GOING GREEN: INCENTIVES FOR THE ELECTRIC POWER INDUSTRY

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ABSTRACT

The electric power industry finds itself at a critical juncture—increased regulation of its emissions combined with a shift in U.S. energy policy to emphasize renewable energy. Industry executives must determine the timing and the extent of their investments in clean technology to preserve the use of coal as a viable option. It is time for those executives to question whether they should make investments merely to comply with new regulations or to go beyond meeting regulations to enhance the industry's environmental (green) performance and reputation. We argue that an industry with a poor reputation in some areas (e.g., emissions) should want to improve its reputation. This could lead to enhanced profits for the industry, reduced pressure from regulatory bodies, and enhanced goodwill in the community. We investigate the company and industry-wide profit incentives for firms in the electric power industry to use clean versus dirty coal technology. Our model provides equations to show the total industry profit as a function of the participation percentage of players in the industry. We conclude with managerial implications and suggestions for future research.

JEL: C02, C61, M10, O21

KEYWORDS: Green, *n*-person prisoner's dilemma, clean coal, tragedy of the commons

INTRODUCTION

As the climate change legislation debate continues, industry faces great uncertainty regarding impending changes in regulations and the investments required to meet those regulations. For example, recently we witnessed attempts at worldwide regulation of greenhouse gases at the Copenhagen Climate Conference at which delegates failed to reach a binding agreement due to disagreements on emissions, payments into a global fund by richer countries, and deforestation reductions (Hawser, 2010). Within the United States, the U.S. Senate considered, but failed to pass, three climate change bills during 2009: the Bingaman-Specter bill, the Lieberman-Warner bill, and the Manager's Amendment to the Lieberman-Warner bill (Richards & Richards, 2009).

The electric power industry, in particular the sector using coal as fuel, appears to be operating under extreme uncertainty regarding greenhouse gas regulation. For example, in October 2007, Kansas denied a permit for a proposed coal-fired plant based on the plant's anticipated carbon dioxide (CO_2) emissions (Sioshansi, 2007). Since 2007, at least 84 projects and $64 billion of investment in coal-fired plants were canceled and/or put on hold in the U.S. due to the uncertainty regarding legislation of greenhouse gases and the lack of a breakthrough in carbon capture and sequestration (Sioshansi, 2010). Victor and Rai (2009) lamented that the financial crisis in the U.S. has killed plans for investment in clean coal technology. However, during this same period of reduced investment in clean coal technology, the U.S. Department of Energy earmarked $16.8 billion toward *renewable* energy (Holden, 2009).

The electric power industry finds itself at a critical juncture—increased regulation of its emissions combined with a shift in U.S. energy policy to emphasize renewable energy. However, coal is still the dominant fuel source, accounting for about 59% of electric power generation (Energy Information Administration, 2007b). Industry executives must determine the timing and the extent of their investments in clean technology to enable continued use of coal in the electric power industry. It is time for those executives to question whether they should make investments merely to comply with new regulations or to go beyond meeting regulations to enhance the industry's environmental (green) performance and reputation. We argue that an industry with a poor reputation in some areas (e.g., emissions) may want to improve its reputation. This could lead to enhanced profits for the industry, reduced pressure from regulatory bodies, and enhanced goodwill in the community. We investigate the company and industry-wide profit incentives for firms in the electric power industry to invest in clean coal technology. Our model provides equations to show the total industry profit as a function of the participation percentage of players in the industry. The remainder of our paper is organized as follows: a literature review of environmental regulations, technology, and obstacles to industry-wide adoption of clean technology; a model illustrating the payoffs to the electric power industry from using cleaner technology; and managerial implications and suggestions for future research.

LITERATURE REVIEW

In the first section, we provide an overview of environmental regulations affecting the use of coal by the electric power industry. Second, we discuss environmental technology for reducing coal-fired emissions. Third, we elaborate on the benefits of using environmental technology to achieve clean production. Fourth, we present the *n*-person prisoner's dilemma as a model for explaining why electric power firms are not proactive in implementing environmental technology.

Environmental Regulation: The U.S. Department of Energy enacted the 1990 Clean Air Act Amendments to address problems with acid rain caused by sulfur dioxide (SO_2) and nitrous oxides (NO_x) emissions from electric power plants using fossil fuels (Energy Information Administration, 2007a). The 1990 Clean Air Act Amendments established the U.S. Acid Rain Program (ARP) and created the world's first large cap-and-trade program for air pollution (Napolitano et al., 2007). The ARP set a limit (cap) on total SO_2 emissions from electric power generators. Every year, the Environmental Protection Agency (EPA) issues allowances for emissions equal to the cap by using pre-defined formulas. The EPA also auctions a small percent (2.8%) of the allowances each year. Each allowance allows a firm to emit one ton of SO_2. The ARP also required a two million ton annual NO_x emission reduction from projected emissions in 2000, however, electricity power generating companies were provided some flexibility in meeting the caps, e.g., by averaging emission rates at two or more units owned by the same company (Napolitano et al., 2007). Napolitano et al. (2007) attributed the greater than 99% compliance with these caps to rules that are clear and easy to enforce.

More recently, in the United States, we witnessed the consideration and failure of three climate change bills during 2009: the Bingaman-Specter bill, the Lieberman-Warner bill, and the Manager's Amendment to the Lieberman-Warner bill (Richards & Richards, 2009). Each of those bills would have forced caps on and overall reduction in carbon dioxide emissions. For example, the Lieberman-Warner bill would have mandated a 17% decrease in CO_2 by 2025 (relative to 2000 levels). One of the greatest concerns regarding carbon dioxide caps is the lack of viable environmental technology to meet the caps and desired reductions in CO_2. Environmental technology is discussed in the next section.

Environmental Technology: Given the worldwide push to reduce greenhouse gases, investment in environmental management technologies has become an increasingly important topic. Environmental technology falls into two categories: (1) end-of-pipe technology and (2) cleaner production (Frondel, Horbach, & Rennings, 2007). End-of-pipe technology is an add-on to existing technology to reduce pollution, and cleaner production decreases pollution at the source.

Examples of end-of-pipe (abatement) technology are selective noncatalytic reduction (SNCR) and selective catalytic reduction (SCR) used to reduce NO_x emissions and flue gas desulfurization equipment (scrubbers) used to reduce SO_2 emissions (Energy Information Administration, 2007a). End-of-pipe technology for CO_2 is referred to as carbon capture and storage (CCS). The primary challenge with CCS is reducing the costs of capturing and storing the CO_2 in geological formations, coal seams, oil and gas bearing seams, and storage options on dry land (Tucker, 2007).

Cleaner production (pollution prevention) technology includes the use of fuel switching and/or blending or using more efficient steam generators. Coal has been ranked into four categories by the Energy Information Administration (Energy Information Administration, 2007a) - lignite, subbituminous, bituminous, and anthracite. Increasing in rank from lignite to anthracite increases carbon content and recoverable heat energy. Furthermore, the EIA notes that using scrubbers to remove SO_2 is estimated to cost \$322 per ton. Modifying a high sulfur bituminous coal-fired plant to burn lower sulfur subbituminous coal is estimated to cost \$113 per ton of SO_2 removal, which is the least expensive method for SO_2 removal. The EIA (2007a) lists fuel switching and/or blending with a lower sulfur, subbituminous coal, e.g., from the Powder River Basin (PRB) in the western U.S., as the dominant compliance method for achieving SO_2 reductions. However, the use of PRB coal by utilities in the central and eastern U.S. has drawbacks, e.g., higher water content (about 28% water content compared to 8% water content for bituminous coal), lower heating value, and longer transportation routes than local bituminous coal (Labbe, 2009). The transportation of PRB coal and its higher water content lead to higher CO_2 production. The Energy Information Administration (2010) lists the CO_2 of subbituminous coal as 213 pounds of CO_2 per million BTU, compared to 205 pounds of CO_2 per million BTU for bituminous coal. Labbe (2009) recommended a strategy of blending PRB coal with bituminous coal, which results in lowering CO_2 emission and continued compliance with SO_2 and NOx emissions. Other forms of cleaner technology center on the steam generators. For example, Labbe (2009) recommended furnace performance optimization to control for the inferior combustion characteristics of PRB coal. As another example, Giglio and Wehrenberg (2009) described a new steam generator technology called circulating fluidized bed that uses fluidization to mix and circulate fuel particles with limestone as the particles burn at low temperature—the limestone captures the sulfur emissions and the lower temperature reduces the nitrous oxide emissions.

Benefits of Industry-Wide Clean Technology: As discussed by Navarro and Brunetto (2007), quantifying the benefits of green technology is a classic problem when dealing with non-marketed goods such as clean air. One method suggested to deal with this problem is contingent valuation, which estimates the willingness of customers to pay for some benefit, by surveying those customers. Farzin (2003) hypothesized that contrary to claims by industrialists that stricter emissions standards make firms unprofitable, pollution reduction could lead to more firms in an industry and greater industry output because increased environmental quality increases the demand for the good. Deva (2006) referred to the benefits of sustainable good governance policies as “goodwill-nomics” through which a corporation could gain and maintain an edge over its competitors if it acts as a good corporate citizen. In some cases, participants in an industry collaborate in voluntary environmental programs to reduce the burden of regulation upon themselves (Delmas & Keller, 2005).

However, whether or not benefits can be quantified, perception is reality. Therefore, an industry may decide that as a strategic move, it will seek to participate voluntary in the use of cleaner coal. Despite the potential benefits derived from firms cooperating on environmental issues, firms still may fail to act collectively due to individual incentives for increased profit at each firm. This situation is modeled as an *n*-person prisoner’s dilemma, as described in the next section.

n-Person Prisoner’s Dilemma: The adoption of clean coal technology by all electric power industry players can be modeled as an *n*-person prisoner’s dilemma. Suzuki and Muto (2005) described the prisoner’s dilemma as follows: each player has two choices—cooperate or defect—and each gains a higher payoff by defecting regardless of the strategy chosen by other players. However, if all players defect, then they all are worse off than if they had cooperated. Hardin (1968) referred to this problem as the "tragedy of the commons," in which multiple individuals, acting independently and rationally, deplete a shared resource even when it is clear that it is not in anyone's long-term interest. In the context of voluntary environmental programs, the commons would include the industry's reputation (Prakash & Potoski, 2007).

Even if players agree initially to coordinate their actions, e.g., by all using clean coal, the free-rider problem might be difficult to avoid. Some firms may choose to free ride, i.e., to benefit from the actions of other players without sharing the cost of cooperation (Delmas & Keller, 2005). Prakash and Potoski (2007) described another type of free riding, shirking, as firms joining a voluntary club claiming to produce positive externalities, but not living up to their promises.

In the next section, we present a model illustrating the profit curves for each member firm in the industry for using clean versus dirty coal.

MODEL

The model involves two profit curves and *n* players. The lower profit curve is the profit per player at percentage *p* of participation in clean coal technology. The higher profit curve is the profit for a firm at point *p* that moves from participation using less clean, but more cost efficient, coal. The participation curve is increasing due to the electric power generation perception that as more firms use clean coal, the overall industry image and mitigation of future regulation have a positive benefit to the industry.

<u>Variables</u>

n the total number of players in the industry

p the percent of companies in the industry participating in the clean coal program

f(p) the profitability of the *p* percent of companies participating in using clean coal

g(p) the profitability of the *(1-p)* percent of companies still using dirtier coal

subject to the following assumptions:

$g(i)>f(i)$ firm *i* always makes a higher profit by using dirty coal versus clean coal, for a given *p*.

$g(0)<f(1)$ 100% participation $(p=1)$ has a greater benefit to the industry than when there is no participation $(p=0)$.

$f(p),g(p)>0$ expected profits are positive, non-zero.

Each additional firm that participates has a positive impact, but with diminishing returns, to total industry payoff.

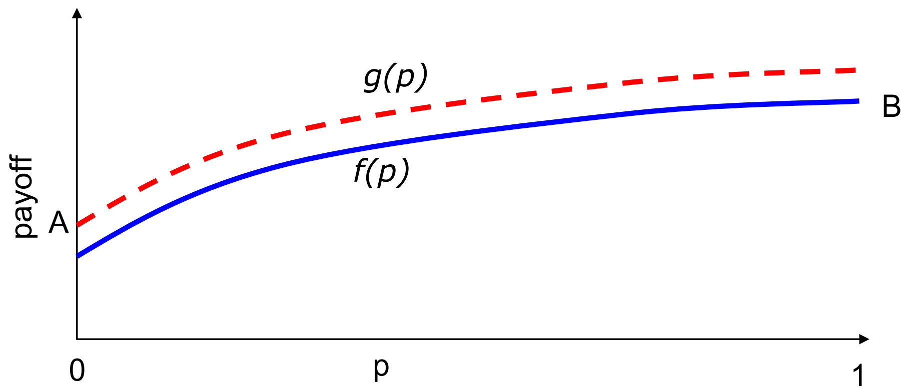
f(p) and *g(p)* are monotonically increasing.

f'(p) and *g'(p)* are positive, but decreasing in probability *p*, $0 \le p \le 1$.

f''(p) and *g''(p)* are negative, indicating that *f(p)* and *g(p)* are strictly concave.

Total industry profit is $f(p)p + g(p)(1-p)$ (1)

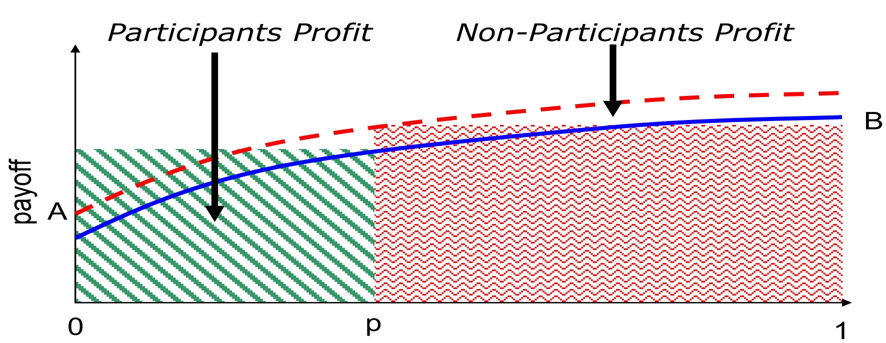
Figure 1: Industry Profit Curves For Participation *f(p)* And Free-Riding *g(p)*



Industry profit curves for participation f(p) and free-riding g(p) for each percent p of the population of companies that participate in the clean coal program.

Each player participating (indicated by the lower profit line) at the percent *p* has an incentive to shirk (i.e., to move to the dashed, higher line), thus making *p* slightly smaller. Then, the payoff for the industry decreases slightly. Each player has this incentive at all percentages *p;* thus, the trend is for *p* to decrease down to 0% participation over time. Hardin (1968) referred to this as the "tragedy of the commons." This indicates that the Adam Smith invisible hand model (Smith & Cannan, 2003), i.e., every firm acting in its own best interest is what is best for all, does not model markets for not-marketed goods such as clean air or brand reputation well. The industry's profits and reputation suffer from individual firms acting in their own self-interest.

Figure 2: Total Profit for the Industry



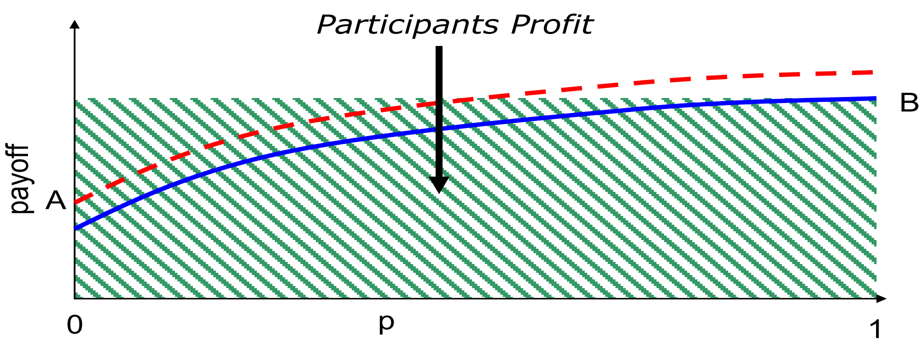
Total profit for the industry is the sum of the two shaded regions above: Participant profit and non-participant profit.

Given our assumptions, point B is the optimal point, maximizing the value of equation (1) for a profit of *f(1)*100% = B*.

When player *i* jumps from *f* to *g*, that player immediately increases its own profit given that *g>f*, and decreases the percent *p* of participating companies. When *p* decreases, the payoffs for all *n* players lower slightly.

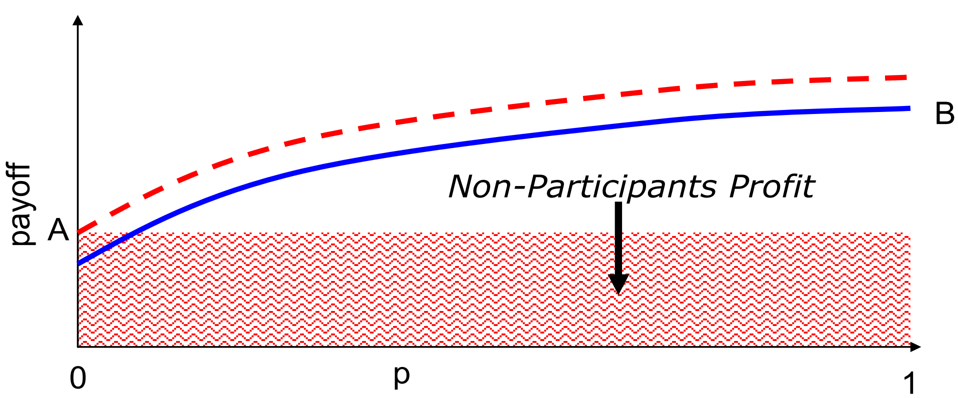
Each player will lose a little profit, and will follow suit and shirk by moving from participation *f*, to non-participation *g*. If all players do not participate, the profit will be at point A, for a total profit of *g(0)*100% = A*.

Figure 3: Participants Profit



In Figure 3, total profit is maximized with p=1, full participation by 100% of the industry players. Profit = B.

Figure 4: Non-Participants Profit



In figure 4, total profit is minimized when all players use dirty coal. Profit = A. This is the result of individual firms acting independently to maximize their own profit, thus moving one at a time from the clean coal f profit to the locally more profitable dirty coal on the g curve.

Because individual firms will seek to maximize their own profit, the solution is an industry-wide regulation imposed within the industry itself or from government. Counterintuitively, a regulation that forces all companies within the industry to comply with the use of clean coal technology would increase the profit of all players, and of course be beneficial to the community, with better air quality.

MANAGERIAL IMPLICATIONS AND CONCLUSIONS

Although participation in the use of clean coal by all members of an industry maximizes the total profit of the industry, the incentive to shirk (i.e., to use dirty coal) is high. An individual firm always improves its individual profit by moving from clean coal to dirty coal. Therefore, without any external incentives, each individual firm, acting as a rational profit maximizer, would use dirty coal.

Prakash and Potoski (2007) recommend that voluntary clubs could reduce shirking by creating monitoring and sanctioning mechanisms. Therefore, the solution is for the industry to adopt binding regulations, or have regulations imposed upon it by the government or a regulatory agency. Although forced compliance sounds limiting, it actually maximizes the total industry profit while giving external benefits (e.g., cleaner air) to society. It is a true win-win scenario.

The goal of our paper was to present a theoretical model of the benefits to the electric power industry from using clean coal. Our model showed potential payoffs to individual companies and to the electric power industry for varying percentages of participation in using clean coal technology by companies within the industry. By definition, clean coal is more costly to use than dirty coal, so the participation and free riding lines are directionally correct. Regardless of the exact shape of the lines, there will be an incentive for any individual firm to defect. We have found that given the incentive to defect, firms would all choose to defect eventually, leading to a siutation of no participation by the industry. To counteract this, we have proposed industry or government regulation to ensure compliance to the mutual benefit of all industry players.

A limitation of this paper is that we have not collected empirical data from industry members. A good next step would be to meet with industry members to determine how receptive they would be to self-regulation and to discuss which metrics would be most useful to ensure participation (i.e., the use of clean coal technology) by companies in the industry.

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