Congressional Research Service
Informing the legislative debate since 1914

Recovery Act Funding for DOE Carbon Capture and Sequestration (CCS) Projects

Peter Folger
Specialist in Energy and Natural Resources Policy

February 18, 2016

Congressional Research Service
7-5700
www.crs.gov
R44387

CRS REPORT
Prepared for Members and
Committees of Congress

Summary

Federal policymakers have long been interested in the potential of carbon capture and sequestration (CCS) as a mitigation strategy for lowering global emissions of carbon dioxide (CO_2). Congress has appropriated more than $7 billion since FY2008 to CCS activities at the U.S. Department of Energy (DOE). The Obama Administration has promulgated rules on CO_2 emissions from fossil fuel-burning power plants and entered into a global agreement to limit CO_2 emissions. Congress remains divided over those executive branch decisions. DOE, however, has continued to embrace CCS as part of the Administration's strategy to reduce CO_2 emissions from power plants. Several bills introduced in the 114th Congress address CCS directly or indirectly (e.g., S. 601, S. 1283, H.R. 3392, and others).

The American Recovery and Reinvestment Act (Recovery Act; P.L. 111-5) provided $3.4 billion for CCS projects and activities at DOE. The large infusion of funding was intended to help develop technologies that would allow for commercial-scale demonstration of CCS in both new and retrofitted power plants and industrial facilities by 2020. Nine individual projects garnered approximately $2.65 billion of the $3.4 billion—about 78%. Each of the nine projects was awarded more than $100 million, and these projects illustrate that DOE prioritized large-scale demonstration projects with Recovery Act funding. The lion's share of funding went to DOE's flagship CCS project FutureGen, which was awarded nearly $1 billion from the Recovery Act.

Authority to spend Recovery Act funds expired on September 30, 2015. Of $3.4 billion allocated for CCS activities, approximately $1.4 billion went unspent as of the spending deadline. The largest portion of the unspent funds, $795 million, was intended for FutureGen, which DOE suspended in February 2015. FutureGen faced various impediments that led to its cancellation, including delays in receiving required injection well permits from the Environmental Protection Agency, court challenges to its plan to sell electricity, and a lawsuit from an environmental advocacy group. Several other large CCS demonstration projects also were canceled, suspended, or failed to spend all of their Recovery Act funding before the 2015 deadline.

Some stakeholders argue that DOE's CCS programs have been inadequately funded, providing less incentive than they should for deploying CCS. One study concluded that even the financial boost from the Recovery Act was insufficient. To be sure, large-scale CCS projects are complex endeavors, requiring substantial capital investment and multiyear planning and construction schedules. However, the conclusion that more federal funding by itself would be sufficient to support development and commercialization of CCS technology may be overly simplistic. DOE acknowledges that many of the Recovery Act-funded projects were technologically difficult and challenging, but it does not consider the relinquishment of unspent funds to signify project failure. DOE notes that due to its spending on CCS and its partnerships with industry, the costs of capturing CO_2 have dropped significantly and its projects have stored more than 10 million metric tons of CO_2.

The U.S. Environmental Protection Agency's (EPA's) final rule for reducing CO_2 emissions from new fossil fuel power plants, part of the Administration's Clean Power Plan, found plants incorporating partial CCS to be the Best System of Emission Reduction (BSER). EPA asserts that CCS is technically feasible. Technical feasibility, however, is just one factor of many that determine whether a project successfully reaches its goal of producing electricity and capturing CO_2 at commercial scale. EPA states that implementing partial CCS in the rule is likely to boost future research and development in CCS technologies and to make CCS implementation more efficacious and cost-effective. That may be the case; however, other issues also affect CCS implementation. These issues, as well as the outcomes from promulgation of EPA's final rule, will likely continue to shape the outlook for CCS commercialization and deployment.

Contents

Figures

Tables

Appendixes

Contacts

Introduction

The American Recovery and Reinvestment Act (Recovery Act; P.L. 111-5, enacted February 17, 2009) provided $3.4 billion for carbon capture and sequestration (CCS) projects and activities at the U.S. Department of Energy (DOE). The large and rapid influx of funding for industrial-scale CCS projects was intended to accelerate development and demonstration of CCS in the United States. Recovery Act funding represented the lion's share of CCS support at DOE in the six-year period from FY2010 through FY2015. By comparison, DOE separately allotted a total of approximately $2.3 billion over the same time period to CCS-related activities from annual appropriations—not Recovery Act funding—under its coal program activities within the Office of Fossil Energy.

Authority to spend Recovery Act funds expired on September 30, 2015. Of the $3.4 billion allocated for CCS activities, approximately $1.4 billion went unspent as of the 2015 spending deadline. The largest portion of the unspent funds, $795 million, was intended for DOE's flagship CCS project, FutureGen, which DOE suspended in February 2015. However, several other large CCS demonstration projects were canceled, suspended, or failed to spend all of their Recovery Act funding before the deadline. This report provides a preliminary assessment of Recovery Act-funded CCS projects and discusses possible factors that led to project delay, suspension, or cancellation within the context of DOE's broader CCS effort.

Recovery Act funding was intended, in part, to help DOE achieve its research, development, and demonstration (RD&D) goals as outlined in the department's 2010 *Carbon Dioxide Capture and Storage RD&D Roadmap*.[1] DOE states that the mission for the DOE Office of Fossil Energy is "to ensure the availability of ultra-clean (near-zero emissions), abundant, low-cost domestic energy from coal to fuel economic prosperity, strengthen energy security, and enhance environmental quality."[2] Over the past several years, the DOE Fossil Energy Research and Development Program increasingly shifted activities performed under its coal program toward emphasizing CCS as the main focus.[3] For example, the coal program represented between 60% and 70% of total Fossil Energy Research and Development appropriations from FY2010 to FY2015—even without Recovery Act funding—indicating that CCS has come to dominate coal RD&D at DOE.[4] This development reflects DOE's view that "there is a growing consensus that steps must be taken to significantly reduce [greenhouse gas] emissions from energy use throughout the world at a pace consistent to stabilize atmospheric concentrations of [carbon dioxide], and that CCS is a promising option for addressing this challenge."[5]

Congress has long been interested in the future of CCS as a mitigation strategy for lowering global emissions of carbon dioxide (CO_2). Since FY2008, it has appropriated more than $7 billion

[1] Among other goals, the roadmap was intended to lay out a path for rapid technological development of carbon capture and storage (CCS) so that the United States could continue to use fossil fuels despite potential restrictions on carbon emissions. U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), *DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap*, December 2010, at http://www.netl.doe.gov/File%20Library/Research/Carbon%20Seq/Reference%20Shelf/CCSRoadmap.pdf. Hereinafter referred to as the DOE 2010 *CCS Roadmap*.

[2] DOE 2010 *CCS Roadmap*, p. 2.

[3] The coal program contains CCS research, development, and demonstration (RD&D) activities and is within DOE's Office of Fossil Energy, Fossil Energy Research and Development, as listed in DOE detailed budget justifications for each fiscal year.

[4] DOE, FY2010-FY2016 Congressional Budget Requests. Percentages for FY2011 and FY2012 were calculated without including rescissions shown in **Table 1**.

[5] DOE 2010 *CCS Roadmap*, p. 3.

for CCS activities at DOE. Several bills introduced in the 114th Congress address CCS directly or indirectly (e.g., S. 601, S. 1283, H.R. 3392, and others).

The Obama Administration has promulgated rules on CO_2 emissions from current and future fossil fuel-burning power plants and entered into a global agreement to limit CO_2 emissions.[6] Congress remains divided over those executive branch decisions. DOE, however, has continued to embrace CCS as part of the Administration's strategy to reduce CO_2 emissions from power plants:

> Roughly one-third of U.S. carbon emissions come from power plants and other large point sources. DOE is committed to enabling the safe and permanent storage and utilization of CO_2 captured from these sources. Building on available first generation technologies, next generation carbon capture and storage (CCS) technologies or carbon dioxide utilization technologies, expected to become commercially available in the mid-2020s, will help put us on a path to a clean energy option for a world currently dependent on fossil fuels for 80% of its energy.[7]

The Recovery Act provided a de facto doubling of appropriations for CCS RD&D from enactment until the end of FY2015. A preliminary assessment of Recovery Act-funded CCS projects might help to inform lawmakers about factors that affect the rate of progress of developing and demonstrating CCS technology. Understanding these factors also might help to clarify the potential for CCS as a greenhouse-gas (GHG) mitigation strategy as Congress debates whether and how to reduce CO_2 emissions from large, stationary sources.

CCS and the Clean Power Plan

The U.S. Environmental Protection Agency's (EPA's) final rule for reducing CO_2 emissions from new fossil fuel power plants, part of the Administration's Clean Power Plan (CPP), found newly constructed power plants incorporating partial CCS to be the Best System of Emission Reduction (BSER).[8] EPA determined that the BSER is technically feasible and available at reasonable cost. EPA based its claim, in part, on an example of demonstrated, full-scale operations in the electricity-generating industry, as well as on other smaller projects that are reasonably predictive of results at full scale.[9] In a separate rule, also part of the CPP, EPA found that CCS was not the BSER for existing power plants.[10]

Several of the projects cited by EPA in the final rule received Recovery Act funding and are discussed below. The project cited in most detail to support EPA's final rule, however, was Boundary Dam, a Canadian venture that is the world's only full-scale, fully integrated, and currently operating power plant with CCS. The Boundary Dam project received about $240 million from the Canadian federal government; the overall cost was about $1.3 billion, according

[6] For more information about these developments, see CRS Report R44145, *EPA's Clean Power Plan: Highlights of the Final Rule*, by Jonathan L. Ramseur and James E. McCarthy; and CRS Insight IN10413, *Climate Change Pact Agreed in Paris*, by Jane A. Leggett.

[7] DOE, *U.S. Department of Energy Strategic Plan 2014-2018*, March 2014, p. 4, at http://www.energy.gov/sites/prod/files/2014/04/f14/2014_dept_energy_strategic_plan.pdf.

[8] U.S. Environmental Protection Agency (EPA), "Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units; Final Rule," 80 *Federal Register* 64513, October 23, 2015.

[9] Ibid., p. 64548.

[10] EPA, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Final Rule," 80 *Federal Register* 64728, October 23, 2015.

to one source.[11] None of the Recovery Act-supported power plant demonstration projects discussed in this report are currently operating; however, EPA asserts in its final rule that the projects support the conclusion that CCS is technically feasible.[12]

Technical feasibility is just one factor of many that determine whether a CCS demonstration project successfully reaches its goal of producing electricity and capturing CO_2 at commercial scale. Some of the Recovery Act-supported projects cited in the final rule did not meet their original schedules and were not able to expend their full Recovery Act awards prior to the spending deadline, although they still may become operational. One project cited in the final rule, the AEP Mountaineer project, was canceled in 2011, well before the scheduled operation date of 2015. FutureGen, arguably DOE's flagship CCS demonstration project, was not cited in EPA's final rule as an example demonstrating technical feasibility for CCS. FutureGen was canceled in 2015 after spending only 20% of a nearly $1 billion Recovery Act award.

In its final rule, EPA states that implementing partial CCS as the BSER is likely to boost future research and development in CCS technologies. Further, the boost would make CCS implementation even more efficacious and cost-effective.[13] That may be the case; however, this report touches on some of the other issues that affected a number of large, Recovery Act-supported CCS demonstration projects. These issues, as well as the outcomes from promulgation of EPA's final rule, will likely continue to shape the outlook for CCS commercialization and deployment.

DOE Carbon Capture and Sequestration Funding Since FY2010

Table 1 shows the DOE Office of Fossil Energy spending from FY2010 through FY2016, including the amounts provided by the Recovery Act. In the table, Recovery Act programs are organized under the CCS Demonstrations category. CCS-related programs funded by annual appropriations apart from the Recovery Act are organized under the Coal CCS and Power Systems category. The remainder of Fossil Energy spending is organized under Other Fossil Energy R&D. DOE changed the program structure for coal after FY2010, renaming and consolidating program areas. In **Table 1**, the Coal CCS and Power Systems bottom line total is provided for FY2010, but the amounts for individual programs are not provided for that year because of the reorganization.

Recovery Act funding supported four main categories of activities: (1) FutureGen; (2) the Clean Coal Power Initiative (CCPI); (3) Industrial Carbon Capture and Storage (ICCS); and (4) Site Characterization, Training, and Program Direction. FutureGen, CCPI, and ICCS garnered the bulk of Recovery Act funds for CCS ($3.32 billion, or 98%). Funding was made available as a one-time appropriation, but DOE had authority to spend Recovery Act funds through FY2015. Accordingly, **Table 1** shows the Recovery Act funding amounts in one column for 2009, but those funds were available through FY2015. Zeroes in the columns for FY2010 through FY2015

[11] MIT Carbon Capture & Sequestration Technologies, CCS Project Database, *Boundary Dam Fact Sheet: Carbon Capture and Storage Project*, at http://sequestration.mit.edu/tools/projects/boundary_dam.html. A SaskPower fact sheet describes it as a $1.4 billion partnership between the government of Canada and SaskPower, http://saskpowerccs.com/ccs-projects/boundary-dam-carbon-capture-project/7913%20CSS%20Factsheet-Boundary%20Dam-newtense.pdf.

[12] EPA, "Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units; Final Rule," 80 *Federal Register* 64551, October 23, 2015.

[13] Ibid., p. 64514.

indicate that no *new* Recovery Act funds were made available during those years. However, DOE continued to fund other CCS programs and activities with regular appropriations in each of those years, as shown by the rows in the table below Recovery Act programs.

Table 1. Funding for DOE Fossil Energy Research, Development, and Demonstration Program Areas

Fossil Energy R&D Coal Program Areas	Program/Activity	Recovery Act Aapprops.	FY2010 Approps. ($1,000s)	FY2011 Approps. ($1,000s)	FY2012 Approps. ($1,000s)	FY2013 Approps. ($1,000s)	FY2014 Approps. ($1,000s)	FY2015 Approps. ($1,000s)	FY2016 Approps. ($1,000s)
Carbon Capture and Storage (CCS) Demonstrations	**FutureGen 2.0**	$1 billion	0	0	0	0	0	0	0
	Clean Coal Power Initiative (CCPI)	$800 million	0	0	0	0	0	0	0
	Industrial Carbon Capture and Storage Projects (ICCS)	$1.52 billion	0	0	0	0	0	0	0
	Site Characterization, Training, Program Direction	$80 million	0	0	0	0	0	0	0
Coal CCS and Power Systems	**Carbon Capture**	—	—	58,703	66,986	63,725	92,000	88,000	101,000
	Carbon Storage	—	—	120,912	112,208	106,745	108,766	100,000	106,000
	Advanced Energy Systems	—	—	168,627	97,169	92,438	99,500	103,000	105,000
	Cross Cutting Research	—	—	41,446	47,946	45,618	41,925	49,000	50,000
	Supercritical CO_2 Technology	—	—	—	—	—	—	10,000	15,000
	NETL Coal Research and Development	—	—	—	35,011	33,338	50,011	50,000	53,000
Subtotal Coal		**$3.4 billion**	**393,485**	**389,688**	**359,320**	**341,864**	**392,202**	**400,000**	**430,000**
Other Fossil Energy R&D	**Natural Gas Technologies**	—	17,364	0	14,575	13,865	20,600	25,121	43,000
	Unconventional Fossil	—	19,474	0	4,859	4,621	15,000	4,500	20,321
	Program Direction	—	158,000	164,725	119,929	114,201	120,000	119,000	114,202
	Plant and Capital	—	20,000	19,960	16,794	15,982	16,032	15,782	15,782
	Environmental Restoration	—	10,000	9,980	7,897	7,515	5,897	5,897	7,995

Fossil Energy R&D Coal Program Areas	Program/Activity	Recovery Act Aapprops.	FY2010 Approps. ($1,000s)	FY2011 Approps. ($1,000s)	FY2012 Approps. ($1,000s)	FY2013 Approps. ($1,000s)	FY2014 Approps. ($1,000s)	FY2015 Approps. ($1,000s)	FY2016 Approps. ($1,000s)
	Special Recruitment	—	700	699	700	667	700	700	700
	Coop R&D		4,868	—	—	—	—	—	—
	Congressionally Directed Projects		35,879	—	—	—	—	—	—
Subtotal Other Fossil R&D		**—**	**266,285**	**195,364**	**164,754**	**156,851**	**178,229**	**171,000**	**202,000**
Rescissions/use of prior-year funds				(151,000)	(187,000)				
Total Fossil Energy R&D		**$3.4 billion**	**659,770**	**434,052**	**337,074**	**498,715**	**570,431**	**571,000**	**632,000**

Sources: U.S. Department of Energy (DOE) Budget Justifications for FY2010-FY2016.

Notes: Recovery Act = American Recovery and Reinvestment Act (P.L. 111-5); R&D = research and development. On February 3, 2015, DOE announced that it was suspending the FutureGen program. Funding in nominal dollars.

Under the 2010 DOE *CCS Roadmap*,[14] and with the large infusion of funding from the Recovery Act, DOE's goal has been to develop the technologies that will allow for commercial-scale demonstration in both new and retrofitted power plants and industrial facilities by 2020. The DOE 2011 strategic plan set a more specific target: to bring at least five commercial-scale CCS demonstration projects online by 2016.[15] The DOE 2014-2018 strategic plan is less specific, stating that next-generation CCS technologies, available sometime in the 2020s, would put the United States on a path toward a clean-energy option for the world.[16]

In its FY2016 budget justification, DOE stated that the CCS and Power Systems research and development (R&D) program "supports secure, affordable, and environmentally acceptable near-zero emissions fossil energy technologies through research, development, and demonstration (RD&D) to improve the performance of advanced CCS technologies."[17]

Some programs are directly focused on one or more of the three steps of CCS: capture, transportation, and storage. For example, the Carbon Capture program supports R&D on post-combustion, pre-combustion, and natural gas capture. The Carbon Storage program supports the regional carbon sequestration partnerships,[18] geological storage technologies, and other aspects of permanently sequestering CO_2 underground.

Also shown in **Table 1** are funding levels under Other Fossil Energy R&D. Activities in this category include programs pursuing fossil energy R&D and support activities. The largest activity

[14] DOE 2010 *CCS Roadmap*, p. 13.

[15] DOE, *Strategic Plan*, May 2011, p. 18, at http://energy.gov/sites/prod/files/2011_DOE_Strategic_Plan_.pdf.

[16] DOE, *U.S. Department of Energy Strategic Plan 2014-2018*, March 2014, p. 4, at at http://www.energy.gov/sites/prod/files/2014/04/f14/2014_dept_energy_strategic_plan.pdf.

[17] DOE, FY2016 Congressional Budget Request, volume 3, *Fossil Energy Research and Development*, p. 569.

[18] In 2003. DOE created seven regional carbon sequestration partnerships (RCSPs), essentially consortia of public- and private-sector organizations grouped by geographic region across the United States and parts of Canada. See http://www.netl.doe.gov/research/coal/carbon-storage/carbon-storage-infrastructure.

is Program Direction ($114.2 million in FY2016), which provides DOE headquarters support and federal field and contractor support of the overall fossil energy R&D programs. These activities support CCS-related activities directly and indirectly. The next-largest activities are Natural Gas Technologies ($43 million in FY2016) and Unconventional Fossil ($20.3 million in FY2016), which support collaborative research to foster safe and prudent development of shale gas resources, the reduction of methane emissions from natural gas infrastructure, and research on gas hydrates.[19] The other activities listed in **Table 1**—Plant and Capital, Environmental Restoration, and Special Recruitment—total approximately $24.5 million for FY2016.

The FY2016 appropriated amount for coal R&D is a 7.5% increase over the previous year's enacted amount. The total fossil energy FY2016 appropriation is about 10% higher than the FY2015 appropriation (in unadjusted dollars). FY2016 marks the first year since FY2009, however, in which Recovery Act funds are not available for CCS-related projects in addition to regular appropriations. The following section reviews where DOE allocated Recovery Act funds for CCS-related activities, the status of those endeavors, and which projects left portions of their Recovery Act awards unspent at the September 30, 2015 deadline.

Recovery Act-Funded Projects

Nine individual projects garnered approximately $2.65 billion of the $3.4 billion—about 78%—made available under the Recovery Act for CCS projects and activities. Five of the nine projects are large-scale demonstration projects that were intended to capture CO_2 from electric power plants (FutureGen and four CCPI Round III projects,[20] see **Table 2**). The remaining four projects listed in **Table 2** are large, industrial-scale demonstration projects under the ICCS program.[21] The projects in each category were awarded more than $100 million. They are listed to illustrate that DOE prioritized large-scale demonstration projects with Recovery Act funding. For comparison, the ICCS projects not included in **Table 2** (combined in the All Other Projects category; see **Appendix** for detailed listing by project) are smaller in scope and received Recovery Act funds in amounts ranging from less than $1 million to $72 million, averaging about $12 million.

The CCPI program originally provided federal support to new coal technologies that helped power plants to cut sulfur, nitrogen, and mercury pollutants. As CCS became the focus of coal RD&D, the CCPI program shifted to reducing GHG emissions by boosting plant efficiencies and capturing CO_2.[22] The ICCS program demonstrates carbon capture technology for the non-power plant industrial sector.[23] Both these program areas focus on the demonstration component of RD&D. FutureGen was unique as originally conceived because it was intended to include the full CCS spectrum—capture, transportation, and storage—as one state-of-the-art, unified facility.

[19] DOE, FY2016. Congressional Budget Request, volume 3, pp. 603-616.

[20] DOE had solicited and awarded funding for Clean Coal Power Initiative (CCPI) projects in two previous rounds of funding: CCPI Round 1 and Round 2. The Recovery Act funds were to be allocated in CCPI Round 3, focusing on projects that utilize CCS technology and/or the beneficial reuse of CO_2. For more details, see http://www.fossil.energy.gov/programs/powersystems/cleancoal/.

[21] The last project listed in **Table 2**, Research Triangle Institute, was included somewhat arbitrarily because it was the largest project in the Industrial Carbon Capture and Storage (ICCS) category not categorized as a large demonstration project and that exceeded $100 million in Recovery Act support. Only four ICCS projects other than those listed in **Table 2** exceeded $50 million in Recovery Act support (see **Appendix**).

[22] DOE, FY2015 Congressional Budget Request, volume 3, *Fossil Energy Research and Development*, p. 551.

[23] DOE 2010 *CCS Roadmap*, p. 12.

Approximately 60% of the nearly $995 million in Recovery Act funds allocated to FutureGen went to capture, with the remaining 40% used for transportation and storage.

Table 2. DOE CCS Projects with Recovery Act Funding

(nominal dollars)

Project	Type	Amount of Recovery Act Award ($)	Amount Unspent at Sep. 30, 2015, Deadline ($)	Net Recovery Act Spent ($)	% Spent	% Returned
FutureGen—Capture	Stand-Alone	589,744,000	(473,077,241)	116,666,759	20%	80%
FutureGen—Transport & Storage	Stand-Alone	404,985,000	(321,716,380)	83,268,620	21%	79%
FutureGen Total		**994,729,000**	**(794,793,621)**	**199,935,379**	**20%**	**80%**
Hydrogen Energy California	CCPI Round III	275,000,000	(122,171,564)	152,828,436	56%	44%
Summit Texas Clean Energy	CCPI Round III	211,097,445	(104,223,677)	106,873,768	51%	49%
NRG Energy/Petra Nova	CCPI Round III	163,007,179		163,007,179	100%	0%
AEP Mountaineer	CCPI Round III	146,493,376	(129,613,108)	16,880,268	12%	88%
CCPI Totals		**795,598,000**	**(356,008,349)**	**439,589,651**	**55%**	**45%**
Leucadia Energy, LLC	ICCS Large Demo	261,382,000	(248,623,661)	12,758,339	5%	95%
Archer Daniel Midlands	ICCS Large Demo	141,405,945		141,405,945		
Air Product & Chemicals, Inc.	ICCS Large Demo	284,012,496		284,012,496		
Research Triangle Institute	ICCS Advanced Gasification	168,824,716		168,824,716		
ICCS Large Project Totals		**855,625,157**	**(248,623,661)**	**607,001,496**	**71%**	**29%**
All Other ICCS Projects	ICCS[a]	630,751,232		630,751,232		
ICCS Totals		**1,486,376,389**	**(248,623,661)**	**1,237,752,728**	**83%**	**17%**
Grand Totals		**3,276,703,389**	**(1,399,425,631)**	**1,877,277,758**	**57%**	**43%**

Sources: USAspending.gov; U.S. Department of Energy, "Recovery Act," at http://www.energy.gov/recovery-act; telephone conversation with Joseph Giove, DOE Office of Fossil Energy, March 19, 2012; email from Andrew HLasko, General Engineer, DOE Headquarters, January 29, 2016.

Note: Grand totals do not include $80 million of Recovery Act funding for site characterization, training, and program direction shown in **Table 1**.

a. The "All Other ICCS Projects" category includes the following types: innovative concepts/beneficial use, advanced gasification technologies, advance turbo-machinery, post-combustion capture, and geologic site characterization.

FutureGen

On February 3, 2015, DOE announced it was canceling funding for the FutureGen project.[24] The main reason for the program's suspension was the September 30, 2015, deadline for spending the Recovery Act funding and the likelihood that the FutureGen Alliance—an industrial consortium—would not be able to commit the funds by that date. That situation led, in turn, to uncertainty about the alliance's ability to secure private-sector funding to make up the rest of the project costs after Recovery Act funding was exhausted. The FutureGen Alliance had expended nearly $200 million of Recovery Act funding at the time of cancellation, leaving approximately $795 million unspent (**Table 2**).

By itself, FutureGen's cancellation resulted in, by far, the largest dollar amount of CCS-related Recovery Act funds left unspent: $795 million of a total of $1.4 billion unspent overall, or 57%. Including FutureGen, approximately 43% of all CCS-related Recovery Act funds were unspent as of the September 30, 2015, deadline (**Table 2**). Excluding FutureGen (i.e., subtracting $995 million from the total awarded and $795 million from the total left unspent), the percentage of unspent-to-awarded funds improves to about 26% for CCS-related Recovery Act-funded projects. In addition to FutureGen, two other projects listed in **Table 2** were canceled or suspended: Leucadia Energy, LLC, an ICCS major demonstration project, and American Electric Power (AEP) Mountaineer. These projects spent 5% and 12% of their total Recovery Act awards, respectively. FutureGen spent close to $200 million, or 20% of its total project award.

A question lawmakers may consider is whether the FutureGen effort produced tangible results benefitting the DOE goal to allow for commercial-scale demonstration in both new and retrofitted power plants and industrial facilities by 2020. Or, alternatively, would the funding have been better directed to the other major demonstration efforts within the CCPI and ICCS programs?

Background and Development

FutureGen did not begin with the $995 million Recovery Act award in 2010. As originally conceived by the George W. Bush Administration in 2003, the plant would have been a coal-gasification facility that would have produced and sequestered between 1 million and 2 million tons of CO_2 annually. The project changed fundamentally five years later in January 2008, when DOE announced that it was "restructuring" the FutureGen program away from a single, state-of-the-art "living laboratory" of integrated R&D technologies—a single plant—to pursue instead a new strategy of multiple commercial demonstration projects.[25] After passage of the Recovery Act, FutureGen changed again. DOE under the Obama Administration announced its plans to build FutureGen 2.0,[26] which differed from the original concept for the plant. FutureGen 2.0 aimed to retrofit an existing power plant in Meridosia, IL, with oxy-combustion technology rather than to build a new, state-of-the-art plant.

Despite its 2003 origin, FutureGen 2.0 arguably began a new effort in 2010 to construct an integrated capture-transport-sequestration facility. The timetable initially proposed for this

[24] As reported in Manuel Quinones, "Lawmakers Likely to Scrutinize DOE Closeout of FutureGen Project," *Environment & Energy Daily*, February 4, 2015, at http://www.eenews.net/eedaily/stories/1060012838/search?keyword=futuregen.

[25] U.S. Department of Commerce, Office of Energy and Environmental Industries, *Coal News and Trends*, http://www.ita.doc.gov/td/energy//February%20Coal%20News%20and%20Trends.pdf.

[26] U.S. Department of Energy, Office of Fossil Energy, DOE Techline, "Secretary Chu Announces FutureGen 2.0," http://energy.gov/fe/articles/secretary-chu-announces-futuregen-20.

effort—which would have spent the nearly $1 billion in Recovery Act funds by September 30, 2015, for capture, transportation, and storage engineering, equipment, and infrastructure—proved to be overly ambitious.

Challenges and Delays

As an early mover fully-integrated CCS project in the United States, FutureGen likely experienced some delays that were difficult or impossible to predict. For example, many other CCS projects plan to sell the captured CO_2 for enhanced oil recovery (EOR), a long-standing practice of injecting CO_2 into aging oil fields to boost production. In contrast, FutureGen planned to inject CO_2 into the subsurface for permanent sequestration. To do so, the project required a first-of-its-kind injection permit from the U.S. Environmental Protection Agency—a Class VI Underground Injection Control well permit, issued under authority of the Safe Drinking Water Act (P.L. 93-523).[27] Projects that inject CO_2 for EOR purposes are not required to obtain Class VI permits. EPA issued its first Class VI well permit to FutureGen on September 2, 2014, four years after Recovery Act funding was awarded and only one year before the deadline for spending Recovery Act funds.[28]

In addition, FutureGen encountered challenges in court that may have contributed to the project's delay. For example, the project received approval in late December 2012 from the Illinois Commerce Commission for a power procurement plan that would have guaranteed that utilities would purchase only FutureGen-generated electricity for 20 years. That action faced a challenge from the Illinois Competitive Energy Association, which represents retail electricity suppliers, among others. FutureGen survived the first challenge in the Illinois Appellate Court in July 2014,[29] but in 2014 the Illinois Supreme Court agreed to consider another appeal.[30] The court had not decided the issue by the time DOE canceled FutureGen funding.

FutureGen also faced a lawsuit filed by the Sierra Club against the project. The environmental advocacy group argued that FutureGen did not obtain the proper well permit and would be in violation of the Clean Air Act (P.L. 88-206).[31] The CEO of the FutureGen Industrial Alliance, Inc., Ken Humphreys, filed a motion with the Illinois Pollution Control Board to expedite the review of the case. Humphreys testified that "time is of the essence in this case," and that "one billion dollars ($1B) in contractually-obligated government funding and seven hundred million ($700M) in commercial financing is at stake if the case is not resolved expeditiously."[32] His testimony continued, "The Claim casts a dark shadow over the ongoing commercial financing effort, which raises investor concern." Further, Humphreys acknowledged that major construction spending could not occur prior to resolution of the lawsuit.[33]

---

[27] For more information about Class VI wells under the Safe Drinking Water Act (P.L. 93-523), see CRS Report RL34201, *Safe Drinking Water Act (SDWA): Selected Regulatory and Legislative Issues*, by Mary Tiemann.

[28] U.S. Environmental Protection Agency, "U.S. EPA Approves Carbon Sequestration Permits in Central Illinois," Release No. 14-OPA106, September 2, 2014, at http://yosemite.epa.gov/opa/admpress.nsf/0/28813E70CC4C222A85257D47006FF568.

[29] Steve Daniels, "Court Victory Gives FutureGen a Green Light; ComEd Challenge Rejected," *Crain's Chicago Business*, July 22, 2014.

[30] Steve Daniels, "Illinois Supreme Court Takes Up FutureGen Appeal," *Crain's Chicago Journal*, November 26, 2014.

[31] Jeffrey Tomich, "FutureGen Officials Say Sierra Club Complaint Jeopardizes Project," *EnergyWire*, August 18, 2014.

[32] Sierra Club v. Ameren Energy Medina Valley Cogen, llc, and FutureGen Industrial Alliance, Inc., PCB 2014-134 pp. 1-3 (Illinois Pollution Control Board 2014).

[33] Ibid.

The court challenge, lawsuit, and other actions likely contributed to delays in construction and the concomitant expenditure of Recovery Act funds. Those delays eventually led to the project's termination. FutureGen was a technically challenging project as well, but the technical challenges do not appear to have been causes for undue delay in project construction. Rather, uncertainty in the legal, financial, and regulatory spheres probably were more acute challenges to keeping the project on schedule to meet its September 30, 2015 spending deadline.

Clean Coal Power Initiative Projects

Of the four CCPI projects listed in **Table 2**, three projects—Hydrogen Energy California, Summit Texas Clean Energy, and AEP Mountaineer—did not expend all Recovery Act funding prior to the September 30, 2015 deadline. The NRG Energy/Petra Nova project did expend its $167 million prior to the deadline and is moving forward. The project broke ground in September 2014 and, as of September 2015, engineering, procurement, and construction activities were over 60% complete.[34] The Summit Texas Clean Energy Project spent about 51% of its Recovery Act funding. DOE and its private-sector partner are currently evaluating the future of the project, according to DOE,[35] although the private company has indicated that it plans to move forward on the project with financial closing in spring 2016 and groundbreaking shortly thereafter.[36] The status of the Hydrogen Energy California Project is uncertain. DOE lists the project as suspended on its CCPI website.[37] In July 2015, DOE suspended funding for the project because it failed to meet certain benchmarks, according to one source.[38] Other sources indicate that the private company partner continues to fund project development independently while DOE evaluates the Hydrogen Energy California project's future.[39]

The AEP Mountaineer project is different from the other three CCPI projects in **Table 2** because AEP, the private-sector partner in the project, terminated the project in July 2011. The project is included in **Table 2** because it received and expended Recovery Act funding, even though AEP withdrew its support at an early stage of project development. DOE expended only a small amount of federal funding for the project—about $17 million—compared to the other CCPI projects. As **Table 3** shows, the federal share of the AEP Mountaineer project was $334 million in its original conception, and the total project cost was estimated to be $668 million. Of the $334 million that was DOE's share, $129 million was unspent Recovery Act funding. Also unspent was $187 million of non-Recovery Act funding for the project, which Congress rescinded in 2012 (See **Table 1**, FY2012 column).

[34] See "Timeline" section at DOE, Office of Fossil Energy, "Petra Nova – W.A. Parish Project," at http://energy.gov/fe/petra-nova-wa-parish-project.

[35] See "Timeline" section at DOE, Office of Fossil Energy, "Texas Clean Energy Project," at http://energy.gov/fe/texas-clean-energy-project.

[36] Christa Marshall, "Major Texas Coal Project Moves Ahead as Lawmakers Push CCS in Paris," *ClimateWire*, December 9, 2015, at http://www.eenews.net/climatewire/stories/1060029210/search?keyword=texas+clean+energy+project.

[37] DOE, Office of Fossil Energy, "Clean Coal Power Initiative Round III: Recovery Act," at http://energy.gov/fe/clean-coal-power-initiative-round-iii.

[38] Manuel Quinones, "DOE Suspends Stimulus Funding for Calif. Carbon-Capture Project," *Greenwire*, July 9, 2015, at http://www.eenews.net/greenwire/stories/1060021604/search?keyword=hydrogen+energy+california+project.

[39] Massachusetts Institute of Technology, CCS Project Database, "Hydrogen Energy California Project (HECA) Fact Sheet: Carbon Capture and Storage Project," at http://sequestration.mit.edu/tools/projects/heca.html.

Table 3 also shows two other projects—Southern Company Plant Barry and Basin Electric Power—originally selected for CCPI Round III support with Recovery Act funding. These projects withdrew from CCPI very early after selection.

Table 3. Withdrawn CCPI Round III Projects

Round III Project	Location	Total DOE Share of Funding ($ millions)	Amount of DOE Funding from the Recovery Act	Total Project Cost ($ millions)	Percentage DOE Share of Total	Project Status
AEP Mountaineer Project	New Haven, WV	334	146.5	668	50%	Withdrawn July 2011
Southern Company Plant Barry Project	Mobile, AL	295	295	665	44%	Withdrawn February 2010
Basin Electric Power Project	Beulah, ND	100	100	387	26%	Withdrawn December 2010
Total		**729**	**541.5**	**1,720**	**42.0%**	

Sources: DOE Fossil Energy Techline; "Feds. NRG Energy Plan Texas-Sized Carbon Capture and Storage Project, *Environment News Service*, March 12, 2010, at http://www.ens-newswire.com/ens/mar2010/2010-03-12-093.html; National Energy Technology Laboratory (NETL) Clean Coal Power Initiative (CCPI) website, at http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/index.html; NETL, "Recovery Act: Texas Clean Energy Project, November 2014, at http://www.netl.doe.gov/research/coal/major-demonstrations/clean-coal-power-initiative/ccpi-summit; NETL, Recovery Act: Hydrogen Energy California Project: Commercial Demonstration of Advanced IGCC with Full Carbon Capture, November 2014, at http://www.netl.doe.gov/research/coal/major-demonstrations/clean-coal-power-initiative/ccpi-heca; NETL, Recovery Act: Petra Nova Parish Holdings: W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project, November 2014, at http://www.netl.doe.gov/research/coal/major-demonstrations/clean-coal-power-initiative/ccpi-petra-nova.

Notes: In contrast to the AEP Mountaineer project, the Southern Company Plant Barry project and Basin Electric Power project were never awarded Recovery Act funds. Both projects were selected for awards but withdrawn before DOE awarded the funds.

Reasons for Withdrawal from the CCPI Program

Southern Company—Plant Barry Project: DOE Secretary Steven Chu announced $295 million in DOE funding for the 11-year, $665 million project that would have captured up to 1 million tons of CO_2 per year from a 160 megawatt coal-fired generation unit.[40] Southern Company withdrew its Alabama Plant Barry project from the CCPI program on February 22, 2010, slightly more than two months later. According to some sources, Southern Company's decision was based on concern about the size of the company's needed commitment (approximately $370 million) to the project and its need for more time to perform due diligence on its financial commitment, among other reasons.[41]

Basin Electric Power—Antelope Valley Project: On July 1, 2009, Secretary Chu announced $100 million in DOE funding for a project that would capture approximately 1 million tons of CO_2 per year from a 120 megawatt electric-equivalent gas stream from the Antelope Valley power

[40] MIT Carbon Capture & Sequestration Technologies, "Plant Barry Fact Sheet: Carbon Dioxide Capture and Storage Project," at http://sequestration.mit.edu/tools/projects/plant_barry.html.

[41] Ibid.

station near Beulah, ND.[42] In December 2010, the Basin Electric Power Cooperative withdrew its project from the CCPI program citing the lack of a long-term energy strategy for the country and regulatory uncertainty with regard to capturing CO_2, the project's cost (one source indicates that the company estimated $500 million total cost; DOE estimated $387 million—see **Table 3**),[43] and environmental legislation.[44]

AEP—Mountaineer Project: In July 2011, AEP decided to halt its plans to build a carbon capture plant for a 235 megawatt generation unit at its 1.3 gigawatt Mountaineer power plant in New Haven, WV. The project represented the second phase of an ongoing CCPI project. Secretary Chu had announced a $334 million award for the project on December 4, 2009.[45] According to some sources, AEP dropped the project because the company was not certain that state regulators would allow it to recover the additional costs for the CCS project through rate increases charged to its customers.[46] In addition, company officials cited broader economic and policy conditions as reasons for canceling the project.[47] Some commentators suggested that congressional inaction on setting limits on GHG emissions, as well as the weak economy, may have diminished the incentives for a company such as AEP to invest in CCS.[48] One source concluded that "Phase 2 has been canceled due to unknown climate policy."[49]

Reshuffling of Funding for CCPI

According to DOE, $140 million of the $295 million in Recovery Act funds allotted to the Southern Company Plant Barry project was redistributed to the Summit Texas Clean Energy project and the Hydrogen Energy California project. DOE provided additional funding, resulting in each project receiving $100 million above its initial award.[50] The remaining funding from the canceled Plant Barry project (up to $154 million) was allotted to the NRG Energy/Petra Nova project.[51]

[42] DOE, Fossil Energy Techline, *Secretary Chu Announces Two New Projects to Reduce Emissions from Coal Plants*, July 1, 2009, at http://energy.gov/fe/articles/secretary-chu-announces-two-new-projects-reduce-emissions-coal.

[43] Lauren Donovan, "Basin Shelves Lignite's First Carbon Capture Project," *Bismarck Tribune*, December 17, 2010, at http://bismarcktribune.com/news/local/a5fb7ed8-0a1b-11e0-b0ea-001cc4c03286.html.

[44] Daryl Hill and Tracie Bettenhausen, "Fresh Tech, Difficult Decisions: Basin Electric has a History of Trying New Technology," *http://www.dakotagas.com/Miscellaneous/pdf/FeatureArticles/Fresh_Tech,_difficul.pdf*.

[45] DOE, Fossil Energy Techline, *Secretary Chu Announces $3 Billion Investment for Carbon Capture and Sequestration*, December 4, 2009, at http://energy.gov/fe/articles/secretary-chu-announces-3-billion-investment-carbon-capture-and.

[46] Matthew L. Wald and John M. Broder, "Utility Shelves Ambitious Plan to Limit Carbon," *New York Times*, July 13, 2011, at http://www.nytimes.com/2011/07/14/business/energy-environment/utility-shelves-plan-to-capture-carbon-dioxide.html?_r=1.

[47] Michael G. Morris, chairman of AEP, quoted in Matthew L. Wald and John M. Broder, "Utility Shelves Ambitious Plan to Limit Carbon," *The New York Times*, July 13, 2011.

[48] Wald and Broder, *New York Times*, July 13, 2011.

[49] MIT Carbon Capture & Sequestration Technologies, "AEP Mountaineer Fact Sheet: Carbon Dioxide Capture and Storage Project," at http://sequestration.mit.edu/tools/projects/aep_alstom_mountaineer.html.

[50] Telephone conversation with Joseph Giove, DOE Office of Fossil Energy, March 19, 2012, and email from Andrew HLasko, General Engineer, DOE Headquarters, January 29, 2016.

[51] DOE Fossil Energy Techline, "Secretary Chu Announces Up To $154 Million for NRG Energy's Carbon Capture and Storage Project in Texas," March 9, 2010, at http://energy.gov/fe/articles/secretary-chu-announces-154-million-nrg-energys-carbon-capture.

According to DOE, the department announced the selection of the Basin Electric Power project but never reached a cooperative agreement.[52] Funds that were set aside for the Basin project were made unavailable in the spring of 2012 when Congress rescinded $187 million in non-Recovery Act funding from the AEP Mountaineer project.[53] About $129.6 million of Recovery Act funding was left unspent for the AEP Mountaineer project in January 2012.[54]

Industrial Carbon Capture and Storage Projects

Table 2 indicates that only one ICCS project, Leucadia Energy, LLC, left Recovery Act funding unspent. DOE disbursed only $12.76 million for the project out of a total DOE project share of about $261 million, or about 5% of the total award. The Leucadia Energy project represented the second-largest DOE investment in ICCS projects (see **Table 2** and **Appendix**). However, as a class of CCS spending, the ICCS program spent 83% of its total Recovery Act funds disbursed by DOE. That figure compares favorably to the overall spent-to-unspent percentage of 55% for CCPI projects and 20% for FutureGen.

The ICCS projects listed in **Table 2** each received between $141 million and $284 million in Recovery Act funding, totaling $856 million, or 58% of total ICCS spending ($1.49 billion). The $100 million threshold for inclusion in **Table 2** is somewhat arbitrary but illustrates that DOE allocated the bulk of Recovery Act funds to large demonstration projects within the ICCS category. Including the large ICCS projects also provides for a comparison with the large demonstration projects in the CCPI program. As **Table 2** shows, ICCS projects in total expended 83% of allocated Recovery Act funds, versus 55% for total CCPI projects. However, if only the four largest ICCS projects are considered, the amount-spent to amount-allocated ratio drops to 71%, closer to the value for large CCPI demonstration projects.

Spending the full amount of Recovery Act funding may not be an appropriate metric for project success. Five of the nine projects in **Table 2** left Recovery Act funds unspent, however, suggesting that the larger and presumably more complex demonstration projects were more susceptible to project delays than the smaller ICCS projects listed in the **Appendix** that left no funds unspent.

Discussion

Stakeholders and observers long have emphasized the importance of large-scale demonstration projects to the future commercial deployment of CCS at large, stationary sources of CO_2, such as power plants and large industrial facilities. [55] DOE's shift in emphasis to the demonstration phase

[52] Telephone conversation with Joseph Giove, DOE Office of Fossil Energy, April 11, 2011, and email from Andrew HLasko, General Engineer, DOE Headquarters, January 29, 2016.

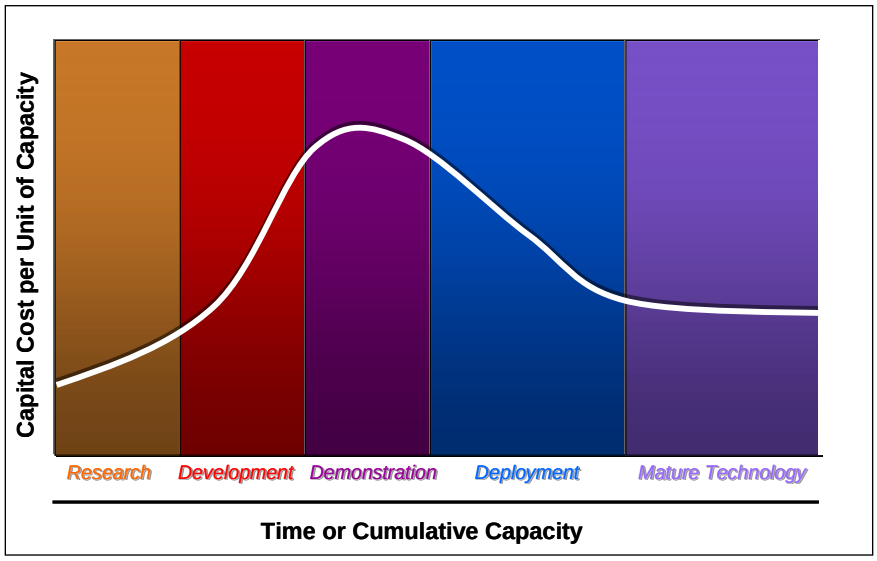
[53] Email from Andrew HLasko, General Engineer, DOE Headquarters, January 29, 2016.

[54] U.S. Congress, House Committee on Appropriations, Subcommittee on Military Construction, Veterans Affairs, and Related Agencies, *Military Construction and Veterans Affairs and Related Agencies Appropriations Act, 2012*, conference report to accompany H.R. 2055, 112th Cong., 1st sess., December 15, 2011, H.Rept. 112-331 (Washington: GPO, 2011), p. 851.

[55] See, for example, the presentations given by Edward Rubin of Carnegie Mellon University, Howard Herzog of the Massachusetts Institute of Technology, and Jeff Phillips of the Electric Power Research Institute at the CRS seminar *Capturing Carbon for Climate Control: What's in the Toolbox and What's Missing*, November 18, 2009. (Presentations available from the author.) Rubin stated that at least 10 full-scale demonstration projects would be needed to establish the reliability and true cost of CCS in power plant applications. Herzog also called for at least 10 demonstration plants worldwide that capture and sequester 1 million metric tons of CO_2 per year. In his presentation, Phillips stated that (continued...)

of carbon capture technology within its fossil energy RD&D program is therefore not surprising. It was manifest in DOE's allocation of approximately $2.65 billion of the $3.4 billion in Recovery Act funds to nine large-scale demonstration projects (listed in **Table 2**). In addition, DOE's decision to allocate the majority of Recovery Act CCS funding to support demonstration projects aligns with the evolution of cost estimates for new environmental technologies, in which the demonstration phase is the costliest, as illustrated in **Figure 1**.

Figure 1. Typical Trend in Cost Estimates for a New Technology As It Develops from a Research Concept to Commercial Maturity



Source: Adapted from S. Dalton, "CO_2 Capture at Coal Fired Power Plants—Status and Outlook," 9th International Conference on Greenhouse Gas Control Technologies, Washington, DC, November, 16-20, 2008.

In comparative studies of cost estimates for other environmental technologies, such as scrubbers that remove sulfur and nitrogen compounds from power plant emissions, some experts note that the farther away a technology is from commercial reality, the more uncertain is its estimated cost. As **Figure 1** portrays, at the beginning of the RD&D process, initial cost estimates could be low, but they typically increase through the demonstration phase before decreasing after successful deployment and commercialization.

Some stakeholders argue that DOE CCS programs have been inadequately funded, and that the DOE incentive programs for deploying CCS are not as effective as they should be.[56] One study concluded that even the financial boost from the Recovery Act was insufficient support for development and commercialization of CCS technology:

> While the $3.4 billion allocated for CCS in the American Recovery and Reinvestment Act (ARRA) of 2009 was a good start in providing the kind of federal funding assistance needed for CCS technology development, much of those funds were returned to Treasury

(...continued)

large-scale demonstrations are critical to building confidence among power plant owners.

[56] National Coal Council, *Fossil Forward: Revitalizing CCS Bringing Scale and Speed to CCS Deployment*, Study requested by Secretary of Energy Ernest J. Moniz to assess the value of the Department of Energy's Carbon Sequestration Program, January 2015, p. 48, at http://www.nationalcoalcouncil.org/newsletter/Bridging_the_CCS_Chasm.pdf.

> due to canceled projects. Because CCS projects are more complex and carry higher risk, several of the projects that received ARRA funding awards have had challenges achieving financial close. ARRA funding falls short of what will be needed to successfully commercialize and support widespread development of CCS technology.[57]

Large-scale CCS projects are complex endeavors, requiring large capital investment and multiyear planning and construction schedules. Nevertheless, the conclusion that more federal funding by itself—per the quote above—is what is needed to support development and commercialization of CCS technology may be overly simplistic. The ability for projects to achieve "financial close" goes beyond lack of sufficient funding for several projects discussed above, notably FutureGen, the AEP Mountaineer project, and the other projects listed in **Table 3** that were initially selected to receive Recovery Act funding but withdrew for various reasons. Further, delays in the timelines for the Hydrogen Energy California and Summit Texas Clean Energy projects, under DOE CCPI Round III, led to each project relinquishing more than $100 million in Recovery Act funding. The complexity and risk inherent in each of these projects no doubt affected the projects' ability to attract private financing, which may have led to project delay, but financial considerations were one of many challenges.

FutureGen, in particular, faced various impediments that led to its cancellation despite receiving nearly $1 billion of Recovery Act funds. As briefly discussed above (see "Challenges and Delays"), these impediments included delays in receiving the required injection-well permits from the Environmental Protection Agency, court challenges to its plan to sell electricity, and a lawsuit from an environmental advocacy group. FutureGen, a genuine first-mover project with a more than 10-year lifespan, may have been the highest-profile CCS project in the United States, which could have drawn additional attention from CCS opponents. For these reasons and likely others, FutureGen was unable to move its construction schedule forward at a sufficient pace, despite having more than $990 million in Recovery Act funds available to expend over a five-year period. At the end of five years, FutureGen had spent only 20% of its Recovery Act award.

Outlook

Of the four CCPI large-scale CCS demonstration projects listed in **Table 2**, three projects—Hydrogen Energy California, Summit Texas Clean Energy, and NRG Energy/Petra Nova—are still viable and could eventually become operational. Two of the three projects had to return about $226 million of the $486 million in awarded Recovery Act funds, however, which put further strain on private-sector financing for those projects. Including FutureGen and AEP Mountaineer, the five electricity-generating large-scale CCS demonstration projects expended 55% of awarded Recovery Act funds and left the remaining 45% unspent. Of the CCPI projects funded by Recovery Act dollars, NRG Energy/Petra Nova was the only one to expend all its Recovery Act-awarded funds. This project has begun construction and appears to be closest to becoming operational of all the CCPI Round III projects.

Of the three ICCS large-scale demonstration projects in **Table 2**, only one—Leucadia Energy, LLC—failed to expend its Recovery Act award and left about $249 million unspent. The Air Products & Chemicals, Inc., large demonstration project is currently operational and has captured and stored more than 2 million metric tons of CO_2 since late 2012. The Archer Daniels Midland large demonstration project is scheduled to begin operations sometime in 2016. All other ICCS

[57] Ibid., p. 77.

projects appear to have expended their Recovery Act funds prior to the September 30, 2015, deadline.

The example of the Kemper County Energy Facility in Kemper County, MS, an integrated gasification combined-cycle (IGCC)[58] power plant that will be owned and operated by Mississippi Power Company, a subsidiary of Southern Company, provides insight into several Recovery Act-funded projects. DOE awarded Southern Company Services a cooperative agreement under the CCPI Round II program, prior to enactment of the Recovery Act and the CCPI Round III awards, to develop gasification technology called Transport Integrated Gasification (TRIG™).[59] The Kemper project may be the first electricity-generating power plant with CCS to begin operations in the United States. DOE awarded Kemper $270 million, a figure comparable to Recovery Act awards for CCPI and ICCS large demonstration projects shown in **Table 2**. Similar to many of those projects, the complex Kemper project experienced schedule delays and cost overruns. Currently, the projected start date is the third quarter of 2016, and the project's overall cost has increased from less than $3 billion to more than $6.6 billion.[60] The technical challenges for a first-mover demonstration plant of its kind, and the concomitant escalating cost estimates, lend credence to the shape of the cost curve trend shown in **Figure 1**, in which demonstration plants are at peak cost between development and deployment. Most, if not all, of the large CCPI projects likely fall along that portion of the cost curve depicted in **Figure 1**. In contrast to the Recovery Act-funded projects listed in **Table 2**, the Kemper project did not face a September 30, 2015 spending deadline.[61]

DOE acknowledges that many of the Recovery Act-funded projects were technologically difficult and challenging, but it does not consider the relinquishment of unspent funds to signify project failure; rather, DOE takes the relinquishment of funds to mean that the projects simply did not meet the requirement to spend the funds by the deadline.[62] DOE notes that due to its spending on CCS and its partnerships with industry, the costs of capturing CO_2 have dropped significantly and its projects have stored more than 10 million metric tons of CO_2.[63]

Despite these achievements, some stakeholders conclude that the DOE CCS program "has not reached critical mass with regard to the commercialization of CCS in the time frame needed to meet stated U.S. goals for CO_2 emissions reductions."[64] Even though Recovery Act funding predominantly targeted large-scale demonstration projects, "significantly more CCS/CCUS pilot and demonstration projects are needed in order to commercially deploy the technology.... Without adequate demonstration, there can be no commercialization."[65]

The level of funding for CCS projects is a perennial issue for Congress. Given that a substantial amount of appropriated funding through the Recovery Act for CCS demonstration projects went

[58] For more information on integrated gasification combined-cycle power plants and CCS, see CRS Report R41325, *Carbon Capture: A Technology Assessment*, by Peter Folger.

[59] MIT Carbon Capture & Sequestration Technologies, see https://sequestration.mit.edu/tools/projects/kemper.html.

[60] Christa Marshall, "Kemper Plant Delayed Until 2nd Half of Year," *Greenwire*, February 3, 2016, at http://www.eenews.net/stories/1060031719%5C.

[61] For more information about Kemper and the DOE CCS program, see CRS Report R42496, *Carbon Capture and Sequestration: Research, Development, and Demonstration at the U.S. Department of Energy*, by Peter Folger.

[62] Email from Andrew HLasko, General Engineer, DOE Headquarters, January 29, 2016.

[63] Ibid.

[64] National Coal Council, *Fossil Forward: Revitalizing CCS Bringing Scale and Speed to CCS Deployment*, p. 130.

[65] Ibid. CCUS is the acronym for carbon capture and utilization, meaning converting the captured carbon into some other product or use.

unspent, Congress may examine the broader policy, financial, and regulatory factors that posed challenges to several large Recovery Act-funded demonstration projects and led to their delay or cancellation.

Appendix. ICCS Projects With Less Than $100 Million of Recovery Act Funding

Awardee Name	Total Dollars Awarded	Award Date
AIR PRODUCTS AND CHEMICALS, INC.	71,700,000	09/17/10
ELTRON RESEARCH & DEVELOPMENT, INCORPORATED	71,377,413	09/16/10
PHYCAL INC	51,487,018	01/15/10
RAMGEN POWER SYSTEMS, LLC	50,000,000	07/30/09
URS ENERGY & CONSTRUCTION, INC.	44,000,000	09/10/10
PRAXAIR INC	35,000,000	09/17/10
SIEMENS ENERGY, INC.	32,330,423	09/16/10
GENERAL ELECTRIC COMPANY	31,315,237	09/16/10
CLEAN ENERGY SYSTEMS, INC.	30,000,000	09/17/10
SKYONIC CORPORATION	28,000,000	01/15/10
CALERA CORPORATION	21,366,319	01/15/10
NOVOMER, INC.	20,525,889	01/15/10
MEMBRANE TECHNOLOGY AND RESEARCH, INC.	15,000,000	09/17/10
ADA-ES, INC.	15,000,000	09/17/10
ALSTOM POWER INC.	10,000,000	09/17/10
TOUCHSTONE RESEARCH LABORATORY LTD (INC)	6,757,360	12/30/09
UNIVERSITY OF ALABAMA (INC)	5,000,000	09/08/10
TERRALOG TECHNOLOGIES USA INC	5,000,000	09/17/10
NORTH AMERICAN POWER GROUP, LTD.	5,000,000	09/09/10
UNIVERSITY OF ILLINOIS	5,000,000	09/09/10
UNIVERSITY OF KANSAS CENTER FOR RESEARCH INC	5,000,000	09/15/10
SOUTH CAROLINA RESEARCH FOUNDATION	5,000,000	09/09/10
UNIVERSITY OF TEXAS AT AUSTIN	5,000,000	09/09/10
UNIVERSITY OF UTAH , THE	5,000,000	09/17/10
UNIVERSITY OF WYOMING	5,000,000	09/09/10
REGENTS OF THE UNIVERSITY OF CALIFORNIA, THE	4,820,000	01/15/10
SANDIA TECHNOLOGIES, LLC	4,380,000	09/16/10
LAWRENCE LIVERMORE NATIONAL SECURITY, LLC	4,149,776	01/07/10
BATTELLE MEMORIAL INSTITUTE	4,099,098	01/26/10
LOS ALAMOS NATIONAL SECURITY, LLC	4,099,043	01/07/10
ALCOA INC.	3,598,746	01/15/10
ARIZONA PUBLIC SERVICE COMPANY	3,500,000	09/11/09

Awardee Name	Total Dollars Awarded	Award Date
WOLVERINE POWER SUPPLY COOPERATIVE, INC.	2,722,757	11/16/09
CONOCOPHILLIPS COMPANY	2,175,530	11/16/09
C6 RESOURCES LLC	2,032,765	11/16/09
UNIVERSITY OF UTAH , THE	1,773,760	11/16/09
UOP LLC	1,552,449	01/15/10
MIKRO SYSTEMS, INC.	1,508,479	09/28/10
MEMBRANE TECHNOLOGY AND RESEARCH, INC.	1,499,129	09/27/10
SIEMENS ENERGY, INC.	1,411,628	09/24/10
CEMEX, INC.	1,203,651	11/17/09
PRAXAIR INC	1,171,070	11/16/09
RENEWABLE ENERGY INSTITUTE INTERNATIONAL	1,135,903	01/15/10
FARADAY TECHNOLOGY, INC.	992,392	09/27//10
RESEARCH TRIANGLE INSTITUTE	984,258	01/15/10
INSTITUTE OF GAS TECHNOLOGY	933,378	01/15/10
UNIVERSITY OF MASSACHUSETTS	572,891	01/15/10
SUNRISE RIDGE ALGAE INC	503,478	12/24/09
BATTELLE MEMORIAL INSTITUTE	409,581	11/18/09
TECHNOLOGY AND MANAGEMENT SERVICES, INC.	269,000	09/14/09
SANDIA CORPORATION	223,000	02/23/10
POTOMAC-HUDSON ENGINEERING, INC.	169,812	03/18/10

Source: U.S. Department of Energy, "Recovery Act," at http://www.energy.gov/recovery-act.

Note: All of these projects in the Appendix appear to have spent their Recovery Act awards before the September 30, 2015, deadline.

Author Contact Information

Peter Folger
Specialist in Energy and Natural Resources Policy
pfolger@crs.loc.gov, 7-1517