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Community perceptions, environmental impacts, and energy policy

Rail shipment of coal

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Policy changes over the last two decades have dramatically changed the coal and electric utility industries. Many of these changes have led to secondary and environmental impacts which, taken together, affect many communities and individuals but are rarely considered during policy debates. We undertake an analysis of fugitive coal dust emissions during rail transport of coal to illustrate the side effects of public policy and the need for more comprehensive consideration of subjective costs and benefits. The economic and environmental impacts on communities and individuals of one aspect of increased coal usage are measured with non-market valuation techniques. Copyright © 1996 Elsevier Science Ltd.

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The goal of public policy is generally to improve or correct some aspect of social welfare – living standards, economic conditions, the environment, crime, public health etc. For the past 25 years, energy policy in the USA has been directed at reducing dependence on foreign oil and vulnerability to supply interruptions, protecting the environment from the detrimental effects of energy production and consumption, and encouraging the provision of low cost energy through a reduction of monopoly power, developing alternative energy sources, and enhancing the efficient operation of the energy industry. While some policy measures make effective contributions to meeting these goals, nearly all policies also have unintended and unanticipated secondary effects which are often overlooked during the consideration of the costs and benefits of a particular policy measure. While including the costs of such side effects in a benefit–cost calculation may not influence a policy decision, the effects may be substantial to the communities and individuals affected. In designing policy measures, such undesirable consequences as well as equitable and efficient alternatives must be included in the analysis. One commonly overlooked response to secondary impacts is community reaction to and risk perception of industry changes induced by public policy. Ignoring such impacts may force economic agents to incur additional unanticipated costs to mitigate the effect on communities and individuals. This paper considers one secondary impact of increased coal usage resulting from changes in energy and environmental policy.

Shifts in environmental and energy policy over the last two and a half decades have resulted in dramatic changes in the coal and electric utility industries. The 1970 Clean Air Act Amendments (CAAA70) set uniform ambient standards for the entire country for six pollutants. The intent of the CAAA70 was to encourage the adoption of new and existing pollution control technologies, such as scrubbers, but the results were to induce companies to extend the lives of old plants rather than build new facilities and to rely on clean western coals rather than dirtier eastern coals. The 1977 CAAA required new electric generating plants to install scrubbers and other pollution control devices to circumvent the unintended policy affects of CAAA70. The Energy Tax Act of 1978 (ETA) encouraged conversion of boilers to coal, while the 1978 Public Utilities Regulatory Policies Act (PURPA) promoted conservation of electric energy. PURPA fostered the birth of the non-utility generation industry, a portion of which uses coal as a fuel source. In 1990, the Clean Air Act was again amended. Critical new features were marketable permits and performance standards, rather than technology standards.

The dramatic changes resulting from these policies have been well studied, but smaller, more subtle shifts, have occurred as well. While attracting less attention, taken together,

the secondary impacts of these policies affect many communities and individuals. Communities have proved to be very sensitive to coal usage and production. Firms wishing to install coal fired generators have faced community opposition and have been forced to make concessions to the community in order to win approval. Mines have difficulty acquiring permits to extend their operations.

Many of these secondary impacts involve non-market benefits and costs, such as decreased dependence on foreign energy supplies, risk perceptions in communities now hosting coal facilities, environmental costs associated with coal usage, and the impact of increased coal transport on communities and individuals. Although these impacts should be included in public policy debates and benefit–cost evaluations, as with most environmental issues and public goods, no direct method exists to value the economic benefits and costs to affected home owners and businesses. Instead, methodologies for non-market valuation, such as hedonic price analyses and the contingent valuation method, are commonly used in the economic analysis of environmental issues.

The changes in the nature and volume of coal transport provide a useful illustration of the need to consider community reaction and impacts. Fugitive coal dust emissions during rail transport have become an increasingly important issue from the perspective of coal transporters, coal suppliers, legislators and their constituencies, reaching nationwide attention in a front-page *Wall Street Journal* article on 12 October 1993. The increased interest in this problem arises from the economic value of material losses during transit, the economic and psychological damage to businesses and residents, and potential environmental impacts near railway tracks. Fugitive coal dust emissions and their impacts are a hidden cost associated with several of the policy changes of the last 25 years.

The changing nature of coal shipments

As a result of these policies, in addition to variation in economic conditions, the nature of coal shipments is changing in two respects. First, total shipping distances and the number of destinations continues to increase as the electric power industry undergoes structural changes. Second, the physical characteristics and size profile of the coal shipped by rail have been changing in response to technological changes in mining, environmental and energy legislation, and changing economic conditions.

Rail shipping distances

For many years, coal has been the predominant fuel in the electric utility industry, accounting for more than 50% of the USA's utility generation since 1980 (Energy Information Administration (hereafter EIA), 1995). Its consumption has also been steadily growing (see Figure 1). This growth in coal demand is partially attributable to its abundant supply in the USA, the decline of the nuclear power industry since 1977, and the escalation of oil prices in the 1970s.

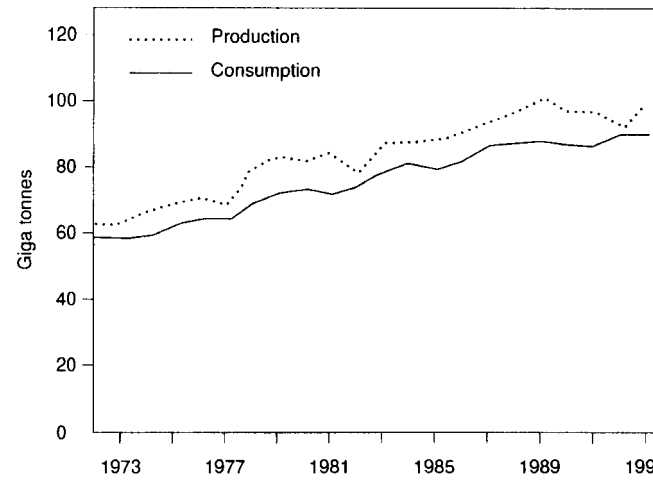

Figure 1 Coal production and consumption, 1973–94

Source: EIA (1995).

Most of this coal is moved by rail whose market share has remained constant over the last three decades. The major change in coal transport, shown in Table 1, is the decline in the proportion of total domestic shipments moved by water (primarily barge movements on US rivers), and the increase in other transport, consisting mainly of conveyor, tramway and slurry pipeline transport. The increase in the 'other' transport method is partly due to the rapid growth of western US coal production, where coal is often moved from the mine to an adjacent power plant by conveyor (EIA, 1992).

As competition intensified among railroads and as coal slurry pipeline proposals posed a competitive threat, railroads made investments and adopted innovations that resulted in greater efficiency and lower coal transport costs after the early 1980s. Foremost among these was the increasing use of unit trains, where coal is shipped directly from one point to another in trains consisting of about 100 rail cars. The entire shipment, usually about 9000 tonnes, is delivered to a single customer. The average round-trip coal journey within the USA is 960 km (Beijer Institute, 1987, p 73). Such transport improvements have led to reduced delivered coal prices and expanding coal markets. In particu-

Table 1 Method of coal transport within the USA (percentage of total shipments)

Method of transport	1970	1980	1990
Rail	54.4	57.4	57.5
Water	29.3	19.4	17.0
Truck	11.9	13.9	11.4
Other[a]	4.4	9.0	13.4

[a]Other consists primarily of tramway, conveyor and slurry pipeline. Components may not add to 100% because of independent rounding and unknown data.

Source: EIA (1992) Table 36.

lar, greater quantities of western coal were shipped to the Midwest. Lower inland transport costs also increased the competitiveness of US coal in world coal markets (EIA, 1992).

The Railroad Revitalization and Regulatory Reform Act of 1976 (the 4R Act) and the Staggers Rail Act of 1980 substantially deregulated the US railroad industry, allowing railroads to abandon unprofitable routes, merge with other railroads, and reduce labour costs. Railroads were also free to enter into confidential contracts (usually with electric utilities in the case of coal) so that rates were determined by negotiations rather than being set and published by rate bureaux.

Rail shipping distances of coal are expected to increase in the future due to the dispersion of demand created by the proliferation of non-utility electric power generation (NUGs). In 1979 electric utilities provided 97% of electric power generation. By 1991, that share had dropped to 91% (EIA, 1993). The balance was produced by 'non-utilities' – generators of electric power who are primarily industrial manufacturers that produce electricity for their own use and for sale to utilities for distribution to final customers. In 1990 and 1991 net increases in nameplate capacity for non-utilities exceeded net increases for utilities. Nameplate capacity of the NUG sector in 1991 was 50.1 GW (EIA, 1993).

NUG sector growth is expected to continue, resulting in more small generating facilities, each requiring a separate delivery of fuel. The probable result is an increase both in the number of destinations and total rail shipping distances. Coal currently accounts for 15% of the fuel for NUGs, and the quantity demanded has been growing (see Figure 2). Generation of electric power from coal by the non-utility sector increased 134% between 1985 and 1991. Planned capacity additions for 1994 through 1996 total 8.1 GW (EIA, 1992).

Particle size distribution

In addition to the growth in coal demand and the resulting increase in the rail shipments of coal, the size distribution of coal demanded and shipped has changed for several reasons. First, in response to several key pieces of environmental legislation, including the Clean Air Act Amendments of 1990, both electric utilities and the end users of metallurgical (coking) coal are demanding coal with a lower ash and slag content. To remove ash and sulphur prior to combustion, the coal is ground into finer pieces, liberating the gangue from the combustible component. The majority of the processing takes place at the mine site prior to shipping. This removal of natural binders and clays during the cleaning process produces a product more susceptible to blowing and dusting.

Second, changing economic conditions and technological breakthroughs have increased the recovery of coal fines that were previously discarded as waste, since their recovery was not cost-effective. Today, flotation circuits that handle particles of less than 200 microns use the gravity separation principle to recover large quantities of marketable coal fines. Discarded piles of coal fine waste are also being 'remined' by separating the combustible material from the gangue and selling it to utilities. The recovered coal fines are combined with newly mined and processed coal for shipment to customers. NUGs especially can utilize waste coal, culm banks and coal fines previously considered uneconomic energy sources.

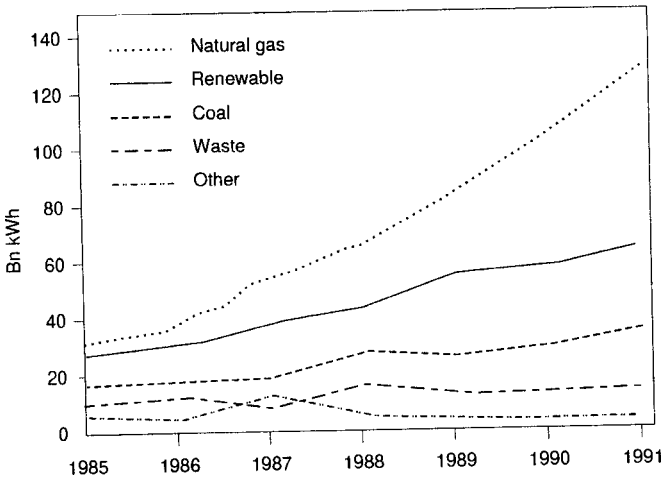

Figure 2 Non-utility generation of electric power by fuel type

Source: EIA (1993).

Third, longwall mining, a relatively recent technological advance in coal mining, produces smaller chunks of coal than other mining methods because the coal is pulverized rather than blasted into chunks. Modern mechanized longwall mining was introduced in the USA in the 1960s and has become more prevalent each year because it improves safety, production and productivity. Although the number of operating longwall faces has levelled off, the production and productivity from longwall mining are still increasing (Sprouls, 1988). The share of longwall mining is projected to grow at the current rate well into the next decade, thus the size distribution of coal produced should continue to shift towards smaller pieces.

Fugitive coal dust incidences

The growth in coal demand and rail shipping distances, in conjunction with the increased use and production of coal fines, will result in an increased incidence of fugitive coal dust emissions during rail transport. The nature and frequency of dusting events depend on the physical characteristics of the coal being shipped. Some coals are more prone to dusting than others. On average, 0.27 tonnes of tested coal are lost from each rail car during a 960 km trip from mine to port. The range is 0.0 to 0.7 tonnes per car. This equates to 280 grams per kilometre per car or about 93 grams per hectare within 150 metres on either side of the track, where most dusting occurs (Simpson Weather Associates Inc, 1993, p 3). The more severe incidents occur when trains travelling in opposite directions pass at normal

speeds. Geographical conditions also affect dusting. Tunnels, rock cuts, trestles and open fields tend to create dusting events because of lateral wind stresses (Simpson Weather Associates Inc, 1993, p 4). Meteorological conditions are also important factors.

The size distribution of the coal being shipped, combined with the lack of natural binders, creates the dusting problem. When coal shipments were comprised of both very fine particles and large chunks, the pile became stable after the top layer of dust was blown away. Even if the proportion of fines remains unchanged, the smaller size of the coal chunks has reduced the stability of the pile. Coal fines blow away and unpack the slightly larger particles, which in turn roll down the coal pile and expose more coal fines. The cycle can continue for the length of the journey. Dusting complaints also rise on the empty return trip of the train, where leftover coal particles in the rail car are sometimes blown out.

The coal dust blown from trains is comprised mainly of fine black particles that are carried by winds on to properties adjoining the railway tracks. Coal dust from trains is classified as a nuisance pollutant, soiling personal property, house exteriors and sometimes the interiors of residences and businesses. Residential coal dust soiling complaints concern damage to curtains, desks, automobiles, lawn furniture, clothing, boats and cars. Complaints from local businesses centre on concern over cross-contamination of industrial products by wind-blown coal dust from trains. In British Columbia, several pulp and paper operations have voiced concern (Cope *et al*, 1994), and complaints have arisen from the baby formula/pharmaceutical company Abbott Laboratories in Altavista, Virginia (Williams, 1994).

As a result of fugitive coal dust emissions, trackside residents and businesses are exposed to a variety of problems. Homes and cars need repeated washing, windows and doors must remain closed, outdoor activities can be limited, and outside furniture, toys and gardens receive coatings of coal dust. The dust leaves a greasy black film, and keeping doors and windows closed does not entirely prevent its entry into homes. Conditions are especially severe during a blow-out, a 30 m high cloud of dust billowing upwards which can occur during extreme meteorological conditions. Blow-out episodes can force vehicles off the road or require drivers to turn on their headlights. Homes have occasionally required intensive cleaning; Norfolk Southern Railroad has made some reimbursements ranging from US$750 to US$3000 (Joint Subcommittee, 1994, p 4). At least one trackside business has to periodically clean its new roofing system at a cost of US$3000 per cleaning.[1] In this instance a white roofing system had been installed to reflect summer heat and reduce energy requirements, and discolouration due to coal dust impedes its effectiveness.

'Coal dust' is actually an umbrella term for several particle classifications. Coal fines are particles of coal that are 0.5 mm (500 μm) or smaller in diameter. This category can be broken down into many subcategories of increasingly finer particles. Dust smaller than 7–10 μm in diameter is termed respirable dust and is particularly important because these particles are the cause of the emphysemic condition called black lung. This dangerous condition affected a great number of coalminers until the connection was made between respirable dust and black lung emphysema, and preventative measures taken. The problem of respirable coal dust is primarily confined to the underground mining environment. Experts generally agree that the amount of respirable dust generated from coal trains is too small to pose any threat to the health of residents living along the railways (Hogg, 1994). The coal fines which comprise the bulk of fugitive dust emissions from trains are larger than respirable dust.

Coal fines or dust larger than 10 μm have not been linked to negative effects on human health, ecosystems or agricultural activity. Coal dust levels in ambient air arising from rail transport are not considered a hazard to human health (Cope *et al*, 1994). Though dust concentrations in the vicinity of the tracks during a fugitive dust incident can be high, these emission incidents are brief, generally lasting six to ten minutes. Even repeated exposure to high level, short duration dusting from coal trains has not been identified as a hazard to human health.

Environment Canada commissioned a study of four Canadian coal samples for possible mutagenic activity in an effort to determine the effect of coal on biological systems. The results of this study and a similar study in the USA were inconclusive (Cope *et al*, 1994). A study by the US Environmental Protection Agency (EPA) found no effect of coal dust on agricultural production or soils. The concentration of heavy metals in the coal dust was lower than existed naturally in soils. Furthermore, coal dust had no effect on the photosynthetic process of plants. No evidence of possible adverse ecosystem effects were found (Emmitt, 1994).

The study site: Central Virginia

In Virginia, citizen concerns about the detrimental effects of coal dust emissions on their quality of life were sufficient to initiate legislation in the 1991 General Assembly Session of the Commonwealth of Virginia. Senator Madison E Marye introduced a bill that would have required railroad cars transporting coal to be covered so that their contents would not escape. Norfolk, Virginia, is the USA's dominant port for international coal trade, handling 52% of US coal exports in 1990 (EIA, 1992, p 59). Most of the coal arrives at the port from interior portions of the country by rail. The coal is primarily exported to markets in Japan and Europe. The primary complaints of coal dusting were received from the area of central Virginia, around Altavista. This area also

[1] Avoidance costs (such as the costs of cleaning) provide some information on the value of the impact of coal dusting. Because not all of the dusting impacts can be mitigated through cleaning (eg impacts on breathing when out of doors), avoidance costs represent a lower bound on values. Only the contingent valuation method can capture non-use values (such as existence and bequest values).

includes the larger communities of Lynchburg and Roanoke, which were also subject to train traffic. This Virginia site was selected because it presents a current public policy issue that has not been resolved at the time of this study.

The Norfolk Southern Railroad, a large Virginia based railroad that transports coal 580 km from the mines of south-west Virginia to the ports of Norfolk and is one of the largest railroads in the state, testified that coal car covers would cost US$700 a piece and increase loading and unloading costs of each car by US$200 (Joint Subcommittee, 1994, p 1). Norfolk Southern operates a fleet of 45 000 cars, and its typical coal train consists of 180 cars. During committee discussions of the bill, the railway industry successfully argued that such a legislative mandate was premature and would be financially crippling. The result was the creation of a Joint Subcommittee Studying Ways to Reduce Emissions from Coal-Carrying Railroad Cars, who were tasked to further investigate the issue.

The Joint Subcommittee continued to hear testimony from residents living alongside tracks while Norfolk Southern engaged a consulting firm, Simpson Weather Associates (SWA), to study the fugitive dusting issue. SWA's work involved quantifying coal losses during transit, determining the key physical factors responsible for fugitive emissions from coal shipments, driving key emission factors, and selecting, assessing and evaluating dust control options (Joint Subcommittee, 1994, p 5). SWA designed a test water spray facility to measure the effect of spraying coal cars with water, conducted field studies and laboratory experiments to study how atmospheric conditions and the type of coal transported affect emissions, and made a preliminary test of the effectiveness of chemical sealants. The railroad has established a coal-dust citizen hotline, the Dust Information Telephone Line, to incorporate citizen reporting into their study. In November 1994, the Subcommittee felt that significant progress has been made towards understanding fugitive coal dust incidents, and was satisfied with the aggressive action Norfolk Southern was displaying to address the issue. The Subcommittee recommended to the General Assembly of Virginia that the study continue pending results from the continued testing of chemical sealants, and that no legislative action be taken at that time.

Non-market methodologies for valuing coal dusting impacts

The value of commodities can generally be estimated in one of three ways: (1) observation of a market for the commodity, (2) observation of a market for a commodity related to the commodity of interest, and (3) direct questioning of preferences for the commodity. For many commodities, all or some portion of the total value of the commodity has no market or even a related market (eg beautiful sunrises are not bought and sold in markets), requiring economists to rely on direct questioning of preferences.

Non-marketed commodities are commodities that provide utility to an individual (or are an input to a firm) but where no markets exist through which revealed preferences can provide evidence of their marginal valuation. Such markets may fail to exist for several reasons. Natural resources and environmental commodities often have characteristics which place them in the categories of public goods or common property goods, where economists widely recognize that markets will fail. Property rights may not be allocated in some commodities (eg the right to a clean house or the right to have coal dust blown off of trains) and thus markets may not exist. Due to the nature of these commodities, some portion of the value is not reflected in market transactions.

Many of the impacts of coal dust are non-market impacts, affecting an individual's utility or a firm's profitability outside any market transactions. For nuisance pollutants such as coal dust, often no associated market exists that allows indirect valuations, either because no closely related substitutes or complements exist or because property rights have not or cannot be allocated. To measure many of these impacts requires non-market valuation techniques. For many of these non-marketed commodities, the only way of establishing values is thorough direct questioning of individual preferences.

In addition to classifying values as market or non-market, values can also be distinguished as use values (eg living in the house being affected by coal dust) or non-use values (valuing a clean trackside environment even if one never expects to go there). A variety of subcategorizations between use values and non-use values are possible. The importance in recognizing a distinction is that different valuation methods may be indicated depending on the nature of the values, use and/or non-use. In general use values may be either market or non-market values but, by their nature, non-use values are recognized as non-market values.

For environmental and natural resource commodities a variety of non-market valuation methods have been developed which may assess different components of value. These include travel cost methods (use values), hedonic methods (use values), averting expenditures (only for controllable impacts/private good outcome), and the contingent valuation method (use and non-use values) (Augustyniak, 1993). In addition, a fundamental difference exists between attempts to measure use and non-use (bequest and existence) values, because respondents to surveys evaluating non-use values may be essentially uninformed about the commodity that they are asked to value. Continent valuation is recognized as the only method available for estimating non-use benefits (Freeman, 1993).

The external effects of coal dusting in terms of either environmental or social impacts represent extra-market impacts that necessitate the use of non-market valuation methodologies to quantify their consequences. A contingent valuation study establishes trade off situations and observes an individual's decisions when faced with those trade offs. For evaluation of non-marketed commodities, this involves 'developing' a hypothetical market framework within which values can be revealed. This hypothetical market must meet the criteria of accepted economic theory of utility maximization subject to certain constraints.

The design and implementation of contingent valuation surveys

Well-designed CVM studies must adhere to several principles in describing the hypothetical market: (1) the default/baseline commodity and the alternative commodities to be valued must be well-defined (eg through use of photographs, maps, detailed descriptions of impacts etc); (2) the social choice rule must be realistic and designed to encourage preference revelation; and (3) a realistic payment vehicle, such as an entrance fee, must be used so that respondents would consider the hypothetical situation as a transaction rather than as a charitable donation (Randall *et al*, 1974; Schulze *et al*, 1981; Cummings *et al*, 1986; Mitchell and Carson, 1989).

In the case of non-use values, since the survey instrument itself must provide the information necessary for respondents to construct values, opportunity for bias exists in the survey design if anything less than perfect information is provided. Perfect information includes not only information on the commodity itself but also information on substitute commodities and how changes in the level of provision of the commodity will affect the respondent. In addition, perfect information implies the necessity of providing the complete psychological context of the economic decision (Fischhoff and Furby, 1988). As the provision of perfect information is infeasible (even for marketed commodities), the objective in CVM design is to provide the information necessary for the valuation of the commodity while not biasing the valuation process.

The current debate regarding the use of the contingent valuation methodology (CVM) in natural resource damage claims led the US National Oceanic and Atmospheric Administration (NOAA) to convene a panel of experts to assess the validity of the CVM. NOAA's interest in CVM stems from requirements under the Oil Pollution Act of 1990 (OPA) 33 USC 2701 *et seq* to determine methodologies viable for natural resource damage assessment (NRDA). Following this panel's review, NOAA published proposed guidelines for the design and implementation of contingent valuation surveys for natural resource damage claims. These guidelines, if and when adopted, are likely to become the industry standard for CVM studies regardless of whether used for NRDA or non-damage related environmental valuation. While not attempting to meet the standards of a NRDA, the coal-dust survey described here follows the guidelines suggested by the Proposed Natural Resource Damage Assessment Rule: Federal Register, 7 January 1994, to the extent feasible. Several of the key issues involve survey design and implementation.

Survey development and design

The design of the coal-dust survey followed an approach from cognitive psychology called cognitive survey design.[2] The first step is to define the problem that the study will address. Second, information is gathered from a variety of experts with technical understanding of the problem. Parallel to the collection of expert information, focus groups with lay people are used to examine the public's perception of the problem. These focus groups are implemented to examine how to 'translate' the language of the experts into the terminology of lay people. Using this information, a preliminary survey instrument is compiled to present the information to additional lay people. Initial testing is undertaken using more focus groups and individual 'interviews' (verbal protocols and retrospective reports). The survey may be redesigned based on the verbal protocols and retrospective reports, omitting or reducing little used or unused information to achieve a more condensed survey instrument. The process allows the researcher to feel assured that the final survey instrument presents the information necessary for a respondent to provide meaningful valuations of the commodity. The CVM survey designed to elicit values for reducing coal dusting incidents generally followed this methodology.

Several key issues were raised during the pre-test process that influenced the survey design:

(1) Individuals recognize coal dusting as a nuisance problem. Fugitive dust incidents are recognized as a problem by individuals and have amenity value impact related to the extra cleanup required or avoidance measures necessary. Some subjects stated that such a 'nuisance' problem may actually represent a health problem in sensitive populations such as asthmatics.
(2) Individuals may exhibit scenario rejection due to the assignment of responsibility for this problem to railroad, utility and coal companies. This suggested that the scenario must emphasize to respondents that the coal will be used in their community, and they will eventually pay for increased control costs through increased utility bills. The payment vehicle issue is thus of potential bias.
(3) Individuals may reject providing a WTP value without some concept of project costs. Based on a strong argument against providing open-ended WTP without some cost concept, the survey was adapted to a multi-option choice approach. This follows previous CVM approaches which have found that such choice methods provide more information than dichotomous choice methods (Brown *et al*, 1994).
(4) Individuals reveal a willingness to pay but this is not a high priority environmental or health related issue.

The survey was designed to solicit responses to the hypothetical situation of home owners accepting responsibility to pay for any policy measures through increases in their

[2]The goal of cognitive survey design is to improve the reliability of data generated in CVM surveys. While more and more sophisticated methods for data analysis have dominated the CVM literature in recent years, there has been insufficient attention paid to the reliability and validity of data generated by the survey instrument. Cognitive survey design is a systematic methodology developed to address this issue. See Wheeler and Lazo (1995) and Jobe and Mingay (1989).

electricity bill. Three variants were developed (indicated in Table 2) to vary the dimensions of the cost and level of dusting to permit data analysis. Varying the dimensions across the two vectors of costs and dusting impact (initial dusting) could allow for conditional logit/ordered probit analysis of the marginal valuation along these characteristics. Except for the vector of costs of the cleanup options and the different initial level of dusting in the hypothetical scenario, the survey instruments are identical in every other aspect.[3]

Table 2 Cost of option by version (US$)

Beginning and final level of dusting by option	Version A	Version B	Version C
Heavy–none	20	40	na
Heavy–light	10	20	na
Heavy–medium	5	10	na
Heavy–heavy	0	0	na
Medium–none	na	na	20
Medium–light/none	na	na	10
Medium–light	na	na	5
Medium–medium	na	na	0

Survey design and administration

Survey design

The mailable variants of the survey were designed consistent with the Dillman total design method (TDM) (Dillman, 1978). The TDM procedure aims to maximize survey response rates through specific design and implementation strategies. The procedure includes personalizing the mailing to include a cover letter hand signed in blue ink in a hand stamped envelope, a follow up postcard, and a second mailing to households that did not respond to the survey following the first mailing. The surveys, printed and folded into a booklet measuring 3.15 cm by 2.36 cm, were 12 pages long including the cover and space for comments. Each survey had a stamped identification number on the cover for purposes of tracking responses and identifying the surveys by region for data analysis.

Surveys and follow up correspondence were always mailed to arrive on Tuesdays to avoid having respondents receive the survey on days when they either normally receive a lot of junk mail (ie Wednesdays) or when they are less likely to examine their mail (ie Fridays). No monetary incentive was included, although such incentives have increased response rates in past studies.

The survey instrument explained the link between coal and the electric utility industry, the transport of coal, and the nature of coal dust and its known effects on health, property and the environment. Each respondent was asked to choose one of four options to reduce or control coal dust from trains: permanent mechanical covers for coal cars, removable covers, chemical sealant sprays, or to do nothing at this time. Demographic data on each household was also requested.

Sampling of respondents and mailing

A proportional sample was drawn from an area in central Virginia. An oversample was drawn from eight towns located on or near the Norfolk Southern rail lines (the same railroad lines going through Altavista). The towns selected were Altavista, Brookneal, Christiansburg, Narrows, Pembroke, Shawsville and Pearisburg. The only search criterion other than location was single family residences.

Six hundred and thirty surveys were mailed in an effort to achieve a data set of approximately 200 usable observations. A final response rate of only 40% (see Table 3) was due in part to the lack of a monetary incentive in the survey enclosure and to the low priority this issue represented to many individuals. (Surveys on high priority issues which include a monetary incentive can expect a response rate of 65%.) The 630 initial surveys (210 of each version) were mailed on 16 January 1995. Each mailing package included a covering letter, a return self-addressed stamped envelope and one version of the survey. Reminder postcards were mailed to all households one week after the first mailing. Two weeks later, a second copy of the survey was sent to individuals who had not responded and had not been deleted due to bad addresses. The second mailing included the same materials as the original mailing with a revised covering letter.

Results

Table 4 presents summary statistics of the response for key demographic variables. Based on the range and distribution of demographic characteristics of the survey response, a reasonable demographic cross-sample is represented in the data.

Table 3 Calculation of survey response rate

Total surveys mailed	630
Bad addresses	86
Valid addresses	544
Returned surveys	215
Usable response rate as of 6 April 1995 (%)	39.5

Table 4 Demographic information[a] (number of observations = 215)

	Version A	Version B	Version C	All versions
Age (years)	51.00	58.00	66.00	58.33
Income (US$)	30 649	32 608	33 188	32 148
Gender				
Female	23	20	23	66
Male	48	47	39	134
Education (years)	13.10	12.87	13.38	13.12

[3]A copy of the survey is available from the authors.

[a]Fifteen respondents did not provide their gender.

Table 5 Level of concern for public and environmental issues

Public/environmental issue	Mean
Improving the education system	6.37
Reducing crime	5.99
Improving the healthcare system	5.87
Improving environmental quality	5.63
Cleaning up rivers and lakes	5.61
Reducing air pollution	5.46
Improving public roads	4.95
Reducing global warming	4.89
Saving endangered species	4.60
Reducing coal dusting	4.23

In order to understand how individuals ranked the secondary impact of coal dusting with respect to more direct policy goals, respondents were asked to state their level of concern for a variety of public and environmental issues. The mean responses are presented in Table 5, where 'not at all concerned' = 1 and 'greatly concerned' = 7. As expected, coal dusting ranks below the other choices. However, its mean response of 4.23 indicates that while other goals take precedence, individuals are still concerned with the issue and its impacts. Nearly half of the respondents were aware of coal dusting prior to receiving the survey (Table 6); 35% felt coal dusting is a serious problem and another 41% were unsure.

Two survey questions highlighted an interesting issue. The concern for reducing coal dusting (*CDUST*) was negatively correlated with the respondents' stated distance from the closest train tracks (*DIST*) (correlation coefficient = −0.22 with a *t*-statistic of −2.50 for houses within 3.2 km of the track). This confirms expectations that individuals closer to a railroad track have greater concern for the issue of coal dusting. Many other studies have found that distance from a disamenity strongly affects economic variables such as property values, which would imply that attitudes are also affected by distance, as the survey results indicate. As a contingent valuation survey captures use as well as non-use values, the effect of distance from the commodity in a CVM may also represent a diminishing use value, while non-use values may hold for a considerable (and undetermined) distance from the commodity (in this case coal dust from trains). A more detailed analysis of the implicit value for coal dust reduction as a function of distance from track could be carried out with regression techniques in future work.

Even after reading statements explaining that most experts consider coal dust a nuisance pollutant which is not classified as a health risk (or the cause of black lung), 27% still regarded coal dust as a health risk (*HRISK*), and 42% were not sure (Table 6). Only 31% agreed with the expert's opinion. The following question explained that agricultural experts feel coal dust does not cause damage to crops, trees and other vegetation, and that the US EPA found no accumulation of coal dust in surrounding soils. None the less, while 38% agreed with the experts, 16% of respondents considered coal dust an environmental hazard (*ENVRISK*), and 46% were unsure. Even when presented with expert evidence to the contrary, many individuals remained convinced that coal dusting was a health and environmental problem. This situation has important ramifications for planners and public officials. In the design or implementation of policy, officials may rely on expert findings and opinions. However, if the general public disagrees with expert opinion, community opposition may be strong and the public may resist the passage or implementation of a policy.[4] A similar situation may arise when officials attempt to site an undesirable public facility.

In large part, individuals' values are influenced by their perceptions of the situation, which may differ from the objective analysis of risks that policy makers use in considering secondary impacts. Even though individuals were informed in the survey that experts felt that there was little health or environmental risk associated with coal dust emissions, several individuals still felt there were risks from coal dusting. Such perceptions will be closely related to how individuals and communities respond to the impacts of energy policy and private sector decisions affecting their communities (Smead, 1996). For instance, respondents were asked to indicate how responsible they felt for controlling or eliminating coal dust from trains (*RESPONSE*). Individuals who perceived a greater health or environmental risk felt more responsible for controlling or eliminating coal dust than those who did not perceive a risk (correlation between *HRISK* and *RESPONSE* and between *ENVRISK* and *RESPONSE* are 0.13 and 0.15 respectively, both significant at 5% or higher). Individuals who perceived a health risk in general were the same individuals who perceived an environmental risk. In addition, individuals who had been exposed or knew of someone who had been exposed to the soiling effects of coal dust (*EXPOSED*) were more likely to perceive coal dust as a health or environmental risks than those who had no previous exposure to coal dust (*EXPOSED* and *HRISK* and *EXPOSED* and *ENVRISK* $r = 0.18$ and 0.25, *t*-statistic = 2.48 and 3.46, significant at the 5% and 1% levels respectively).

Individuals that felt more responsible indicated preferred options leading to more control of coal dust (*PREFER*) (correlation coefficient = −0.46, *t*-statistic = −6.67, significant at the 1% level; a negative correlation is due to a lower number control option indicating greater levels of dust control). In addition, individuals who felt more concerned about coal dust also felt more responsible for controlling coal dust from trains ($r = 0.29$, *t*-statistic = 3.98, significant at the 1% level).

[4]There is a positive and significant correlation (0.36) between the percentage of total WTP for coal dust control and whether or not individuals believed that coal dust represented a health problem (eg those stating they felt coal dusting from trains represented a health hazard also stated a higher percentage of their WTP was because of health concerns). Similarly there is a positive and significant correlation (0.29) between the percentage of total WTP for coal dust control and whether or not individuals believed that coal dust represented an environmental problem. Even when presented with information stating that experts have not identified coal dusting as a health or environmental risk, due to their subjective perceptions, individuals state a willingness to pay for control of the health or environmental risk factors.

Table 6 Beliefs about coal dusting impacts

Survey question	Yes	No	Don't know or not sure
Have you ever read or heard anything about coal dusting from trains?	47	46	6
Do you think that the losses of coal in the form of dust is a serious problem?	35	24	41
Do you feel that coal dust from trains is a health hazard?	27	31	42
Do you feel that wind-blown coal dust has an impact on crops, vegetation and the environment surrounding train tracks?	16	38	46

The individuals' perceptions of health or environmental risks was also closely related to their choice of a preferred control programme. *HRISK* and *PREFER* and *ENVRISK* and *PREFER* were correlated (–0.12 and –0.17, significant at the 10% and 5% levels respectively). Such a situation should be of concern to a policy maker where misperceptions may play a significant role in community responses to secondary impacts of public policies.

Table 7 presents the distribution of respondents' choice of preferred options, which serves as the basis for determining revealed preferences. The results indicate that individuals respond to variations in costs and level of dusting. As the cost of dust prevention rises (version A as opposed to version B), respondents shift towards the less expensive options, even though these will result in less complete remediation of dust. The results are consistent with decreasing marginal rate of substitution between money and coal dust control. As the level of nuisance dusting falls (version A as opposed to version C), the expected preference again shifts towards the less complete control options. Such a response is consistent with the 'scoping' requirement that is now considered necessary to validate responses to CVM studies.

Conclusions and recommendations for future research

Changes in public policy, technology and economic conditions have generated a negative externality in terms of the increased fugitive dust emissions associated with rail transport of coal. While fugitive coal dust emissions do not appear to create identifiable health or ecosystem impacts, they do cause nuisance problems to those individuals or firms located within a relatively short distance from railroads. Rail carriers have begun to respond to complaints from affected parties in some areas of Virginia and Canada, but the total magnitude of the problem in other areas is unknown.

The initial results of a contingent valuation survey of this problem in the central Virginia area suggest that the economic impact is positive but not large. The main effect can be identified in terms of increased cleaning costs, which economists would identify as non-market use values. Non-use values associated with fugitive dust emissions appear to be small as the environmental impact is minimal, and the ecosystems associated with rail lines are probably not seen as generating significant amenity or existence values. Some individuals state an altruistic motivation in stating a willingness to pay for reducing coal dust emission, which could extend aggregate values beyond the area of geographical impact from dusting. When properly implemented, non-market valuation methodologies, such as contingent valuation, are becoming readily available tools for including non-market values and impacts in energy policy analysis.

As the rail transport of coal fines increases due to increased demand for finer coals, a higher proportion of longwall mining, and general increased use of coal, the economic and social impacts of fugitive coal dust may increase. If this is combined with increased population near rail lines, the aggregate impact may become such that more aggressive preventative measures will be necessary. At this time, the results of this study are too limited to provide a basis for any aggregate damage estimates from fugitive coal dust emissions.

This study suggests that non-market secondary impacts from energy policy need to be considered in evaluating such policies. While they may not be identified by those affected as resulting from a particular policy initiative, such secondary impacts still impose individual and community costs which should be accounted for in policy decisions. Policies which do not account for all such effects can unexpectedly face community resistance. Such resistance may be based on values not associated with identified primary and/or objective impacts. As a result, dealing with secondary impacts

Table 7 Distribution of choice of preferred programme

	Version A Low cost/heavy dusting	Version B High cost/heavy dusting	Version C Lost cost/medium dusting	Total
Mechanical covers (%)	10.0	3.3	6.6	6.8
Soft covers (%)	20.0	16.4	14.7	17.2
Chemical sealants (%)	27.1	34.4	27.9	29.7
Do nothing at this time (%)	42.9	45.9	50.8	46.3
Total (%)	100	100	100	100
Complete answers	70	61	61	192

may force economic agents to incur additional unanticipated costs (such as installing mechanical covers on rail cars) to ameliorate the impacted communities.

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