



# The return on investment of the clean coal technology program in the USA

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## HIGHLIGHTS

- ▶ Its benefits far exceed costs, and benefits are increasing rapidly.
- ▶ The ROIs to federal govt. and private industry are very high.
- ▶ It will create 100,000 jobs annually.
- ▶ Independent reviews find it to be exemplary and well-managed.

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## ABSTRACT

We analyze the return on investment of the U.S. federal government's clean coal technology (CCT) program for the period 2000–2020. We estimate total costs to government and industry and quantify benefits for: (1) Reduced capital costs of advanced technologies in new plants; (2) Reduced capital and operating costs at existing plants to remain compliant with environmental regulations; (3) Reduced fuel costs due to higher efficiencies; (4) Avoided environmental costs; (5) The value of clean coal technology export sales; (6) Jobs created. We find that benefits over the 20-year period total \$111 billion (2008 dollars); the benefits in individual categories range from \$15 billion in fuel cost savings to \$39 billion for capital and technology cost savings in new and existing plants; and that total jobs created exceed 1.2 million, with an annual average of about 60,000 jobs created. We also find that the return on investment to DOE from the CCT program is favorable and is growing rapidly: By 2020, the cumulative DOE costs will likely total \$8.5 billion, for an ROI of more than 13.

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*“Coal is an abundant resource in the world. It is imperative that we figure out a way to use coal as cleanly as possible”. Dr. Steven Chu, Secretary of Energy, at his Senate Confirmation Hearing, January 13, 2009.*

## 1. Introduction

Coal was the most rapidly growing fuel in the world during the past decade and will be the fastest growing fuel over the next decade, and will continue to be the leading source of electric power in the USA for decades to come. At the global level, increasing coal consumption and environmental goals necessitate the rapid deployment of clean coal technologies. The clean coal technology program in the USA has pioneered these critical technologies and demonstrates the benefits of the research and development program.

## 2. The clean coal technology program

“Clean coal technology” (CCT) describes a new generation of energy processes that significantly reduce air emissions and other pollutants from coal-burning power plants. The clean coal technology demonstration program (CCTDP) was initiated 1985 to develop and demonstrate, at commercial scale, innovative technologies that meet strict environmental standards and allow electric power utilities and other industries to cleanly and efficiently use coal as an energy source. The CCTDP was developed as a government-industry partnership, with the share of federal funds limited to a maximum of one-half of the funding for each project.

The first CCTDP projects started in 1987, and over the course of the program 33 projects were completed at a cost of \$3.3 billion, with the U.S. Department of Energy (DOE) investing \$1.3 billion. Because of the program's success, the Power Plant Improvement Initiative (PPII), was begun in 2001. This program resulted in five projects and cost \$71 million, with DOE contributing \$32 million. A third program followed the PPII—the Clean Coal Power Initiative (CCPI). This resulted in 12 projects

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**Table 1**  
**CCT technologies.**

Source: U.S. Department of Energy, Office of Fossil Energy, 2009.

Technology	Impact
<b>Low nitrogen oxide burners</b>	Now on 75% of U.S. coal power plants 1/2 to 1/10 the cost of older systems 25 million ton reduction in U.S. NO <sub>x</sub> emissions through 2005 \$25 billion national benefit
<b>Selective catalytic reduction</b>	Achieves NO <sub>x</sub> reduction of 80% to 90% or more Technology today costs half what it did in the 1980s, and is deployed on about 39% of U.S. coal plants
<b>Flue gas desulfurization (FGD)</b>	Systems now cost 1/3 what they did in the 1970s More than 400 commercial units deployed 7 million ton reduction in SO <sub>2</sub> (beyond what would have occurred without DOE R&D) through 2005 Over \$50 billion savings from the lower FGD costs and environmental improvement
<b>Fluidized bed combustion (FBC)</b>	170 units deployed in the U.S.; 400 units worldwide Highly commercialized with more than \$6 billion in domestic sales and nearly \$3 billion in overseas sales Inherently low NO <sub>x</sub> emitting technology capable of using coal waste fuels not previously usable Providing economic/environmental benefits of \$2 billion through 2020
<b>Integrated gasification combined cycle (IGCC)</b>	In early stage, but 7.5 GW projected to be operating in U.S. by 2020 Estimated economic/environmental benefits of over \$12 billion by then Key component of <i>Futuregen</i>

costing \$2.7 billion, with the DOE contribution totaling \$530 million (U.S. Department of Energy, 2009). All three programs, including the PPII and the CCPI, are commonly referred to as the CCTDP.

Technologies in four categories were demonstrated under the CCTDP: Advanced Electric Power Generation, Environmental Control Devices, Coal Processing for Clean Fuels, and Industrial Applications. The program's critical technology needs include Integrated Plants, Emissions Control, Advanced Combustion, Advanced Gasifier System, Gas Cleaning, Syngas Utilization for Power and Fuels, CO<sub>2</sub> Capture, and CO<sub>2</sub> Sequestration. In the late 1980s and early 1990s, DOE conducted a joint program with industry and state agencies to demonstrate the best of these new technologies at scales large enough for companies to make commercial decisions. More than 20 of the technologies tested in the original program achieved commercial success (U.S. Department of Energy, Assistant Secretary for Fossil Energy).

The early program focused on the environmental challenges of the time—primarily concerns over the impact of acid rain on forests and watersheds. In the 21st century, additional environmental concerns have emerged, such as the potential health impacts of trace emissions of mercury, the effects of microscopic particles on people with respiratory problems, and the potential global climate-altering impact of greenhouse gases (GHGs). Building on the successes of the original program, the new clean coal initiative encompasses a broad spectrum of research and large-scale projects that target pressing environmental challenges.

The CCPI is providing government co-financing for new coal technologies that can help utilities reduce sulfur, nitrogen, and mercury pollutants from power plants—Table 1. In addition, some of the early projects are showing ways to reduce GHG emissions by increasing the efficiency of coal plants. DOE provides up to 50 percent of the project funding for the Clean Coal projects. The Power Plant Improvement Initiative Program successfully completed the fourth and final project, and the Clean Coal Technology Demonstration Program concluded with 33 successfully completed demonstration projects (National Energy Technology Laboratory, 2009). In addition, DOE manages a portfolio of clean coal programs that research and develop CCS technology or demonstrate its application (Gaffigan, 2009).

**Table 2****CCTDP funding** (millions of 2008 dollars).

Source: U.S. Department of Energy and Management Information Services, Inc.

FY	Funding	FY	Funding
1986	\$171	1998	\$(131)
1987	249	1999	(52)
1988	323	2000	(175)
1989	296	2001	11
1990	831	2002	10
1991	567	2003	(56)
1992	589	2004	(109)
1993	0	2005	(176)
1994	315	2006	(21)
1995	48	2007	(21)
1996	195	2008	0
1997	\$(3)	Total	\$2978

### 3. Estimating CCT costs and benefits

#### 3.1. Costs

Congress appropriated a net amount of \$2.1 billion (2.98 billion in 2008 dollars) for the CCTDP based on appropriations bills that began in 1986 (Table 2).

Table 3 summarizes the funding by fiscal year for the PPII and CCPI programs and shows that funding totaled \$727 million (\$887 million in 2008 dollars). The amount of appropriated funds available for project awards is reduced by Program Support, the Small Business Innovation Research (SBIR) program, the Small Business Technology Transfer (STTR) program, and other adjustments. Program Support provides for a share of the DOE administrative expenses of the programs. The SBIR program implements the Small Business Innovation Development Act of 1982, and provides funding for small, innovative firms in selected research and development areas. The STTR program implements the Small Business Technology Transfer Act of 1992, which provides funding for small business concerns performing cooperative R&D efforts. Other adjustments include across-the-board general and omnibus reductions imposed by Congress.

Projects in the CCTDP, PPII, and CCPI are subject to similar requirements and oversight. A principal characteristic of the demonstration projects is the cooperative funding agreement between the participant and the federal government referred to

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