 through 2017. DOE's involvement with the project is scheduled to conclude in September 2019, according to DOE documentation. During calendar year 2017, the project captured and stored over 500,000 metric tons of CO₂, according to DOE officials.
- Air Products and Chemicals of Pennsylvania designed, constructed, and began operating a system to capture the CO₂ emitted from two large steam-methane reformers, which produce hydrogen from methane, for its demonstration project in Texas.²⁴ The captured gas is compressed and sent via pipeline to oil fields in eastern Texas to be used for enhanced oil recovery and thereby sequestered, according to DOE documentation.²⁵ DOE provided \$284 million in funding for the project from fiscal years 2010

²²While our scope included advanced fossil energy R&D projects that started in fiscal years 2010 through 2017, DOE officials told us that in a few instances they provided some funding at the time of the award, in fiscal year 2009, prior to the start of the project.

²³A saline reservoir is a subsurface saline aquifer (water-bearing stratum of permeable sand, rock, or gravel).

²⁴Most hydrogen produced today in the United States is made via steam-methane reforming, a mature production process in which high-temperature steam (700°C–1,000°C) is used to produce hydrogen from a methane source, such as natural gas.

²⁵Enhanced oil recovery is the process in which heat, chemicals, or gases such as CO₂ are injected into depleted oil and gas formations to recover those resources that would otherwise be difficult to reach. Gas injection accounts for nearly 60 percent of enhanced oil recovery production in the United States.

through 2017. DOE's involvement under this demonstration project's award concluded the last day of fiscal year 2017.²⁶

DOE Withdrawn Support for Four Large Demonstration Projects

DOE provided assistance for four large demonstration projects until the agency withdrew support for them. Of the total \$1.12 billion in funding for the nine advanced fossil energy demonstration projects, DOE provided \$475 million in funding for these four projects. Demonstration projects are inherently risky, and DOE withdrew support for these projects for a number of reasons, including:

- DOE provided financial assistance for two large demonstration projects through FutureGen 2.0 that started at the beginning of fiscal year 2011.²⁷ The first project was expected to use oxy-combustion technology to create a near-zero emissions coal-fired power plant by capturing and compressing at least 90 percent of the plant's CO₂ and eliminating almost all the sulfur oxides, nitrogen oxides, particulate, and mercury pollutants from plant emissions, according to DOE documentation.²⁸ The second project concurrently planned to construct and operate a CO₂ pipeline from the plant site to a storage site located about 30 miles to the east where approximately 1 million metric tons per year of compressed and purified CO₂ were to be injected into the Mt. Simon Sandstone formation (a saline reservoir) in Illinois. DOE provided just over \$200 million in total funding for both projects.

²⁶As of May 1, 2018, the project was still in operation and had captured and stored 4.5 million metric tons of CO₂, according to DOE officials.

²⁷In 2003, DOE announced its FutureGen program as a \$1 billion venture, partnering with the electric power industry to design, build, and operate the world's first coal-fired, zero-emissions power plant. In 2005, the FutureGen Industrial Alliance, a nonprofit consortium of some of the largest coal producers and electric power companies in the world, formed to join DOE in this effort. In January 2008, DOE announced that it would not continue its cooperative agreement with the Alliance and that it was going to take a different approach to FutureGen. The original FutureGen was a DOE research and development project, but the restructured FutureGen was a DOE commercial demonstration project. For more information, see GAO, *Clean Coal: DOE's Decision to Restructure FutureGen Should Be Based on a Comprehensive Analysis of Costs, Benefits, and Risks*, GAO-09-248 (Washington, D.C.: Feb. 13, 2009).

²⁸Oxycombustion is a process in which coal is burned in oxygen instead of in air, with the resulting exhaust containing only CO₂ and water vapor. Because it yields an almost 100-percent CO₂ stream that is readily transportable, the process has strong potential but is extremely energy-intensive, according to DOE documentation.

According to a DOE fact sheet on FutureGen 2.0, DOE initially estimated the cost expected to be borne by the federal government for the completion of both projects to be over \$1 billion. DOE directed the suspension of FutureGen 2.0 project development activities in February 2015 because DOE concluded that there was insufficient time to complete the projects before the closure of the Recovery Act appropriations account on September 30, 2015.

- DOE provided assistance for one large demonstration project started in fiscal year 2010 by Hydrogen Energy California. This project was to design, build, and operate a commercial scale, advanced integrated gasification combined cycle power plant and fertilizer production facility with CCS in California.²⁹ The project was expected to achieve at least 90 percent carbon capture efficiency while storing approximately 2.6 million tons of CO₂ per year in an enhanced oil recovery application. DOE provided a total of \$154 million in funding for the project. According to a DOE fact sheet on this project, DOE initially estimated the cost expected to be borne by the federal government for the completion of this project to be \$408 million. However, according to DOE officials, the recipient faced a number of challenges, such as obtaining permits, planning a railroad extension, and securing additional financing sources for construction. The recipient repeatedly missed milestones under the award that delayed the project's ability to meet DOE's objectives, according to DOE officials. As a result of these delays, and the closure of the Recovery Act appropriations account on September 30, 2015, DOE withdrew funding for this project after the recipient's period of performance ended on January 20, 2015.
- DOE provided assistance for one large demonstration project started in fiscal year 2010 by Summit Texas Clean Energy. This project was to integrate carbon capture technology with a new integrated gasification combined cycle power facility in Penwell, Texas. Captured CO₂ was to be sold for various enhanced oil

²⁹In integrated gasification combined cycle (IGCC) power plants, coal is gasified to produce synthesis gas, consisting primarily of hydrogen, carbon monoxide, and CO₂. Through IGCC, electricity is generated more efficiently than through conventional pulverized coal-fired technology—the process most widely in use—because IGCC uses less coal to generate the same amount of electricity. In addition, oxygen-fired IGCC plants produce CO₂ as a concentrated gas stream at high pressure that may be captured and stored more easily and cheaply than CO₂ from a typical pulverized coal-fired power plant, which emits CO₂ that must be separated from other gases before storing.

recovery operations. The project was originally slated to have a groundbreaking in mid- to late-summer 2015. Construction was expected to be completed in mid-2018 with a ramp up to full commercial operations to begin soon afterward. DOE provided \$120 million in funding for the project. According to a DOE fact sheet about this project, DOE initially estimated the cost expected to be borne by the federal government for the completion of this project to be \$450 million. In 2017, DOE withdrew funding for this demonstration project because the recipient had failed to achieve the technical objectives specified under the DOE award and had not secured financing for the project, according to DOE officials. The DOE Office of Inspector General issued a special report on this project in 2016 to discuss its concern about the viability of the project.³⁰ In 2018, after DOE had withdrawn its support for the project, the Inspector General issued a full audit report, stating that DOE had not always effectively and efficiently managed financial aspects of this project.³¹ According to DOE officials, DOE management accepted the Inspector General's audit recommendations and initiated steps to address them.

Two Recipients Withdrew Their Projects

DOE provided assistance for two large demonstration projects from which the recipients subsequently withdrew. Of the total \$1.12 billion in funding for the advanced fossil energy demonstration projects, DOE provided a total of \$30 million in funding for these two demonstration projects.

- American Electric Power of West Virginia, starting in fiscal year 2010, was to lead the design, construction, and operation of a CCS system using the chilled ammonia process, which was expected to capture at least 90 percent of the CO₂ from the Mountaineer coal-fired power plant located near New Haven, West Virginia.³² Captured CO₂ was to have been permanently

³⁰Department of Energy, Office of Inspector General, *The Department of Energy's Continued Support of the Texas Clean Energy Project Under the Clean Coal Power Initiative*, OIG-SR-16-02 (Washington, D.C.: Apr. 26, 2016).

³¹Department of Energy, Office of Inspector General, *The Office of Fossil Energy's Oversight of the Texas Clean Energy Project Under the Clean Coal Power Initiative*, DOE-OIG-18-17 (Washington, D.C.: Feb. 8, 2018).

³²In the chilled ammonia process, an ammonia based solution reacts with CO₂ of cooled flue gas. Raising the temperature reverses this reaction and pressurized CO₂ is released. The solution is then recycled.

sequestered in a subsurface geologic formation. DOE provided \$17 million in funding for the project. According to a DOE fact sheet about this project, DOE initially estimated the cost expected to be borne by the federal government for the completion of this project to be \$334 million. The project ended on September 30, 2011 with the completion of all phase I milestones and deliverables. The recipient withdrew after completion of phase I and terminated this demonstration project before advancing to the design, construction, and operations stages. This decision to withdraw was the result of challenges that the recipient faced in its ability to fund its portion of the cost share for the commercial scale project, among other things, according to DOE documentation.

- Leucadia Energy of New York, starting in fiscal year 2010, was to demonstrate the capture of CO₂ from an industrial facility for use in an independent, enhanced oil recovery application. The industrial source of CO₂ was to be a petcoke-to-chemicals (i.e., methanol and other by-products) gasification plant being developed by Lake Charles Clean Energy in Lake Charles, Louisiana.³³ DOE provided \$13 million in funding for the project. According to a DOE fact sheet about this project, DOE initially estimated the cost expected to be borne by the federal government for the completion of this project to be \$261 million. On September 24, 2014, due to its business assessment of the core methanol plant, Leucadia Energy informed DOE that it would withdraw and not pursue the main petcoke-to-methanol project, and as such could not continue with the proposed demonstration project. DOE officials told us this decision was unrelated to the additional deployment of the CCS technologies that were supported by the DOE demonstration project, which ended at that point.³⁴

³³Methanol is one of the world's most widely-used industrial chemicals in applications including paints and plastics, furniture and carpeting, automotive parts, windshield washer fluid, and fuel blending.

³⁴On December 21, 2016, DOE announced a conditional commitment for a loan guarantee of up to \$2 billion via its Loan Programs Office's LGP to the Lake Charles Methanol Project, which would leverage upon the work and experience gained from the earlier Leucadia Energy project. We discuss the Lake Charles Methanol Project later in this report.

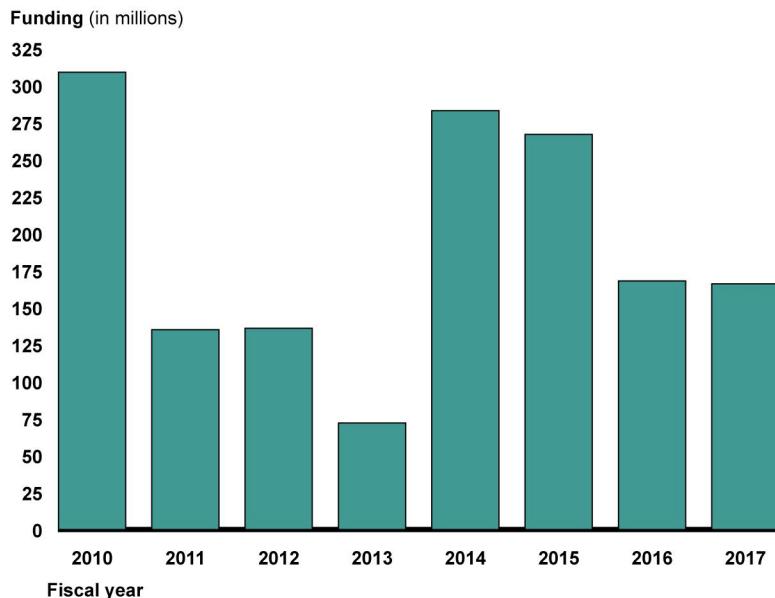
DOE Provided \$1.54 Billion in Funding for 785 Other R&D Projects Started from Fiscal Years 2010 through 2017 to Support Advanced Fossil Energy

DOE provided \$1.54 billion in funding for 785 other advanced fossil energy R&D projects started from fiscal year 2010 through 2017. For these 785 R&D projects, DOE provided:

- on average, \$2.0 million per project;
- a median of \$0.8 million per project;
- less than \$5 million to 91.8 percent (721) of the 785 projects; and
- less than \$1 million to 58.1 percent (456) of the projects.

For projects started from fiscal years 2010 through 2017, total funding for projects by fiscal year started ranged from less than \$100 million to more than \$300 million (see fig. 2).

Figure 2: Department of Energy's (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects Other than Large Demonstration Projects Started from Fiscal Years 2010 through 2017, by Fiscal Year Started



Source: GAO analysis of DOE data. | GAO-18-619

Note: Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of our report, we used the term funding to mean obligations, and we defined the 785 R&D projects to be inclusive of the advanced fossil energy R&D projects except for

the 9 large demonstration projects in our scope. This bar chart includes 785 research and development projects—that is, all of the projects in our scope that were not the large demonstration projects. The data for each fiscal year represent total obligations for the projects that started in that fiscal year, rather than total obligations by fiscal year.

As noted earlier, recipients of DOE's R&D funding were generally required to provide cost share to support the cost of each R&D project. For 661 of the 785 projects, the initially agreed-upon dollar amount to be covered by recipients was \$617 million in cost-share. Recipients did not provide a cost-share for the remaining 124 of the 785 projects, which were predominantly grants without cost share requirements, according to DOE officials.

According to DOE data, DOE provided the largest amount of funding for projects started in 2010 because DOE received a supplemental appropriation for fossil energy R&D through the Recovery Act. DOE provided funding for 72 of the coal technologies research projects—totaling \$237 million—using appropriations from the Recovery Act, according to DOE data.

Of the 785 R&D projects for which DOE provided funding, most advanced fossil energy projects researched coal technologies rather than oil and gas, and recipients of the funding were generally universities and industry groups that were distributed across the country.

Most of DOE's 785 Advanced Fossil Energy Projects Researched Coal Technologies

Of the 785 projects, 698 (about 89 percent) involved coal technologies, receiving \$1.40 billion (about 91 percent) of the \$1.54 billion in funding DOE provided for the projects. The remaining projects and funding supported R&D for oil and gas technologies, according to DOE's categorization of the projects by fuel type (see table 1).

Table 1: Department of Energy's (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017 by Fuel Type

Fuel type ^a	Number of projects	Funding amounts (in dollars)
Coal	698	1,396,712,035
Oil and Gas	87	141,888,174
Total	785	1,538,600,209

Source: GAO analysis of DOE data. | GAO-18-619

Note: Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of our report, we used the term funding to mean obligations, and we

defined the 785 R&D projects to be inclusive of the advanced fossil energy R&D projects except for the 9 large demonstration projects in our scope.

^aDOE identified the fuel types for each project. This table represents funding for R&D projects provided through DOE's National Energy Technology Laboratory.

Within each fuel type, projects researched various technology types, such as R&D on coal gasification systems and the mitigation of methane emissions from natural gas infrastructure.³⁵ The funding for the 785 R&D projects ranged from \$5,000 for a research conference (oil and gas) to \$125 million for a research facility focused on next-generation CCS technologies (coal).

The funding for the 698 R&D projects that are coal-related ranged from \$28,000 for detection of low concentrations of heavy metals in power plant water supplies to the active \$125 million project for a research facility focused on next-generation CCS technologies. In a 2017 report, DOE identified the following six categories as coal-related research areas for its R&D projects:³⁶

- **Carbon Capture:** The development of research to enable the cost-effective implementation of carbon capture technologies throughout the power generation sector, including at new and existing coal-based power plants. For example, DOE provided FuelCell Energy Inc., of Connecticut, about \$4 million in funding for a 3-and-a-half-year active project for a pilot test of a novel system for CO₂ capture and power generation.
- **Carbon Storage:** The development of processes of storing the CO₂ that has been separated and captured from coal-powered processes in deep underground geological formations. For example, DOE provided the University of Texas at Austin \$1 million in funding for a 1-and-a-half-year project to study the feasibility of integrated CCS in the northwest Gulf of Mexico.
- **Advanced Energy Systems:** The development of energy technologies that can minimize the environmental impact of coal use and optimize energy resources. DOE has provided financial assistance for R&D in this category for the process of converting carbon-containing material (i.e., coal) into synthesis gas, and the development of advanced turbines that will serve to improve the

³⁵Coal gasification is the process in which carbon-containing material is converted into synthesis gas.

³⁶Department of Energy, *National Energy Technology Laboratory (NETL) Coal Research and Development: Overview* (Aug. 15, 2017).

efficiency and reduce the cost of coal-fueled power plants with carbon capture, among other areas. For example, DOE provided Ohio State University over \$600,000 in funding for a 3-year active project on revolutionizing turbine cooling.

- **Supercritical CO₂ Technology:** The development of directly-heated power cycles using more advanced coal conversion systems based on supercritical CO₂ cycles.³⁷ This technology seeks to use CO₂ as the working fluid in the turbomachinery compared to existing steam-based power cycles in coal plants. For example, DOE provided the Institute of Gas Technology Inc., of Illinois, \$35 million in funding for a 6-year active project for a supercritical CO₂ pilot plant test facility planned to be completed at the end of fiscal year 2022.
- **Crosscutting Technologies:** The development of tools, support of research, and sponsorship of science and engineering education designed to contribute to, and encourage, greater collaboration among disciplines and across each of the coal-related research areas. DOE transitions successful crosscutting technologies to its other coal R&D programs. DOE has provided financial assistance for R&D in this category for the development of functional materials for advanced fossil energy power production technologies and the treatment of water extracted by injection of CO₂ into deep saline aquifers, among other areas. For example, DOE provided the Research Triangle Institute in North Carolina \$750,000 in funding for a 2-year project on a low-cost, low-energy treatment process using a non-aqueous solvent extraction to recover water from deep aquifer brines.
- **Rare Earth Elements:** The development of research and methods for rare earth elements' separation and recovery from coal and coal by-products, among other things. For example, DOE provided the University of Kentucky \$400,000 in funding for a 1-and-a-half-year project to identify and characterize rare earth elements from coal and coal by-products.

The other 87 of the 785 projects (about 11 percent) researched oil and gas technologies, such as hydraulic fracturing (fracking) and the

³⁷ Supercritical power cycles are operated above the critical point of CO₂ so that it does not change phases, but rather undergoes drastic density changes over small ranges of temperature and pressure. Such cycles have shown the potential for increased heat-to-electricity conversion efficiencies, high power density, and simplicity of operation compared to existing steam-based power cycles.

production of hydrocarbons—primarily natural gas—from shale formations. The funding for the oil and gas R&D projects ranged from \$5,000 for a research conference to \$29 million for the University of Texas at Austin’s active project on the deep-water characterization and scientific assessment of gas hydrates. Specifically, DOE identified the following four categories as oil and gas-related research areas:

- **Gas Hydrates:** The development of technologies to find, characterize, and recover methane from gas hydrates through field testing, numerical simulation, and laboratory experimentation, among other things. For example, DOE provided the University of California-San Diego \$350,000 in funding for a 3-year active project to characterize the baselines and changes in gas hydrate systems.
- **Natural Gas Infrastructure:** The monitoring of the U.S. natural gas pipeline network, which includes more than 300,000 miles of interstate and intrastate transmission pipelines. For example, DOE provided the University of Pittsburgh \$1.2 million in funding for a 3-year active project on multi-functional fiber sensors for pipeline monitoring and methane detections.
- **Onshore Unconventional Resources:** The production of hydrocarbons—primarily natural gas—from shale formations. For example, DOE provided the Ground Water Protection Council, of Oklahoma, \$13 million for an 8-year project for data management and regulatory approaches related to hydraulic fracturing and geologic sequestration of CO₂.

Offshore Oil and Gas: Although this research area is not currently active, according to DOE documentation, the multiyear oil and gas R&D projects that received funding prior to 2014 continued through September 2016.³⁸ The R&D projects in this area included research on geologic uncertainty prediction of oil and gas, and improvement of subsea systems reliability through automation and advanced technology.

³⁸Section 301 of the Bipartisan Budget Act of 2013 repealed provisions of the Energy Policy Act of 2005 that had authorized an R&D program relating to ultra-deepwater and unconventional natural gas and other petroleum resource exploration and production. Pub. L. No. 113-67, § 301, 127 Stat. 1165, 1181 (2013) (repealing Pub. L. No. 109-58, Title IX, Subtitle J, 119 Stat. 594, 916 (2005)). The 2013 law also rescinded any unobligated funds appropriated for carrying out that program.

Recipients Were Generally Universities and Industry Groups That Were Distributed Across the Country

The recipients of the funding for the 785 advanced fossil energy R&D projects were mostly universities and industry groups that were located in 47 states and the District of Columbia. Of these recipients, approximately 51 percent were universities; 43 percent were industry groups; and 5 percent were other entities, including other federal agencies, such as the U.S. Geological Survey (see table 2).

Table 2: Recipient Types for the Department of Energy's (DOE) Advanced Fossil Energy Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017

Recipient type	Number of recipients	Percent of all recipients
University ^a	165	51
Industry ^b	140	43
Other ^c	17	5
Total	322	100

Source: GAO analysis of DOE data. | GAO-18-619

Note: Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of our report, we defined the 785 R&D projects to be inclusive of the advanced fossil energy R&D projects except for the 9 large demonstration projects in our scope. Percentages may not sum to 100 due to rounding.

^aWe defined university as any institution of higher education, such as a public or non-profit private college, junior college, or university.

^bWe defined industry as any private sector organization that is not an institution of higher education, such as a consulting group or business.

^cOther includes any entity not associated with a university or industry, including federal agencies.

While university recipients received funding for a majority of projects, industry recipients received a majority of the funding (see table 3).

Table 3: Department of Energy's (DOE) Advanced Fossil Energy Research and Development (R&D) Projects and Funding by Recipient Type for Projects Started during Fiscal Years 2010 through 2017

Recipient type	Number of projects	Percent of all projects	Funding amounts (in dollars)	Percent of all funding
University ^a	466	59	566,138,094	37
Industry ^b	289	37	922,989,703	60
Other ^c	30	4	49,472,412	3
Total	785	100	1,538,600,209	100

Source: GAO analysis of DOE data. | GAO-18-619

Note: Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of our report, we used the term funding to mean obligations, and we defined the 785 R&D projects to be inclusive of the advanced fossil energy R&D projects except for the 9 large demonstration projects in our scope.

^aWe defined university as any institution of higher education, such as a public or non-profit private college, junior college, or university.

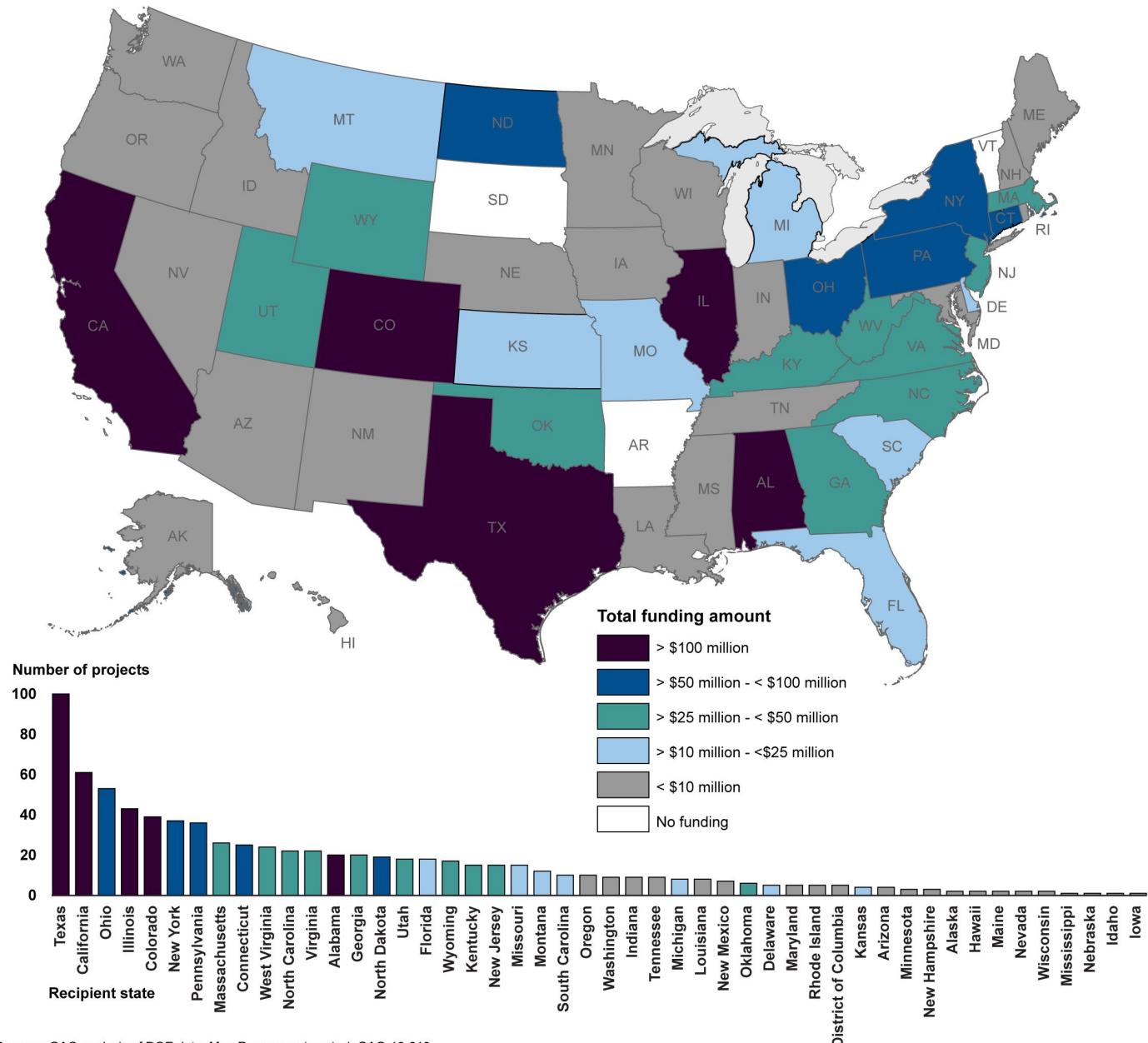
^bWe defined industry as any private sector organization that is not an institution of higher education, such as a consulting group or business.

^cOther includes any entity not associated with a university or industry, including federal agencies.

Recipients were located in 47 states and the District of Columbia.³⁹ The three states with the highest number of projects with recipients located in their states were Texas (100), California (61), and Ohio (53). The three states where recipients received the most funding were Texas (about \$169 million), Alabama (about \$161 million), and California (about \$152 million) (see fig. 3).

³⁹This information refers to the location of the entity that received funding. Projects did not necessarily take place in the states where recipients were located. Additionally, according to DOE officials, four recipients were located outside the United States.

Figure 3: Department of Energy's (DOE) Advanced Fossil Energy Funding for Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017 by Recipient Location



Sources: GAO analysis of DOE data; Map Resources (map). | GAO-18-619

Note: This information refers to the location of the entity that received funding. Projects did not necessarily take place in the state where their recipient was located. Additionally, according to DOE officials, four recipients were located outside the United States. Advanced fossil energy projects include research on innovative coal, natural gas, and oil technologies. For purposes of our report, we

used the term funding to mean obligations, and we defined the 785 R&D projects to be inclusive of the advanced fossil energy R&D projects except for the 9 large demonstration projects in our scope.

DOE Made No Loan Guarantees for Advanced Fossil Energy from Fiscal Year 2006 through August 2018

Although DOE issued three solicitations for applications for advanced fossil energy loan guarantees—most recently in fiscal year 2014, for up to \$8 billion in loan guarantees—DOE had not guaranteed any loans for advanced fossil energy as of August 2018.⁴⁰ Specifically, the 2006 and 2008 advanced fossil energy solicitations were for projects that involved coal-based power generation and that would incorporate CCS, coal gasification, or other beneficial uses of carbon, among other things. However, neither solicitation resulted in any loan guarantees, in part because during this timeframe of the late 2000s, natural gas prices fell, causing a shift in the market, which led to such coal-related projects no longer being economically competitive, according to DOE officials.⁴¹ According to the fiscal year 2014 solicitation, applicants could use any fossil fuel—including coal, oil, or natural gas—that would reduce, avoid, or sequester greenhouse gases.

In response to the 2014 advanced fossil energy solicitation, DOE officials told us that DOE had received 19 applications total. According to DOE officials:

- Five fossil energy applicants were actively moving through the process of review as of August 2018. For example, in January 2018, one applicant issued a press release stating that it was pursuing a \$1.9 billion loan guarantee to support the development of infrastructure for a proposed underground storage facility for natural gas liquids and intermediates.
- Nine fossil energy applicants had been idle or not following up with the Loan Programs Office.

⁴⁰DOE also issued advanced fossil loan guarantee solicitations in 2006, for up to \$2 billion, and in 2008, for up to \$8 billion. Both prior solicitations have closed. The 2014 solicitation will close in fiscal year 2020.

⁴¹According to DOE documentation, DOE received a total of 26 applications for the 2006 advanced fossil energy solicitation, and 8 applications for the 2008 solicitation.

-
- Three applicants did not meet certain eligibility requirements.⁴²
 - Two companies withdrew their applications—one in 2014, and one in 2018.

Of the five advanced fossil energy applicants actively in the process of DOE review, DOE offered a conditional commitment to guarantee up to \$2 billion in loans to one applicant—Lake Charles Methanol—in December 2016. As we have previously reported, a conditional commitment is one where DOE commits to issue a loan guarantee if the applicant satisfies specific requirements.⁴³ According to information on the DOE website, the Lake Charles Methanol plant in Louisiana would produce methanol from the gasification of petcoke, and capture and transport the CO₂ to Texas for enhanced oil recovery. According to DOE documentation, the Lake Charles project planned to leverage the work and experience gained from the earlier DOE demonstration project by Leucadia Energy.⁴⁴

Agency Comments

We provided a draft of this report to DOE for review and comment. DOE provided technical comments, which we incorporated as appropriate.

As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretary of Energy, and other interested parties. In addition, the report will be available at no charge on the GAO website at <http://www.gao.gov>.

⁴²For example, in order to receive loan guarantees under Section 1703 of EPAct, including for advanced fossil energy, projects must meet certain greenhouse gas requirements. Specifically, to be eligible for loan guarantees, projects must avoid, reduce, or sequester air pollutants or man-made emission of greenhouse gases; and must employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time of loan guarantee issuance. 42 U.S.C. § 16513(a).

⁴³The Secretary of Energy has the discretion to cancel a conditional commitment at any time for any reason prior to the issuance of a loan guarantee. See GAO, *DOE Loan Guarantees: Further Actions Are Needed to Improve Tracking and Review of Applications*, GAO-12-157 (Washington, D.C.: Mar. 12, 2012).

⁴⁴Leucadia received funding from DOE as a large demonstration project, as noted previously.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix II.

Sincerely yours,



Frank Rusco
Director, Natural Resources and Environment

Appendix I: Objectives, Scope, and Methodology

In this report, we describe 1) the Department of Energy's (DOE) funding of advanced fossil energy research and development (R&D) projects started from fiscal years 2010 through 2017 and the types of projects and recipients that received funding, and 2) DOE's loan guarantees, if any, for advanced fossil energy projects from fiscal year 2006 through August 2018.¹ You asked us to review DOE's funding for advanced fossil energy projects.

To address the first objective, we reviewed relevant laws, regulations, and DOE guidance. We analyzed DOE advanced fossil energy R&D project data for fiscal years 2010 through 2017. We focused our review on advanced fossil energy R&D projects that received funding through the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL) because the 794 projects represent all of the advanced fossil energy R&D projects in our scope started from fiscal years 2010 through 2017. We used fiscal year 2010 as the start date because DOE officials told us that DOE's current data management system came into use for the R&D projects that started in fiscal year 2010. We used fiscal year 2017 as the end date because that was the most recent complete year for which data were available. DOE provided us with a spreadsheet that included key project information—such as the name of the recipient of the R&D funding and the project start date—as well as obligations data for each project started for the period of our review (fiscal years 2010 through 2017), by the fiscal year during which the project was started, by summing the obligations for the project from each year. We reported on DOE's funding for these R&D projects; DOE generally provided financial

¹For the purposes of this report, we use the term funding to mean obligations. An obligation is a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received, or a legal duty on the part of the United States that could mature into a legal liability by virtue of actions on the part of the other party beyond the control of the United States. Payment may be made immediately or in the future. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another. GAO, *A Glossary of Terms Used in the Federal Budget Process*, GAO-05-734SP (Washington, D.C.: Sept. 2005).

assistance for these projects through grants or cooperative agreements.² Because advanced fossil energy R&D financial assistance for the Small Business Innovation Research and Small Business Technology Transfer programs, as well as for the DOE national laboratories, are not obligated through NETL, we excluded these projects from our scope.³ In addition, NETL's in-house R&D work was outside of the scope of our review. To assess the reliability of the funding data, as well as the specific project information for the 794 R&D projects, we interviewed data specialists at DOE Headquarters, FE, and NETL and reviewed DOE internal guidance for the maintenance of agency data. We found the data to be sufficiently reliable for our purposes. We also reviewed DOE websites and documentation, including fact sheets, and interviewed officials from FE and NETL.

To characterize the kinds of groups that received advanced fossil energy R&D funding, we developed the following definitions for coding each recipient:

- University: any institution of higher education, such as a public or non-profit private college, junior college, or university.
- Industry: any private sector organization that is not an institution of higher education, such as a consulting group or business. Industry includes any for-profit organizations involving a corporation, partnership, sole proprietorship or other organization which is

²Federal financial assistance means assistance that non-federal entities receive or administer in the form of grants, property, cooperative agreements, food commodities, direct appropriations, or other assistance, and can also include loans, loan guarantees, interest subsidies, and insurance, depending on the context, but does not include amounts received as reimbursement for services rendered to individuals in accordance with OMB-issued guidance. 2 C.F.R. § 200.40. See also 31 U.S.C. § 7501(5). A grant agreement is generally defined as a legal instrument of financial assistance between a federal awarding agency and a non-federal entity that is used to enter into a relationship the principal purpose of which is to transfer anything of value from the federal awarding agency to the non-federal entity to carry out a public purpose authorized by law, and not to acquire property or services for the federal awarding agency's direct benefit or use. 2 C.F.R. § 200.51. A cooperative agreement is distinguished from a grant in that it provides for substantial involvement between the federal awarding agency and the non-federal entity in carrying out the activity contemplated by the federal award. 2 C.F.R. § 200.24. For purposes of our report, we use the term awards to refer to both grants and cooperative agreements.

³We also did not include tax expenditures administered by the Department of the Treasury, such as the tax credits for industrial carbon dioxide capture and sequestration and investment in clean coal facilities.

organized primarily for profit. Industry includes some organizations that were founded as non-profit corporations but call themselves “companies” and/or describe “serving clients.”

- Other: any entity not associated with a university or industry. Other includes groups such as other federal government agencies, as well as non-profit corporations and other entities which we could not identify conclusively as either industry or universities.

We used these three categories, and their definitions, to guide us in the coding process. After developing these definitions, three analysts independently coded each recipient as a university, industry, or other. Our method was to examine the identifying information on each recipient’s website and decide which category best described the entity. We also had an independent analyst check the coding category that we had assigned to each recipient and verify that we had made a reasonable coding decision.

To describe the status of DOE’s advanced fossil energy loan guarantees, we reviewed relevant laws, regulations, and guidance, as well as past GAO reports describing DOE’s administration of the loan program. We also reviewed summary information that DOE provided on applications for loan guarantees for advanced fossil energy projects. We analyzed information that DOE provided on applications for loan guarantees for advanced fossil energy projects under the Loan Guarantee Program (LGP) and other related information for fiscal year 2006 through August 2018. We used fiscal year 2006 as the start date because it was the first year that DOE issued an advanced fossil energy project solicitation—an announcement of opportunities for loan guarantees for advanced fossil energy projects—and we used August 2018 as the end date in order to provide the most up-to-date information as possible. We also reviewed the advanced fossil energy project solicitations DOE issued during this timeframe. To assess the reliability of the summary information, we interviewed LGP staff who maintain the information for the advanced fossil energy applications, and reviewed DOE documentation. We found the data to be sufficiently reliable for our purposes. In addition, we interviewed officials from the Loan Programs Office who work on the LGP.

We conducted this performance audit from March 2017 to September 2018 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to

obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Frank Rusco, (202) 512-3841 or ruscof@gao.gov

Staff Acknowledgements

In addition to the contact named above, Karla Springer (Assistant Director), Rebecca Makar (Analyst-in-Charge), TC Corless, Cindy Gilbert, Carol Henn, Kirk Menard, Patricia Moye, Sheryl Stein, and Sara Sullivan made key contributions to this report. Also contributing to this report were Carolyn Blocker, Marcia Carlsen, Nirmal Chaudhary, Jaci Evans, Ryan Gottschall, Keesha Luebke, and John Yee.

Appendix III: Accessible Data

Data Tables

Data Table for Figure 2: Department of Energy's (DOE) Funding for Advanced Fossil Energy Research and Development (R&D) Projects Other than Large Demonstration Projects Started from Fiscal Years 2010 through 2017, by Fiscal Year Started

Fiscal Year	Obligations
2010	309
2011	135
2012	136
2013	72
2014	283
2015	267
2016	168
2017	166

Data Table for Figure 3: Department of Energy's (DOE) Advanced Fossil Energy Funding for Research and Development (R&D) Projects Started from Fiscal Years 2010 through 2017 by Recipient Location

Recipient state	Number of Projects	Obligations	Obligations (rounded to millions)
Alabama	20	\$160,620,059	161
Texas	91	\$159,102,593	159
California	59	\$148,766,878	149
Illinois	40	\$113,051,770	113
Colorado	38	\$98,961,227	99
Ohio	53	\$92,496,726	92
New York	36	\$80,987,752	81
North Dakota	19	\$62,270,219	62
Connecticut	24	\$56,032,036	56
Pennsylvania	35	\$55,727,355	56
Kentucky	15	\$39,090,576	39
Unknown	37	\$38,597,645	39
West Virginia	24	\$33,436,867	33
North Carolina	21	\$32,212,634	32
Massachusetts	24	\$31,484,301	31

Appendix III: Accessible Data

Recipient state	Number of Projects	Obligations	Obligations (rounded to millions)
Virginia	22	\$30,055,406	30
New Jersey	15	\$29,437,599	29
Georgia	20	\$28,679,945	29
Oklahoma	4	\$25,646,116	26
Utah	17	\$25,413,403	25
Wyoming	17	\$25,341,628	25
Kansas	4	\$23,497,255	23
Missouri	15	\$21,253,085	21
South Carolina	10	\$21,052,824	21
Florida	18	\$17,024,541	17
Montana	12	\$12,419,489	12
Delaware	5	\$10,513,070	11
Maryland	5	\$8,298,540	8
Michigan	7	\$8,107,616	8
Washington	8	\$5,720,198	6
Indiana	9	\$5,083,415	5
Oregon	8	\$5,000,437	5
Minnesota	3	\$4,815,201	5
Tennessee	9	\$3,825,363	4
New Mexico	6	\$3,707,569	4
Louisiana	8	\$3,546,723	4
Arizona	4	\$3,527,670	4
Alaska	2	\$3,302,344	3
Hawaii	2	\$2,058,917	2
Maine	2	\$1,718,737	2
Nevada	2	\$1,628,725	2
Rhode Island	4	\$1,366,413	1
New Hampshire	2	\$993,041	1
District of Columbia	4	\$826,440	1
Wisconsin	2	\$799,925	1
Nebraska	1	\$400,000	0
Idaho	1	\$399,938	0
Iowa	1	\$299,998	0

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's website (<https://www.gao.gov>). Each weekday afternoon, GAO posts on its website newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to <https://www.gao.gov> and select "E-mail Updates."

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's website, <https://www.gao.gov/ordering.htm>.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

Connect with GAO

Connect with GAO on [Facebook](#), [Flickr](#), [Twitter](#), and [YouTube](#).
Subscribe to our [RSS Feeds](#) or [E-mail Updates](#). Listen to our [Podcasts](#).
Visit GAO on the web at <https://www.gao.gov>.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Website: <https://www.gao.gov/fraudnet/fraudnet.htm>

Automated answering system: (800) 424-5454 or (202) 512-7700

Congressional Relations

Orice Williams Brown, Managing Director, WilliamsO@gao.gov, (202) 512-4400,
U.S. Government Accountability Office, 441 G Street NW, Room 7125,
Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548

Strategic Planning and External Liaison

James-Christian Blockwood, Managing Director, spel@gao.gov, (202) 512-4707
U.S. Government Accountability Office, 441 G Street NW, Room 7814,
Washington, DC 20548