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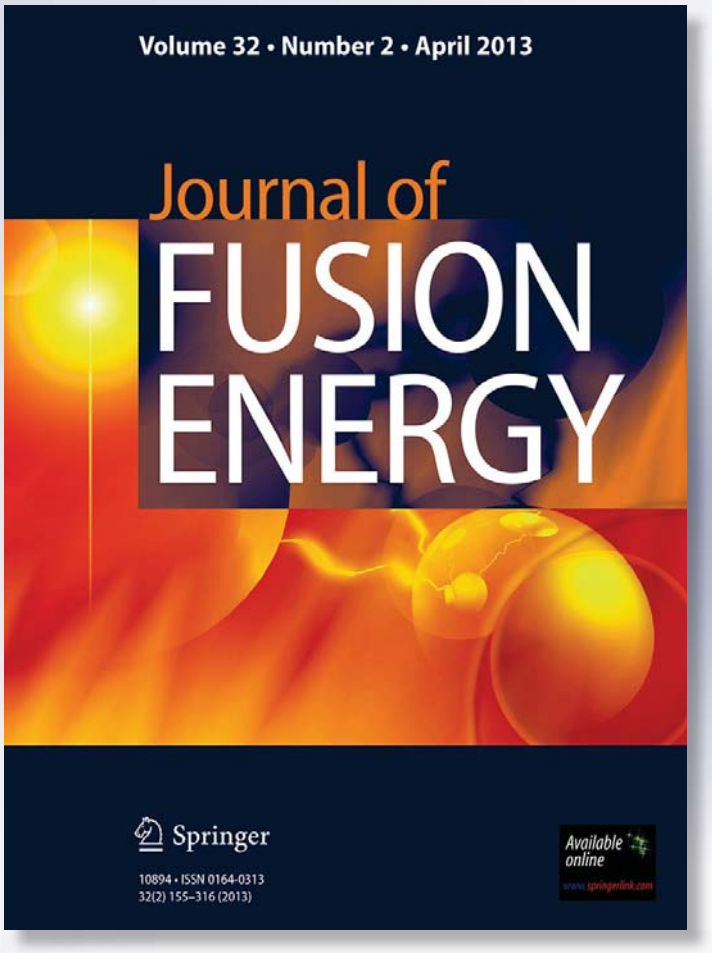

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ORIGINAL RESEARCH

Economic, Environmental, and Job Impacts of Increased Efficiency in Existing Coal-Fired Power Plants

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Abstract Analyses of the CO_2 mitigation potential of increasing the efficiency of existing U.S. coal-fired power plants have indicated that significant CO_2 emissions could be avoided if the efficiency of existing plants could be improved. This paper expands the analysis and estimates the potential economic and employment impacts of engaging in an U.S.-wide efficiency improvement program. Specifically, this study: (1) Discusses the factors affecting the operating efficiency of coal-fired power plants; (2) Identifies feasible efficiency improvements to existing coal-fired power plants; (3) Estimates the costs of coal power plant efficiency improvements; (4) Estimates the costs of a widespread coal power plant efficiency improvement (CPPEI) program; (5) Assesses the potential impacts of the CPPEI program, including the annual jobs created by the CPPEI program, the permanent operations and maintenance (O&M) jobs created by the CPPEI program, and the potential occupational impacts; (6) Evaluates the advantages and disadvantages of two CPPEI program options; and (7) Discusses the broader economic and employment implications of the program.

Keywords Coal power plant efficiency · Economic benefits · Jobs · Environmental impacts

Introduction

The fleet of U.S. coal-fired power plants is relatively old, and age degrades power plant efficiency [1]. However, the efficiency of a specific plant is impacted by many factors, including design choices and tradeoffs between capital costs, efficiency, operational requirements, and availability; operational practices; fuel type; the level of pollutant emission controls; ambient conditions; and other factors [2]. On average, most plants usually operate below plant design capacities.

Studies have found that significant efficiency improvements in existing coal-fired power plants are possible from a variety of retrofit measures [3] and, while a wide range of power plant retrofits, upgrades, and refurbishings are feasible, the efficiency impacts and costs of individual improvements vary widely (Table 1). However, it is unlikely that all of the possible efficiency improvements could be implemented at every plant, efficiency improvements are not necessarily additive, and the cost effectiveness of any specific improvement will depend on a variety of factors.

Efficiency Improvements and Jobs

There are numerous studies discussing the efficiency improvements possible in coal-fired power plants, and many studies conclude that energy efficiency improvements are usually more cost-effective and less expensive than building new plants [4]. Management Information Services Inc (MISI) and the National Energy Technology Laboratory (NETL) estimate that power plant efficiency improvements can be implemented at a cost of between about $25/kW and $250/kW (Table 1; Fig. 1). Research indicates that energy efficiency retrofit improvements to the existing fleet are much more cost effective than building new coal plants, since the U.S. Energy Information Administration (EIA) estimates that the cost of

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Table 1 Estimated costs of coal power plant efficiency improvements

Project	Source	Facility	Retrofit application	Overall efficiency improvement (%)	Cost (U.S. dollars)	Cost/% efficiency improvement	Cost/kW	Cost/kW efficiency gained
Coal Creek Station	NETL Fact Sheet, 9/2008	546 MW coal plant	Coal drying	~4	$31.5M	$7.9M	$58	$1,442
Big Bend Power Station	NETL Fact Sheet, 9/2005	445 MW boiler	Sootblower optimization	2	$3.4M	$1.7M	$7.6	$382
Generic coal power station	*Power Engineering*, July 2008	225 MW coal plant	Turbine Refurbish	~4	$28M	$7M	$124	$3,100
Generic coal power station	*Power Engineering*, July 2008	225 MW coal plant	Air preheaters	~4	$9M	$2.25M	$40	$1,000
Generic coal power station	*Power Engineering*, July 2008	225 MW coal plant	Improve steam turbine-driven feed pumps	~2.5	$2.3M	$920K	$10.2	$409
Green River Station, Unit 3	*Power Engineering*, July 2007	75 MW coal plant	Optimize boiler tuning	3	$250K	$83K	$3.33	$111
Green River Station, Unit 4	*Power Engineering*, July 2007	109 MW coal plant	Optimize boiler tuning	5.4	$250K	$46.3K	$2.3	$42
Banshan Power Station	APEC 2003	125 MW coal plant	Various plant improvements	~14	$3.5M	$250K	$28	$200
Liddell Power Station	APEC 2003	500 MW coal plant	Turbine refurbish	~3	$34M	$11.3M	$68	$2,267
Generic coal power station	*Power Engineering*, October, 2004	600 MW coal plant	Turbine retrofit	~15	$162M	$10.8M	$270	$1,800
Generic coal power station	APEC 2005	150 MW coal plant	Air Heater refurbish	2.2	$1.4M	$636K	$9.3	$193
Generic coal power station	APEC 2005	250 MW coal plant	Steam turbine refurbish	2	$5.2M	$2.6M	$21	$520
Generic coal power station	ASME 2004	125 MW coal plant	Condenser cleaning	0.4	$50K/year	$125/year	$0.4/year	$25/year

Source Management Information Services, Inc., *Economic and Employment Impacts of Increased Efficiency in Existing Coal-Fired Power Plants*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-41817M4462, June 2009

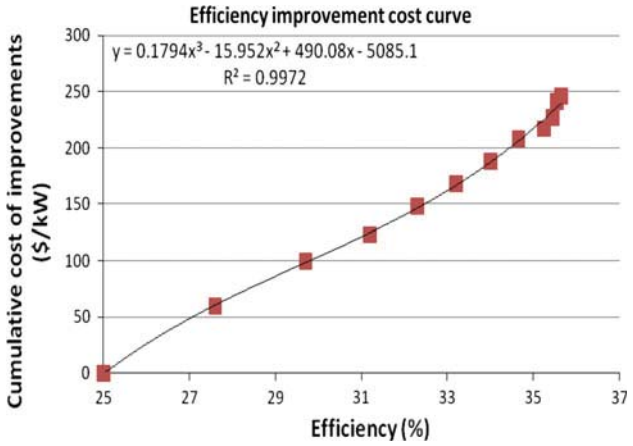

Fig. 1 Power plant efficiency improvement cost curve. *Source* National Energy Technology Laboratory, "Development of a Cost Curve for Efficiency Improvement Projects at Coal-fired Power Plants," May 2009

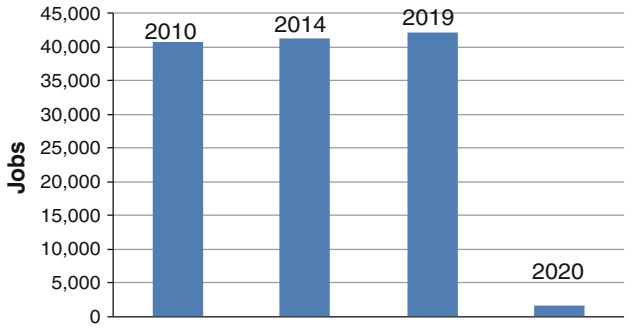

Fig. 2 Net job creation under CPPEI option 1. *Source* Management Information Services, Inc., *Economic and Employment Impacts of Increased Efficiency in Existing Coal-Fired Power Plants*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-41817M4462, June 2009

building new coal plants can range from about $1,800/kW to nearly $2,800/kW for Integrated Gasification Combined Cycle (IGCC) with carbon capture and storage (CCS) [5].

The average operating efficiency of U.S. coal plants is about 31.8 %, and the costs and implications of increasing this average level of efficiency by 5 % points (about 15 %) to 36.8 % were assessed. Using estimates of the average costs for power plant efficiency improvements, to increase the average efficiency of these plants by 5 % points was estimated to cost about $28 billion [6].

Once a plant has improved its efficiency, there are two main options that operators could pursue; they may choose to (1) Generate more electricity at the same CO_2 emissions level; (2) Generate the same amount of electricity and produce less CO_2. The actual outcome will likely be a combination of the two options and will be a plant-specific decision based on various considerations, and one of the most important factors influencing a plant's decision is the U.S. Environmental Protection Agency (EPA) New Source Review (NSR) program. The electric power industry contends that the NSR process is an impediment to power plant efficiency improvement projects, and EPA has also found that NSR may inhibit power plant efficiency programs [7].

Our research assumed that the CPPEI program was to be implemented over a 10 year period, 2010–2019, and, since the total cost would be $28 billion, this represents a cost of about $2.8 billion per year. As noted, a 5 % point increase in the increase in the efficiency of the U.S. coal plant fleet is equivalent to increasing total coal plant fleet generating capacity by about 15 %. Under option 1, the total number of jobs created annually by the CPPEI program would be the sum of the (temporary) retrofit construction jobs and the permanent O&M jobs (Fig. 2):

- In 2010, about 40,750 jobs would be created.
- In 2014, about 41,350 jobs would be created.
- In 2019, about 42,100 jobs would be created.
- In 2020, and thereafter, about 1,500 permanent O&M jobs would be maintained.

It was estimated that the major job impacts of the CPPEI program would be on occupations such as construction supervisors and managers, electricians, electrical engineers, technical helpers and assistants, construction equipment operators, maintenance and repair workers, health and safety engineers and specialists, business operations specialists, welders, etc. (Table 2).

Research indicates that option 1 offers considerable advantages:

- U.S. coal-fired electricity generating capacity could be increased significantly with no increase in coal consumption or CO_2 emissions.
- These efficiency improvements would be the equivalent of building 88 new 500 MW coal-fired plants, and would not encounter the problems that siting and building new coal plants currently confront.
- The efficiency retrofits would be much more cost effective than new plant construction.
- This program would create between about 41,000 and 42,000 jobs over a 10 year period and about 1,500 jobs on a permanent basis.
- Many of these jobs would be engineering and technical jobs paying above average salaries.

However, this option also has potential disadvantages:

- The plant retrofits may trigger NSR issues, and this makes them less attractive to utilities.
- This option could be used to force utilities to make investments they may not be too eager to make for a variety of reasons.

Table 2 Occupational impacts of the CPPEI program (selected occupations)

Occupation	Jobs in 2019
Architectural and civil drafters	120
Business operations specialists	420
Carpenters	210
Civil engineers	90
Computer systems analysts	180
Control and valve installers and repairers	510
Construction managers	980
Cost estimators	290
Electrical and electronics drafters	100
Electrical and electronics engineering technicians	190
Electrical and electronics repairers, power station	270
Electrical engineers	840
Electricians	1,260
Electricians helpers	330
Electro-mechanical technicians	140
Financial analysts	200
First line construction supervisors and managers	1,010
First line supervisors/managers of production and operating workers	180
General and operations managers	320
Health and safety engineers	610
Helpers—installation, maintenance and repair workers	620
Industrial engineers	170
Industrial machinery mechanics	250
Laborers and material movers	370
Machinery maintenance workers	210
Machinists	180
Miscellaneous installation, maintenance, and repair workers	1,520
Network and computer systems administrators	150
Occupational health and safety specialists	80
Operating engineers and other construction equipment operators	800
Painters, construction and maintenance	150
Pipelayers	360
Plumbers, pipefitters, and steamfitters	460
Power plant operators	160
Sheet metal workers	110
Stationary engineers and boiler operators	140
Structural iron and steel workers	420
Training and development specialists	120
Truck drivers	890
Welders, cutters, solderers, and brazers	350
Total, all occupations (including those not listed)	42,100

Source Management Information Services, Inc., *Economic and Employment Impacts of Increased Efficiency in Existing Coal-Fired Power Plants*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-41817M4462, June 2009

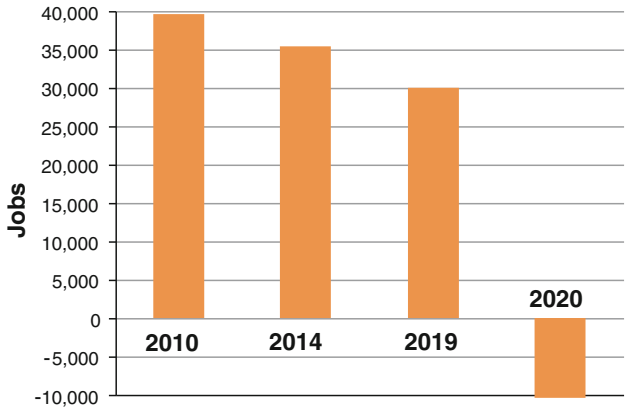

Fig. 3 Net job creation under CPPEI option 2. *Source* Management Information Services, Inc., *Economic and Employment Impacts of Increased Efficiency in Existing Coal-Fired Power Plants*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-41817M4462, June 2009

- A public utility commission could force a utility to make a level of investment that could trigger an NSR review.

Option 2 generates the same amount of electricity, but consumes less coal and produces less CO_2. Since the efficiency improvement program is the same as under option 1, the retrofit construction and O&M jobs impact would be similar; however, there would be job losses in the coal mining industry. Thus, in terms of net job creation, under option 2 (Fig. 3):

- In 2010, about 39,550 net jobs would be created.
- In 2014, about 35,350 net jobs would be created.
- In 2019, about 30,100 net jobs would be created.
- In 2020, and thereafter, about 10,500 net jobs would be permanently lost.

This option has two advantages: (1) Since electricity generation is not increasing, it may raise fewer issues with respect to NSR; (2) it results in significant CO_2 reductions. However, option 2 at least two major disadvantages: (1) since it results in no new electricity production, it does nothing to address future U.S. electricity requirements and impending capacity shortages; (2) it may eventually result in net coal mining job losses.

The benefits of the CPPEI program would include those associated with marginal coal plant operation cost declines which would lead to lower end-user electricity prices. These could, in turn, lead to increased disposable income, increased economic activity, and increased business profits, and the impacts would be significant and widespread throughout the economy [6].

A review of independent studies that estimated the economic and employment benefits in the U.S. generated

by coal as a low-cost energy provider indicated that the major benefit to the U.S. economy from the CPPEI program would be the provision a large increment of new, low-cost, coal-based electricity generation [8]. The CPPEI program would increase total U.S. coal electricity generation by about 11 %. Using the mean estimate of the studies reviewed indicated that the CPPEI program would result in annual net job creation of about 250,000, but even using a smaller estimate indicates net annual job creation of about 120,000. This is net job creation resulting from the electricity price impacts and would be in addition to the jobs created by the CPPEI construction and O&M programs.

Conclusions

The electricity price-induced jobs created by the CPPEI program are orders of magnitude greater than the jobs impacts of the construction, O&M, and mining activities. Under option 1, the more electricity generation option, in the year of maximum impact (2019) a total of about 42,100 construction and O&M jobs would be created, and in 2020, and thereafter, about 1,500 permanent O&M jobs would be maintained. Under option 2, the equal amount of electricity generation option, in the year of maximum impact (2019) a total of about 30,100 construction and O&M jobs would be created, and in 2020, and thereafter, about 10,500 jobs would be permanently lost. Clearly, the job impacts of the CPPEI program resulting from lower electricity costs would overwhelm by orders of magnitude the impacts resulting from construction, O&M, and coal mining.

This finding and the estimates provided here of the likely magnitude of the impacts are significant and have potentially far-reaching implications.

First, the major economic and job impacts of the CPPEI program would result not from the retrofit construction and O&M activities. Rather, while these would be important—especially at the local and regional level where the retrofitted plants are located, they would be literally swamped by the effects on the economy that CPPEI would have in increasing the availability of low-cost electricity.

Second, and at least as important, these findings may indicate a need to rethink current estimates of the impact of energy costs on the economy and of the likely effects of environmental policies that would greatly increase these costs and reduce coal utilization.

Nevertheless, even on the basis of the preliminary results developed here, some things are clear. Most of the focus on the economic and job impacts of different types of energy programs and initiatives is often on the effects of program expenditures. While these can be large, especially for multi-billion dollar programs, the findings here indicate that these effects may likely be overwhelmed by orders of magnitude by the impact of these programs on energy and electricity prices. This issue is too little explored and poorly understood. Further, even when these effects are recognized, the remedies proposed often miss the mark.

For example, in the current debate over GHG control legislation it is generally recognized that a cap-and-trade program would increase electricity prices. Although estimates of the magnitude vary, in some states for some utility customers electricity prices could double. The remedies for this are often advanced as means to reimburse electricity consumers for part of the cost increase and to protect low-income consumers who may be especially hard hit by the electricity price increases. While these are important concerns and the feasibility and efficacy of such policies need to be debated, the whole discussion misses the main point. As shown here, the major negative impact that should be of concern is the impact on industry, business, commerce, and the economy of these anticipated energy cost increases.

Policies that forcibly and significantly reduce coal-fired electricity production may have serious negative consequences for the U.S. economy and for jobs. The studies reviewed here indicate that for every 1 % reduction in coal-generated electricity, somewhere between about 24,000 and 36,000 jobs may be at risk. One does not have to accept these estimates at face value to be concerned. Even if they are high, the implications are ominous. For example, even using the mean estimate, a 20 % reduction in coal generation could cause an annual, permanent net job loss of nearly 500,000. And some GHG control proposals could cause coal generation to decrease by much more than 20 %.

Finally, one thing that many analysts agree on is that, to solve its current economic and financial problems, the U.S. will have to start producing more and exporting more and will have to reverse the decades-long atrophy of its manufacturing sector [9]. The U.S. will no longer be able to shift its energy-intensive production activities abroad and will thus require significantly more reliable, reasonably priced electricity in the coming years. Absent this, the U.S. manufacturing sector will continue to decline, well-paying manufacturing jobs will continue to disappear and to be off-shored, and U.S. living standards will erode. Much of this low cost electricity will have to be provided by coal, and this is not well understood.

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