Examining Social Costs of Electricity Generation in the United States

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Abstract This paper briefly reviews existing literature on social cost estimates for electricity generation in the United States and identifies existing policies intended to internalize these costs. It describes the value of social cost estimation and discusses commonalities among models of social costs resulting from electricity generation. In conclusion, it presents a collection of recommendations for future research and legislation.

Keywords: social costs, electricity generation, energy policy

Introduction: The Rise of Natural Gas

In November 2013, coal, natural gas, and nuclear electric power generating installations collectively comprised 87% of net electric generation in the United States, with renewable, hydroelectric, and a small quantity of petroleum sources providing the remaining capacity (U.S. Energy Information Administration (EIA), 2013). Between 2000 and 2010, the advent of widespread hydraulic fracturing and accompanying low natural gas prices fueled meteoric growth in natural gas-fired electricity generating installations, accounting for 81% of new electric power generating capacity in the United States over that period (U.S. EIA, 2011). During that decade, coal-fired generating capacity grew only slightly (Behrens et al. 2012), while U.S. nuclear power generation remained stagnant (Holt, 2013; World Nuclear Association, 2013). In 2006, natural gas electricity generation eclipsed nuclear sources as a fraction of U.S. net electricity generation (U.S. EIA, 2013a). Six years later, natural gas electricity generation equaled that of coal for the first time in history; in April 2012, coal and natural gas each provided 32% of U.S. net electricity generation (U.S. EIA, 2012).

Analysts have suggested a variety of causes for the anemia of recent growth in coal and nuclear generation, including expectations of continued rapid growth of natural gas supplies and the accompanying opportunity cost of developing coal or nuclear plants rather than potentially cheaper natural gas installations (Campbell et al., 2013). Other explanations include the negative fiscal impacts of environmental regulations on aging coal-fired infrastructure (Campbell et al., 2013) and concerns about waste disposal, weapons proliferation, terrorist attacks, and natural disasters that dominate current discussions about nuclear power development, particularly in the wake of the March 2011 Fukushima Daiichi nuclear plant disaster (Holt, 2013).

Consciously or not, firms weigh all of these factors carefully when deciding where and when to invest their capital. The surging popularity of natural gas provides a compelling example of this fact; lower upfront costs, less aggressive taxation, and lax regulation have made natural gas an attractive investment. Profit-maximizing utility firms, like the investor-owned utilities that provide electricity to 68.2% of customers in the U.S. (American Public Power Association, 2013), consider these private costs and benefits when deciding which sources of electricity generation they will pursue, and which they will phase out. However, profit-maximizing firms do not consider social costs or benefits of their business decisions, and therefore do not always settle on socially optimal choices (Boutilier et al., 2012). Does natural gas remain cheap in comparison with other electricity generation modalities when considering social costs?

This paper explores the existing literature on social cost estimates for electricity generation in the U.S. not to provide a definitive policy recommendation for the nation's response to recent trends, but instead to identify the principal considerations that policy makers must consider to appreciate fully the scope of the costs of electricity generation and answer questions like this one. Though its analysis is by no means exhaustive, this paper will (1) describe the benefits of a social cost estimates in public policy discussions; (2) identify common methods among leading studies of social costs in the existing literature; (3) highlight impacts considered by these leading studies and examine the rationale for their selection; (4) identify existing regulatory strategies to internalize known social costs of electricity generation; (5) suggest priorities for future research; and (6) recommend modification to existing programs and implementation of new mechanisms to internalize remaining social costs of U.S. electricity generation.

The Need for Comprehensive Cost Assessments in Energy Generation

In a competitive environment, firms take the price dictated by the market equilibrium. However, electricity generation has frequently been viewed as a natural monopoly, where the minimum efficient scale is nearly equal to or exceeds the size of the market (Taylor & Weerapana, 2012). As a result, the electricity market is not perfectly competitive; electricity generating firms have some ability to dictate their prices (Berg, 1995). In the interest of maintaining low prices for consumers, the U.S. government has sought to limit the market power of natural monopolists in the energy industry in a variety of ways. Since the early 1990s, incentive regulation has been the preferred method for limiting energy utilities' market power (Berg, 1995). Under incentive regulation, the government sets a price near a firm's average total cost of production and guarantees that price for a certain period, encouraging the firm to contain costs to maximize profit (Taylor & Weerapana, 2012).

However, the average total cost of production fails to account for a potentially significant fraction of real costs to the economy. While conventional cost estimates generally succeed in capturing "explicit" or "internal" private costs and benefits bourn directly by a producer and often passed onto consumers, they frequently fail to incorporate "implicit" or "external" social costs and benefits, which are bourn collectively by society as a result of one entity's actions (Busquin, 2003).

Internalizing these costs results in an entirely different distribution of energy prices, in which costs for fossil fuel sources surge and more intrinsically expensive modes of generation, such as renewable sources, become far more economically attractive. In effect, social cost estimates seek to "level the playing field" for renewable or more sustainable sources against the generally lower internal costs of fossil fuel cycles, encouraging investment in sources with less damaging external impacts (Burtraw & Krupnick, 2012).

Social cost models can improve market performance in other ways, as well. By increasing electricity costs to account for all impacts of production, comprehensive cost models encourage a more optimal level of electricity conservation. Social cost models also account for discontinuous risks that firms and individuals acting in the free market frequently do not internalize successfully.

The Normative Choice Model: Encouraging Energy Conservation

In economics, the normative choice model indicates that individuals and firms act to maximize their utility; that is, they make choices to maximize their benefit while minimizing their harms or costs (Simon, 1955). Social costs of electricity generation are shared by all consumers and implicitly increase the price of consumption. However, consumers do not consider social costs when deciding what quantity of electricity they will purchase from their utility; instead they consider only the explicit price charged by the utility (if they consider the price at all) and their marginal benefit of consuming more electricity, which is decreasing but always positive. As a result, they consume too much electricity, because the lower explicit price is equal to their marginal benefit at a greater quantity than it would be if they were charged a price including social costs. This excessive consumption results in deadweight losses to the economy (Taylor & Weerapana, 2012).

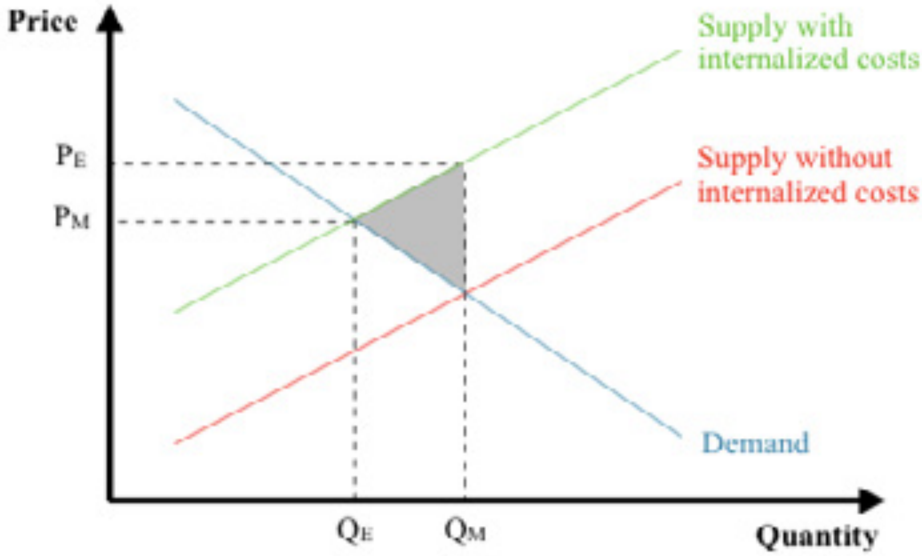

Figure 1. A simple supply and demand diagram illustrating deadweight loss (shaded region) due to the failure to internalize a negative externality. The market price (P_M) is lower than the ideal equilbrium price (P_E), while the market quantity (Q_M) is too great.

Adapted from Taylor & Weerapana (2012).

If social costs are quantified and incorporated into electricity prices, the supply curve "shifts up" to a higher unit price for each quantity of production, resulting in a new intersection of marginal benefit and price. At this new intersection, a higher price and lower quantity reflect the true cost of electricity to the economy and deadweight loss is eliminated as consumers conserve electricity to avoid costs in excess of their marginal benefit from consuming more (Taylor & Weerapana, 2012).

Discontinuous Energy Generation Risks

Individuals and firms respond to risk by either investing in measures to mitigate risk or purchasing insurance, internalizing the cost of their risk (European Commission, 2005). The normative choice model suggests that individuals and firms maximize their utility by considering the probability of the undesirable event and the damage associated with its occurrence and investing accordingly. However, empirical studies do not support the conclusion that individuals and firms behave in this way in energy markets (Kunreuther, 2001). A variety of hypotheses have been proposed to explain this failure to maximize utility, including: misperception of risks, either due to faulty information or the failure to collect necessary information altogether; high social discount rates reflecting a strong preference for present rather than future benefits; perception that improbable risks are impossible; inefficiency of capital markets, inhibiting individuals' and firms' ability to make a utility-maximizing trade of financial or other capital for risk-mitigating measures; and the role of emotion in decision making, causing individuals to make choices based on emotions like fear or dread rather than on empirical dimensions such as potential economic gains or losses (European Commission, 2005; Kunreuther, 2001).

The failure of electricity generating firms to maximize utility by internalizing the costs of their risks results in serious economic hardship when devastating accidents or natural disasters cause unexpected releases of pollutants. The explicit cost of cleaning up the 2008 release of coal fly ash slurry when the impoundment pond failed at the Tennessee Valley Authority's Kingston Fossil Plant is projected to exceed $1.2 billion; this cost must be passed onto the Tennessee Valley Authority's ratepayers (Poovey, 2011). Failure to internalize the cost of a disaster like the Kingston Fossil Plant spill by proactively accounting for risks results in an artificially low price of electricity, skewing the choices of producers, who invest too much labor and capital into electricity production by a given means (in the case of the Kingston disaster, coal burning), and consumers, who consume too much electricity produced by that means (Figure 1).

Common Characteristics of Social Cost Models in Electricity Generation

A number of studies have been undertaken to describe the social costs of electricity generation. These models identify and estimate significant impacts contributing to social costs, which they aggregate into one or more comprehensive cost estimates for a given mode of electricity generation. Four studies identified by Burtraw et al. (2012) are particularly notable for their scope and rigor. These exemplary studies share several attributes that improve their effectiveness.

Location Specificity

The geographic location of a source of pollution or other negative externality has a significant effect on the extent of its social impacts (Burtraw et al., 2012). A coal plant upwind of a major urban area will affect the health of many more people than an identical plant in a sparsely populated area (Grausz, 2011). Meaningful data for social impact estimates must control for the geographic characteristics of the study area.

Accounting for Fuel Cycle Costs

A comprehensive approach to social cost accounting must consider not only the power generation phase of the fuel cycle, but also the "upstream" and "downstream" costs of production, including fuel extraction, processing, distribution, and transportation, plant construction, and decommissioning costs. Analyses that only consider the electricity generating phase of the fuel cycle underestimate the social costs of production (Burtraw et al., 2012).

Willingness to Pay Valuations

Explicit monetary estimates of social costs are most easily comparable with internal costs firms and policy makers consider every day; these difficult estimates are therefore central to many social cost analyses in the literature (European Commission, 2005; Grausz, 2011). These valuations are based on either "revealed preference" or "stated preference" studies. Revealed preference valuations analyze patterns of behavior to estimate a population's willingness to pay for a given resource. For example, the value of a recreation area might be estimated by the willingness to pay to travel to that area (Burtraw et al., 2012). Stated preference studies use carefully structured surveys to ask individuals about their willingness to pay for various improvements, such as reduced mortality risk or improved water quality (Burtraw et al., 2012; European Commission, 2005).

Factors Assumed to be Internal

Some factors are difficult to define as entirely internal or external. For example, the costs of an accident affecting only employees of an electricity generating firm may be internalized by wage premiums paid to workers. However, if labor markets are not perfectly efficient and workers are not well informed about the risks of their occupation, these costs would not be considered internal to production (Burtraw et al., 2012). Some models incorporate a simplifying assumption that all third-party transactions with electricity generating firms, including labor transactions, are based on complete information and internalize all applicable social costs (Rowe et al., 1995).

Factors Not Considered

Other external factors are considered by few, if any existing comprehensive studies of U.S. electricity generation. These factors, including network effects such as transmission costs and the need to balance intermittent and constant sources to meet variable demand, are believed to represent minor fractions of total social costs and affect all current leading modalities similarly. Most importantly, they are particularly difficult to measure based on natural experiments alone. (Burtraw et al., 2012). Natural experiments are those conducted by an observer who cannot control the variables under examination (Taylor & Weerapana, 2012). Without the ability to conduct multiple natural experiments on a factor's effects, analysts are unable to form quantitative estimates of a given source's social impacts.

Identifying Social Impacts

Faced with limited time and resources, researchers studying social costs of electricity generation must decide which social impacts they will seek to measure and monetize (Burtraw et al., 2012). In doing so, researchers must make judgments about the relative importance of different impact vectors (such as carbon dioxide, fine particulate matter, or nuclear radiation) and physical endpoints (such as air pollution from burning of fossil fuels, infrastructure degradation from acid rain, or mortality from catastrophic release of toxins). Table 1 provides a summary of factors considered by four of the most comprehensive studies of the social costs of electricity generation in the existing literature (Burtraw et al., 2012).

Table 1. Summary of factors considered by four major studies of external social costs of electricity generation.

	Lee et al. (1995)	Rowe et al. (1995)	European Commision (2005)	National Research Council (2010)
"Upstream" Considerations				
Operational damages from mining and transport	Assumed internalized	Yes	Assume range of internalization	Assumed internalized
Public health damages from transport	Yes	Yes (nuclear only)	Yes	Not monetized
Road damages	Yes	Not monetized	Yes	No
Facility construction	No	Assumed zero	Yes	Not monetized
"Downstream" Considerations				
Pollutants				

	Lee et al. (1995)	Rowe et al. (1995)	European Commision (2005)	National Research Council (2010)
SO_2	Yes	Yes	Yes	Yes
NO_x	Yes	Yes	Yes	Yes
Fine particulate Matter	No	Yes	Yes	Yes
Coarse Particulate Matter	Yes	Yes	Yes	Yes
Ozone	Yes	Yes	Yes	Yes
Volatile Organic Compounds	Not monetized	No	Yes	Yes
NH_3	Not monetized	No	Yes	Yes
CO_2	Not monetized	No	Yes	Not monetized
CO	Yes	No	Yes	Not monetized
Lead	Yes	Yes	Yes	Not monetized
Metals	Not monetized	Yes	Yes	Not monetized
Physical Endpoints Considered				
Water	Yes	Yes	Yes	Yes

	Lee et al. (1995)	Rowe et al. (1995)	European Commision (2005)	National Research Council (2010)
Crops	Yes	Yes	Yes	Yes
Mortality	Yes	Yes	Yes	Yes
Morbidity	Yes	Yes	Yes	Yes
Infrastructure/Materials	Yes	Yes	Yes	Yes
Climate Change	No	No	Yes	No
Timber	Yes	Yes	Yes	Yes
Visibility	Yes	Yes	Yes	Yes
Recreation	Yes	Yes	Yes	Yes
Ecosystem	Yes	Yes	Yes	No
Noise	Yes	No	Yes	No

Comparing Modalities

Social cost models for electricity generation allow robust comparisons of the true long term economic viability of various generation modalities. While the numeric conclusions of different models may vary considerably, trends that emerge in the results of multiple comprehensive studies may be noteworthy for policy makers and others involved in determining the future of the nation's electricity infrastructure (Burtraw et al., 2012). While four leading studies came to markedly different conclusions about the external costs per unit output of today's leading generation technologies, they showed general concordance in the ordering of the three major fossil fuel sources by social cost per unit electricity generation: coal costs were highest, followed in order by petroleum and natural gas. The studies concluded variously that nuclear was either slightly more socially costly than natural gas or slightly less so, but all agreed that the costs of nuclear electricity generation were less than those of petroleum. Two studies found that social costs from biomass-based electricity generation exceeded those from the fossil fuels, but a third study, which considered an estimate of social costs due to climate change, estimated its costs to be far lower than those of the fossil fuels. Both studies considering wind power found its social costs to be substantially less than those of fossil fuels or nuclear power (Table 2).

Table 2. Summary of estimates from four studies of external social costs, in $0.001 per kilowatt hour (2010 USD). Ranges, where given, reflect 5% and 95% confidence bounds.

	Coal	Oil	Gas	Nuclear	Biomass	Wind
(Lee et al., 1995)	2.3	0.35-2.11	0.35	0.53	3	-
(Rowe et al., 1995)	1.3-4.1	2.2	0.33	0.18	4.8	0.02
(European Commission, 2005)*	27-202	40.3-148	13.4-53.8	3.4-9.4	0.67	0-3.4
(National Resource Council, 2010)	2-126	-	0.01-5.78	-	-	-

**Includes an estimate of social costs due to climate change.*

Existing Taxes and Regulatory Solutions

Several existing U.S. taxes and regulatory measures are intended to internalize some of the social costs of electricity generation. This section introduces a selection of these government programs.

Coal Excise Tax

Coal mined in the U.S. is subject to an excise tax of $1.10 per short ton for coal extracted from underground mines and $0.55 per short ton for coal mined at the surface, capped at 4.4% of the coal's market price (Humphries & Sherlock, 2013; Internal Revenue Service, 2013). At the November 29, 2013 price of Powder River Basin coal (the lowest grade standard reported by the Energy Information Administration), this cap would be $11.00 * 4.4% = $0.484; for Central Appalachian coal (the highest grade reported), the cap would be $62.58 * 4.4% = $2.754, and therefore would not be reached (U.S. EIA, 2013b).

Revenues collected by the coal excise tax, enacted in 1973, are dedicated to the Black Lung Disability Trust Fund, which provides "income maintenance and medical benefits, when no coal mine operator can be held liable for payments," to coal workers suffering from pneumoconiosis, a disease caused by the inhalation of dust (U.S. Department of Labor, 2012; Derickson, 1998). The fund also provides benefits to families of coal workers whose death was hastened or cause by pneumoconiosis (Humphries & Sherlock, 2013).

By providing health benefits to disabled miners whose former employers are bankrupt or otherwise unable to meet their obligation to compensate their employees, the coal excise tax helps to internalize the cost of harms to coal miners, reducing the total social costs unaccounted for in the coal fuel cycle (Burtraw & Krupnick, 2012).

Nuclear Waste Disposal Fee

The Nuclear Waste Policy Act (NWPA) of 1982 provides for the construction of a geologic repository for nuclear wastes, including spent civilian and military nuclear fuels and high-level wastes (HLW) generated by the Department of Defense. The civilian costs of this program were to be covered by a fee assessed to owners of nuclear reactors generating electricity (Holt, 2011). In 1987, Congress amended the NWPA to designate Yucca Mountain, NV as the site of the future nuclear repository (Committee on Technical Bases for the Yucca Mountain Standards, 1995). In 2009, President Obama ordered that work on a disposal project at the Yucca Mountain site be halted (Blue Ribbon Commission on America's Nuclear Future, 2012).

Until recently, the Department of Energy used this authority to collect a fee of $0.001 per kilowatt hour of electricity generated by nuclear reactors, amounting to about 1% of average electricity costs and totaling approximately $750 million annually (Blue Ribbon Commission on America's Nuclear Future, 2012). On November 19, 2013, the United States Court of Appeals for the District of Columbia Circuit ruled that the fee the Department of Energy was collecting for the permanent repository was not permissible under the NWPA. The court reasoned that, because President Obama had halted the Yucca Mountain project, the funds collected were not actively being used for their legislated purpose: providing permanent disposal of nuclear waste. Additionally, because the Secretary of Energy was unable to determine whether the collected funds were adequate for their purpose, the court ruled that the fees could not be permissible at all, regardless of the project's status. Based on these conclusions, the court ordered the Secretary of Energy to submit a proposal to Congress to change the fee to zero until he can determine the appropriate level of fees or Congress "enacts an alternative waste management plan" (Natl Assoc., Reg. Util Commiss. v. Department of Energy, 2013).

As originally intended, the fees collected under the NWPA internalized the significant social costs of radioactive waste disposal by passing the obligation for disposal to the federal government, reducing the external costs of nuclear electricity generation.

The Clean Air Act

In 1970, President Nixon created the Environmental Protection Agency (EPA). Among the new agency's other duties, the Clean Air Act, passed in 1970, provided the EPA with authority to establish air quality standards and limit emissions of hazardous air pollutants (U.S. EPA, 2013a).

On September 20, 2013, the EPA proposed new regulations on power plant installations under the Clean Air Act. The new proposal uses Section 111(b) of the act to set carbon emission standards for new power plants and proposes new regulations limiting carbon emissions of existing power plants under Section 111(d), which provides a framework for federal cooperation with states on state-administered programs meeting national goals (U.S. EPA, 2013a). Under the new proposal, fossil fuel-fired utility boilers, such as coal power plants, would be limited to 1,100 pounds of CO2 per megawatt hour over a 12-operating month period or a slightly lower quantity over an 84-operating month period. The cap for small natural gas units is the same, while larger natural gas installations will be subject to a cap of 1,000 pounds of CO2 per megawatt hour (U.S. EPA, 2013b).

Some commentators have suggested that these new standards would effectively prohibit new coal power plants, as the cost of complying with the carbon emissions cap using existing technologies may be prohibitive (Fazio & Strell, 2013). The 84-operating month compliance period is intended to allow coal plant operators more flexibility to develop and implement new technologies to meet the new standards (U.S. EPA, 2013b); however, critics contend that energy companies will not invest in new plants that rely on technologies that have not yet been proven on a commercial scale, limiting the effectiveness of the longer compliance period (Fazio & Strell, 2013).

The Clean Water Act and the Safe Drinking Water Act

Two years after the Clean Air Act became law, the U.S. Congress amended the Federal Water Pollution Control Act, originally enacted in 1948, to provide the EPA with robust authority to regulate "discharges of pollutants into the waters of the United States." As amended in 1972, the law became known as the Clean Water Act (U.S. EPA, 2013c). While no recent programs developed under the Clean Water Act are specifically intended to target pollutants from electricity generation, the act provides a valuable framework for reducing external social costs from water pollution.

Shortly after enacting the Clean Water Act, Congress enacted the Safe Drinking Water Act of 1974 "to protect public health by ensuring the safety of drinking water" (U.S. EPA, 2013c). Under its combined authority granted by these two new laws, the EPA regulated underground injection wells like those used in modern hydraulic fracturing operations. However, following the 2001 recommendation of a Special Energy Policy Task Force chaired by Vice President Richard Cheney, Congress amended the Clean Water Act and the Safe Drinking Water Act to exempt hydraulic fracturing from all of their provisions (Hines, 2012). Some critics have suggested that Vice President Cheney's former role as Chief Executive Officer of Halliburton, a leading energy company that is credited with inventing the modern hydraulic fracturing process, reflects negatively on the credibility of the task force's recommendations; critics further complain that the task force's secret meetings hindered public input in the decision making process (The Halliburton Loophole, 2009).

Where their provisions are applicable, the Clean Water Act and the Safe Drinking Water Act reduce or internalize many of the social costs resulting from water pollution. However, large exceptions to these acts limit their effectiveness at mitigating impacts from certain key sources, such as hydraulic fracturing (Hines, 2012).

Climate Change

Three of the four comprehensive studies identified here did not estimate social costs due to climate change (Lee et al., 1995; Rowe et al., 1995; National Resource Council, 2010). However, a new method of estimating the costs of climate change developed by the federal government may provide a framework under which future social cost estimates may be more easily able to account for the substantial social costs attributable to climate change. In 2010, President Obama directed several agencies to estimate the social cost per unit of carbon dioxide emitted into the atmosphere over a given period. The resulting figure, called the Social Cost of Carbon (SCC), places a monetary value on the damages caused by each additional unit of carbon released into the atmosphere today. The working group that developed the SCC also provided valuations of damages from carbon emissions in future years, which increase over time because the tolerance of natural systems to increased carbon dioxide input is expected to decline over time as systems approach saturation (Interagency Working Group on the Social Cost of Carbon, 2013). The most recently revised estimate of the SCC was more than double the initial estimate published in 2010 (Interagency Working Group on the Social Cost of Carbon, 2010).

While its numeric value is still the subject of lively debate, the SCC estimate represents an important frontier in social cost discussions. If the figure can be applied successfully to new environmental policy, future social cost studies may benefit from a similar approach by developing robust "cost per unit" estimates for a variety of pollutants and other impacts.

Future Management: Open Questions and Policy Recommendations

A wide range of programs have been proposed to internalize social costs not already accounted for by existing management. This paper recommends the implementation of some of these measures and the conduct of further research in certain areas. It is worth noting that these recommendations consider only the technical suitability of these cost internalizing methods, and do not contemplate their viability in the current political climate.

Carbon Dioxide

As it does for other air pollutants, the Clean Air Act grants the EPA broad discretion in limiting the carbon dioxide emissions of new sources (U.S. EPA, 2013a); the agency should use that authority aggressively to spur investment in cleaner-burning technologies and renewables to reduce the total load of social impacts on the U.S. population. The Congress should also enact a comprehensive tax on carbon dioxide emissions, indexed to the Social Cost of Carbon (SCC). As new information becomes available, it is nearly certain that the SCC estimate will continue to change (Interagency Working Group on the Social Cost of Carbon, 2013). Public policy on carbon emissions must therefore be able to adapt dynamically to different estimates.

Whether imposed as a quota, a direct tax, or a "cap and trade" market, this new tax must not shy away from imposing the full social cost of electricity generation on producers and consumers. While such a move may cause some industries to shift production to other nations, the U.S. cannot continue to ignore the mounting social costs of its dependence on fossil fuels at home. While the World Trade Organization and the United Nations must one day consider and balance the social costs of carbon emissions on a global scale, Congress must not wait for these vast organizations to take the lead in regulating carbon dioxide appropriately; time is of the essence when confronting global climate change, and the short term costs of unilateral action pale in comparison to the vast expenses that will surely result from universal inaction.

Labor Rights

Many studies of social costs assume that injuries sustained by energy workers are internalized by wages because job seekers are well informed of the dangers of their trade and health care costs are often paid by workers' compensation or trust funds (Rowe et al., 1995; Burtraw et al., 2012). The Department of Labor should collaborate with the Department of Energy and the EPA to ensure that this assumption, so long as it is held to be true by policy makers, is supported by fact. Workers are entitled to know all of the dangers they face on the job, and to be adequately compensated for injuries sustained there. Both rights should be guaranteed by law and supported by government trust funds that, like the Black Lung Disability Trust Fund (Internal Revenue Service, 2013), are financed by taxes on energy generation revenues.

Hydraulic Fracturing and Natural Gas Extraction

The EPA has identified a variety of potential impacts from hydraulic fracturing, including stress on surface water resources used to drill and fracture shale deposits, potential contamination of underground water resources including drinking water, and airborne pollution resulting from the release of volatile organic compounds and greenhouse gases (U.S. EPA, 2013d). The public has been particularly concerned about the effects of hydraulic fracturing on drinking water resources, prompting the U.S. Congress to direct the EPA to conduct a comprehensive review of impacts to drinking water (Hines, 2012). In December 2012, the EPA released a progress report on its study, detailing the methods it will use in its comprehensive analysis of effects of 350 representative natural gas wells, as well as the laboratory experiments and data reviews it will conduct to determine the toxicity of chemical agents used in the hydraulic fracturing process and their impacts on drinking water resources (U.S. EPA, 2012). This study, once completed, will provide regulators with vital information about the true impacts of this relatively new technology and will also allow future social cost models to provide more robust accounting for an uncertain phase of the natural gas fuel cycle.

Based on the results of the EPA's review of the impacts of hydraulic fracturing, the agency should seriously consider implementing rigorous new restrictions on the technique. Regardless of the study's conclusion, the so-called "carve outs" of hydraulic fracturing from the Clean Water Act and the Safe Drinking Water Act granted to energy utilities under a friendly administration in 2005 (Hines, 2012) should be repealed. If the landmark legislation this country has relied on to protect its water resources for decades is still good public policy, it should be applied uniformly regardless of the source of a suspected pollutant. As the editors of the New York Times shrewdly asked in a November 2009 column, "if hydraulic fracturing is as safe as the industry says it is, why should it fear regulation?" (The Halliburton Loophole, 2009).

Nuclear Waste Storage and Disposal

Based on the recommendations of the Blue Ribbon Commission on America's Nuclear Future (2012), the Department of Energy should move quickly to establish adequate storage and disposal technologies for civilian nuclear wastes. As the authors of that commission's final report wrote, "this generation has an ethical obligation to proceed toward developing permanent disposal capacity for high-level nuclear wastes without further delay… But until disposal capacity has been developed, society will have no choice other than continued storage of the wastes" (Blue Ribbon Commission on America's Nuclear Future, 2012).

The Department of Energy must also develop an accurate estimate of the costs of this program so that it may resume collecting fees from owners of civilian reactors to cover the social costs of waste disposal (Natl Assoc., Reg. Util Commiss. v. Department of Energy., 2013). Failure to collect these fees on electricity consumed today places an unconscionable burden on future generations for the wastes of today's electricity generation.

Conclusion

While precise valuations of social costs may vary from one study to another, the existence of vast external costs to society of today's electricity generation is incontrovertible. Failing to account for these costs today is not a responsible means of stimulating the economy or encouraging growth; it is a tremendous gamble with modest short term payoff and no viable exit strategy. The costs that we do not internalize today will be bourn by generations to come, who will have no opportunity to legislate or conserve the vast expenses away. It is striking that the legislators who complain most vociferously about the burden of mounting deficits on future generations so frequently oppose reforms to reduce the weight of the environmental damages we will leave our children. If these policy makers cannot be persuaded of the merits of internalizing social costs in today's energy prices, they must be replaced by others who understand the seriousness of the challenges manifested in these costs.

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