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SUMMARY FOR POLICYMAKERS

The True Cost of Electric Power

An Inventory of Methodologies to Support Future Decisionmaking in Comparing the Cost and Competitiveness of Electricity Generation Technologies

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The True Cost of Electric Power

An Inventory of Methodologies to Support Future Decisionmaking in Comparing the Cost and Competitiveness of Electricity Generation Technologies

In energy markets across the world, market prices for fossil fuels are often lower than the prices of energy generated from renewable sources, such as solar, wind, and biofuels. These market prices, however, don't take into account the "true costs" of the energy being sold, because they ignore the external costs to society caused by pollution and its resulting burdens, including damages to public health and the environment. Accounting for these externalities can as much as double the cost of some fossil fuels and, in some cases, make them more expensive than renewables.

Because renewable forms of energy have far lower external costs than energy generated from fossil fuels, if one can implement policies that incorporate those costs into the price of electricity generated from all technologies, the playing field levels out and renewables can compete on a more fair and economically justified basis. The challenge, of course, is determining those "true costs."

Estimating the true costs of electricity generation is both complex and controversial. It is complex because it must take into account several factors, including the population density near a power plant, the fuel it uses, and its pollution abatement technology. It is controversial because it requires assumptions and decisions to be made that the public does not like or does not understand. These include monetizing some types of risks (for example, to health) and ignoring others, such as occupational risks from coal mining when they are already "internalized" by the coal company in the wages it pays. Finally, these approaches are certain to be controversial because they can affect billions of dollars in investments in electricity generation.

This report, *The True Cost of Electric Power,* examines the various methods that have been used to measure such "true" costs and looks at how such estimates can be used in company decisionmaking and public policy to ensure that investments are directed at the electricity generation methods with the lowest true costs to investors and society.

The aim of the report is to provide the background for policymakers and investors who want to incorporate the concept of "true costs" into the discussion of electricity generation. In some geographic areas, adequate data and methods exist to make a solid estimate of the total social costs of energy production. In those places where the data or methods (or both) are less robust, it is possible to use a benefits transfer approach (see "Types of Studies" on the following page) that still gives stakeholders important guidance about the scale of the true costs of their investments and to get started in formulating policies to incorporate those costs into the market price.

Whatever the state of the data and methods, the process of the analysis and stakeholder discussion can be just as important as the final results in providing guidance to decisionmakers. Consideration of the true costs should be a component of decisionmaking for all energy investment worldwide.

Approach

The chosen approach was to review the available conceptual and empirical literature on the estimation of full social costs, and to draw from that literature, as well as from the authors' experience as creators of some of this literature, to identify the strengths and weaknesses of the various methods used to estimate such costs.

Types of Studies

Researchers have tried to estimate the true costs of electricity generation by using three main types of studies: primary studies, benefits transfer studies, and meta-studies (each of which is fully described in the respective sections on the following pages). Each type of study estimates costs using one of two methods: a damage function approach or an abatement cost approach. The damage function approach essentially maps out the relationships between emissions and impacts and then monetizes the accrued damages. The abatement cost approach uses the cost of reducing pollution given current regulations as an estimate of damages from pollution. The damage function approach is far superior to the abatement cost approach, but is more data and methodologically intensive.

Primary studies look directly at a particular region or individual power plant and analyze the benefits and damages resulting from both the production of the fuel that powers the plant and from the plant's operation. The studies follow the primary public health and environmental impact pathways through the life of the plant to estimate the costs to society of that power that are not reflected in the market price of the electricity.

Estimating the true costs of electricity generation is both complex and controversial.

In a primary study, most key elements of the damage function approach are performed with data or findings unique to the study or at least from data or findings from the country where the analysis is occurring.

A benefits transfer study uses and adapts engineering, health, environmental, or economic data taken from an original study site (which we call the donor site) under particular resource and policy contexts and then applies the data to a separate site (the transfer site). Compared to primary studies, a benefits transfer study would have fewer elements than a damage function approach developed uniquely for the site in question. Benefits transfer studies are usually performed when the necessary time, money, or expertise to do a detailed primary study are lacking, or when the data or literature are not of sufficient scope or quality to support a primary study.

Benefits transfer studies can never be as accurate as primary studies. But, by using the results of primary studies and the framework models that embody their work (such as RAINS, TAF, BENMAP, and EcoSense)* as a foundation, a benefits transfer study can take advantage of all the expertise in epidemiology, air quality modeling, and economics that is embedded in such studies and models. Furthermore, a benefits transfer study provides faster and less costly analyses.

* For more information on these models, see www.iiasa.ac.at/rains/gains.html (RAINS), www.lumina.com/uploads/main_images/TAF.pdf (TAF), www.epa.gov/air/benmap (BENMAP), and www.externe.info/externe_d7/?q=node/2 (EcoSense).

A handful of meta-studies have looked across the literature examining the true costs of electricity generation. These studies highlight the wide range of results that can be generated, depending on the assumptions and research methods used, and show directionally the likely result of any attempt to estimate the true costs of power generation. However, the results are only qualitative in nature when applied to any given study site.

If resources and expertise are available, the conduct of a primary study is preferred. However, there are a variety of "benefits transfer" techniques that economize on resources—some are more accurate and illuminating than others.

Once the type of study is settled, the next step is to make choices about its scope. When estimating true costs using the damage function approach, the following parameters need to be determined:

- the method for evaluating a fuel type's impacts to target study resources,
- the treatment of location specificity,
- the focus on new or existing plants (or both),
- the focus on the full fuel cycle or just the generation step,
- the generation and impact categories to consider,
- the methods for estimating impacts and values,
- the treatment of temporal issues,
- the classification of monetized impacts as externalities, and
- the treatment of uncertainties because of data or methodological limitations.

Market prices don't take into account the "true costs" of the energy being sold, because they ignore the external costs to society.

To illustrate some of the challenges involved, consider that the location of observed pollution matters a great deal. A source located near and upwind of population centers will have larger health impacts than a source located on an ocean coast with prevailing winds blowing out to sea. Further, the social costs include more than just those associated directly with generating the electricity. The extraction, processing, distribution, and transportation of fuel—as well as the creation of construction materials and machinery for the power plant, and the burdens associated with building and decommissioning power plants—are some of the more important elements of the life cycle.

Amidst these challenges, it is valuable to note that although many environmental and human health endpoints might be considered, they are not all equally important. By focusing at least initially on the endpoints with the highest expected value for external costs, based on estimates that have been identified in previous studies, most of the external costs can be discovered while streamlining the research process.

Primary Studies

From the primary external cost literature, we identified four major studies for a detailed examination: National Research Council (NRC) (2010), European Commission (2005) (herein referred to as ExternE), Rowe et al. (1995), and Lee et al. (1995) (herein referred to as RFF/ORNL). These four studies were selected primarily on the basis of their thoroughness and rigor. They illustrate differing methods and scopes for estimating "true costs."

The **RFF/ORNL** study (1995) examined seven fuels used in hypothetical power plants constructed in 1990 that meet the current emissions standards. The study developed analysis for all stages of the fuel cycles, beginning with fuel extraction. It excluded upstream effects associated with plant construction, such as emissions associated with manufacturing cement used in construction, but it did include upstream damages associated with fuel, including mining, preparation, and transportation.

The hypothetical plants were placed in specific locations. For example, damages for a new coal-fired power plant are based on two study locations: one in east Tennessee and the other in northwest New Mexico. The study evaluated various technology fuel cycles at the same geographic location and used a damage function approach to estimate the damages accrued within 1,000 miles of the source plant.

Few studies have attempted to estimate the external costs of electricity in developing countries.

As part of the results, the authors demonstrated that health damages from air pollutants are highly dependent on population and spatial distribution. For instance, damages from a coal-fired plant at the highly populated southeast reference site were estimated to be roughly 62 times higher than the southwest reference site. Moreover, external damages from coal transportation either by rail or by truck were found to be of the same order of magnitude as health effects from air pollution. However, coal mining damages—including injuries to workers—were thought to be largely internalized in wage premiums and not an external cost.

Rowe et al. (1995) further developed the methodology for estimating external costs of electricity supply using a damage function approach. The authors examined more than 300 possible impacts over 23 new and relicensed electric resource options. The potential externalities were screened into four categories and those in the primary category were estimated while those in the other three were identified for future research or presumed to be zero. External cost estimates were computed for three case study locations in New York: an urban site near New York City and JFK Airport, a rural site along Lake Ontario, and a suburban site outside Albany. Total damages from a natural gas combined cycle facility were estimated to be approximately 10 times higher at the urban JFK site than the rural Lake Ontario site. And damages from the natural gas combined cycle facility at the suburban Albany site were nearly twice as large as the rural Lake Ontario site. For an oil distillate combustion facility, the distinctions between external damages at different locations were less pronounced.

The **ExternE** project (2005) aimed to develop a systematic approach to the evaluation of external costs over a wide range of different fuel cycles. The project examined new and existing plants meeting current environmental regulations and considered a single representative site for each fuel cycle. The project computed monetary external damages associated with human health, crops, ecosystems, climate change, and materials. For ecosystem impacts, the project team also computed marginal and total reparation costs, where ecosystem costs are defined as the costs necessary to treat regions where critical pollutant loads are exceeded by 50 percent. For climate change, avoidance costs were used and defined as the shadow price for reaching Kyoto targets. Nuclear, hydro, solar, and wind energy all had low external cost estimates. Since the first ExternE project, several incarnations have been developed in Europe using the same methodology.

The authors of the **NRC study** (2010) computed the external damages resulting from the air-pollutant emissions associated with electricity generation from 406 existing coal-fueled plants and 498 existing gas-fueled plants. The authors also quantified the emissions resulting from upstream operations for the coal and gas fuel cycles, but the impacts were not monetized. Damages from air-pollutant emissions and greenhouse gas emissions associated with nuclear, wind, and solar power were also quantified but not monetized. On average, the damages per kilowatt-hour (kWh) associated with coal plants were 20 times higher than the damages associated with gas plants. The results also showed high variance among the distribution of damages from coal and gas plants on a kWh basis, however—hinting at the importance of the geographic location of the plants, emissions intensity, and demographic attributes of the exposed population around the plant site. Because of this, the coal plants exhibiting the lowest damages per kWh were shown to be cleaner than the gas plants exhibiting the highest damages per kWh.

These primary studies show a range of external cost estimates that can be largely explained by differences in the sites, such as geography or exposed population. In general, these studies and the broader literature support a rank order of fossil fuels, wherein the coal fuel cycle is more damaging than the oil fuel cycle and the oil fuel cycle is more damaging than the natural gas fuel cycle. This difference would be magnified with consideration of climate change impacts. The estimates also suggest that damages from the biomass fuel cycle are on the same order of magnitude as the coal or oil fuel cycles when climate change is not taken into account. The nuclear fuel cycle has low external costs in general, although the remote probability of accidents adds a very high consequence factor into the estimates. Photovoltaics (PV) are an essentially emissions-free energy source at the use stage, but impacts over their life cycle are significant. Table A outlines estimates, in 2010 dollars, taken from each of the four major studies summarized above.

Table A. Summary of Estimates from Four External Cost Studies (2010$)

mills/kWh	Coal	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
RFF/ORNL	2.3	-	0.35–2.11	0.35	0.53	3	-	-	-
Rowe et al.	1.3–4.1	-	2.2	0.33	0.18	4.8	-	-	0.02
ExternE	27–202	27–67	40.3–148	13.4–53.8	3.4–9.4	0–67	0–13	8.1	0–3.4
NRC	2–126	-	-	0.01–5.78	-	-	-	-	-

It is important to note that neither the RFF/ORNL, Rowe et al., nor NRC studies include monetized climate change damages in their estimates. The ExternE study does include monetized damages from climate change at the global level, estimated using a shadow price of $6.90–27.80 per ton of CO_2.

Krupnick and Burtraw (1996) compiled a quantitative reconciliation of three of these studies: RFF/ORNL (1995), Rowe et al. (1995), and the first version of ExternE (European Commission 1995). They found the different estimates to be consistent after adjusting for essential differences in the study sites and the treatment of climate change. The greatest sources in variation among the study sites and the studies were atmospheric modeling and the population affected by changes in air quality. The authors concluded that a measure that avoids this component, such as dollars per person per unit change in pollution concentration, would be preferred for benefits transfer. Other reasons the results of the studies are so varied involve the damage pathways and ultimate endpoints, the pollutant burdens included in the studies, and the degree to which estimates of damages to occupational and public health throughout the fuel cycle and damages to transportation infrastructure are featured. These issues are especially topical with the increased use of hydraulic fracturing to produce natural gas. In summary, however, reconciliation across the primaries studies is successful; the methods are robust and deliver consistent and meaningful estimates given various study parameters.

Benefits Transfer Studies

A review of the major benefits transfer studies shows that the quality of the results depends strongly on the choice of donor site and its similarity to the transfer site, the types of values transferred, and whether the authors use a direct benefits transfer approach—which applies specific values taken from the donor site—or the more complex but more refined value-function transfer approach, which applies functions that can be solved with parameters specific to the transfer site.

Benefits transfer studies can never be as accurate as primary studies, but can provide faster and less costly analyses.

One of the clearest comparisons of benefits transfer studies came from a 2006 external cost study funded by the European Commission: Cost Assessment of Sustainable Energy Systems (CASES). The project involved results from four non-EU countries: China, India, Turkey, and Brazil. All four studies involved a direct benefits transfer approach; however, the studies used a detailed process of adapting the primary results from the donor site for the transfer site.

The Chinese study looked at coal and natural gas fuel cycles using a typical 100 megawatt

(MW) power plant. In this study, the "transfer" involved the application of China's "Pollutant Charge Standards" damage estimates to the transfer site.

The Indian team examined the seven major coal fuel-cycle stages: mining, coal preparation, transportation, generation, transmission, waste disposal, and plant decommissioning. To monetize the priority impact pathways, the team conducted a value transfer using U.S. market prices for sulfur dioxide (SO_2) and nitrous oxides (NO_x), and European carbon market prices for carbon dioxide (CO_2) and methane (CH_4).

The authors of the Turkish lignite coal fuel-cycle study used a medium size reference plant located in Mugla Province along the southwestern corner of the country. Unlike the Chinese and Indian case studies, which did not examine plant construction and decommissioning, the Turkish team offered a non-quantitative examination of the cement and steel used in plant construction as well as the transportation of materials. While the original report did not attempt to monetize the damages from primary pollutants, a benefits transfer study using the same data was subsequently conducted using damage estimates from an ExternE study.

The Brazilian case study examined both the natural gas fuel cycle and hydro fuel cycle. For the natural gas cycle, the authors used a study site complex consisting of both a gas-fired thermodynamic cycle plant and a combined cycle plant. To estimate mortality damages, the authors borrowed an estimate from ExternE and adjusted it for the Brazilian application. The study's remaining damage estimates were computed using primary data.

The studies found, generally, that the damage estimates for coal use in non-EU countries were three to five times greater than for natural gas. Damage estimates were highest for the Indian coal fuel cycle and lowest for the Brazilian hydro cycle and Chinese natural gas cycle.

As noted above, benefits transfer studies can never be as accurate as primary studies, but can come close by relying on the work of primary studies and models. Furthermore, a benefits transfer study provides faster and less costly analyses. But as can be seen from the above review, there are credible and less credible ways to do a benefits transfer, and all benefits transfer techniques are not equally accurate; indeed, it is unlikely that one technique will dominate all others all of the time.

The social costs include more than just those associated directly with generating the electricity and include all stages of the life cycle.

Meta-Studies

A third approach avoids specific transfer studies and relies instead on meta-studies, which are broad reviews of the disparate literature with an attempt to reconcile differences in values leading to summary values. Median (50th percentile) values might be a better indication of central tendency than mean values because they do not allow outliers to influence the measure. Comparing median values across many studies, Sundqvist and Soderholm (2002) find the external costs of coal to be about twice that of natural gas and biomass and eight times that of nuclear, with oil being the highest. In terms of absolute values, coal's external costs of about eight cents would exceed the private costs of coal generation and be in the range of or somewhat below current delivered electricity prices (including transmission and distribution costs and based on private costs plus costs imposed by regulations). These results are a reasonable starting point.

Table B illustrates, however, that this metric ignores the huge variation in external cost estimates due to their sensitivity to inclusion of multidimensional components of external damages. For instance, it is crucial for fossil technologies whether climate effects are included, and for nuclear, how one treats the external costs of catastrophic events.

Looking forward, a number of conceptual weaknesses were identified in the existing literature. While conventional fuel cycles have been researched at length, the external costs of renewable fuels like solar have received relatively little attention. Moreover, few studies have attempted to estimate the external costs of electricity in developing countries. This is an important gap in the literature as distinctions in income, population density, and environmental impacts can yield estimates that are dissimilar to those of a developed country.

Table B. Summary of 63 External Cost Estimates from the Literature

Cents/kWh	Coal	Oil	Nat. Gas	Nuclear	Hydro	Wind	Solar	Biomass
No. estimates	36	20	31	21	16	18	11	22
Min	0.01	0.04	<0.01	<0.01	0	0	0.00	0
Max	90.61	53.43	17.69	86.23	35.14	1.18	2.94	29.56
Mean	18.75	16.48	6.17	9.53	4.50	0.41	1.12	6.62
Median	8.54	12.19	3.51	1.08	0.43	0.43	1.02	3.59

Source: Sundqvist and Soderholm 2002.

There are two ways that true costs could affect regulations: in planning and permitting for new investments and in the operation of existing facilities.

How Should These Findings Be Used?

Decisionmakers may choose to use information about the true costs of energy in a variety of ways. Economic theory would suggest that this information be incorporated directly into prices, in the form of emissions fees and other charges that reflect social costs. In practice, the information is more likely to find its way into decisionmaking through regulation. There are two ways that true costs could affect regulations: in planning and permitting for new investments and in the operation of existing facilities.

In planning and permitting, the government could require investors to explicitly demonstrate that an investment option is lowest cost when taking full social costs into account. Under that scenario, the choice between what appeared to be cheap coal and expensive natural gas generation could be flipped if, for example, the private cost of power generation were $0.02 per kWh and $0.04 per kWh, respectively, and the external costs were $0.04 per kWh and $0.01 per kWh, respectively. The limitation of this approach is that it does not restrict how a facility is operated after it is built.

A more influential result is obtained if true costs are considered not only in the investment planning process but also in the operation of facilities to ensure the minimization of true costs throughout the life of the plant. This approach would affect investment as well as operation of the system, because investments will be evaluated taking into account their operation over the long run.

How can this information be useful for decisionmaking? That depends on who is making the decisions and the assignment of risk and responsibility that is assumed. Policymakers have an explicit interest in consideration of social cost. Private investors also should have an incentive in considering social cost, especially if they will be the operator of a facility—one observes that, over time, new regulations often reach back to address emissions at already existing facilities. The owner or operator of a facility therefore may assume risks that external costs will be monetized.

Components of true cost assessments influence electricity planning and system operations around the world through qualitative and sometimes quantitative measures, but less often are they formally addressed in a comprehensive framework. In the United States and the United Kingdom, regulators often explicitly and formally consider external costs and benefits comprehensively. In the 1990s, a movement toward the use of true costs grew in the United States, promoting the use of what was termed "environmental adders" to formally incorporate quantitative estimates of environmental costs in investment and operational decisions for electricity generation.

Several state-level utility regulatory commissions in the United States implemented this approach and European countries were likewise interested in this use of true cost estimates. In many cases, however, such efforts were overtaken by events to deregulate the electricity industry, which removed much of the influence of utility regulators on investment decisions. In these cases, estimates of true costs are working their way through environmental permitting decisions. Moreover, it is routine for investment planners to account for "regulatory risks" in their decisions, and these risks incorporate an assessment of the possibility of regulatory action addressing external costs.

Getting Started

This report illustrates that analysis of the true costs of electricity can be conducted at various levels of detail and rigor. While a full-scale, site-specific primary analysis is clearly the most accurate, in some settings or countries, it may not be possible. This should not, however, be a barrier to getting started. In situations where extensive resources and expertise are not available, benefits transfer methods offer a high value for the cost of the analysis. In general, the value of incremental information from a partial analysis will improve decisionmaking and it will help identify priorities for further research.

One guideline is useful in all cases. Analysts should employ a consistent accounting framework so that various types of damages from the different technologies that are investigated can be compared on a like basis. This will ensure, for example, that consistent assumptions about population demographics, exposure to pollution, and discount rates are used. The primary studies provide an excellent template for accounting frameworks that easily can be replicated or used directly, preserving information for benefits transfer where useful and swapping out other information as appropriate.

It is suggested that the paradigm of modern welfare economics for estimating external costs undergird this accounting framework, meaning that damages should be identified, estimated, and valued. The use of abatement costs as a proxy for external costs is discouraged, for instance; that approach is preferred only to no approach at all. And furthermore, even the nitty-gritty details of dose-response functions, air quality dispersion models, and the like are to be consistently used and replicated in comparing social costs of different generation technologies.

The way forward will differ in various jurisdictions depending on the resources available for the study, institutional capacity, and so on. Two situations are illustrated in Table C, which are labeled Country A and Country B.

Although a full-scale, site-specific primary analysis is the most accurate, in some settings or countries, it may not be possible. This should not be a barrier to getting started.

In Country A, the existence of a high level of expertise is assumed and an interest in putting all generation options, including renewable energy and energy-efficiency investments, onto a level playing field. The purpose of Country A's study is to fully evaluate alternative investments, accounting for the full social cost ("true cost").

Country B, by contrast, has a low level of expertise, but the country has access to expertise. Given a lower level of available resources, Country B might not consider all generation options and would likely concentrate on near-term investment options. Nonetheless, these options should include not only fossil fuel choices but also renewables and investments in energy efficiency. The purpose of a study in Country B is to expedite infrastructure development and achieve sustainable development goals, accounting for social costs.

Table C. Initial Considerations in Designing a Study of True Costs at the Country Level

	COUNTRY A	COUNTRY B
ASSUMPTIONS		
Resources available	High	Low
Generation comparisons	All	Not nuclear
Institutional capacity	High	Low
Expertise	High	Low (but have access)
Purpose of study	To support full evaluation of alternative investments accounting for full social cost ("true cost").	To expedite infrastructure development and achieve sustainable development goals, accounting for social costs.
ATTRIBUTES OF STUDY		
Study type	Primary	Benefits transfer
Screening analysis	Complete. Study should be clear about what is excluded.	Partial. Identify areas that must be included.
Modeling framework	Use country-specific framework, if available. If not, obtain damage function computer models.	Obtain damage function computer models. These models would be used as an accounting platform and provide substantial basis for benefits transfer. In some cases, representation of atmospheric transport would require additional effort.
Use of modeling framework	Generate complete analysis.	Education of decisionmakers, identification of important information gaps for analysts.
Location choice	Multiple, real candidate sites.	Single, representative site.
Energy life cycle	Yes. As far upstream as possible, subject to screening analysis and value of information analysis.	Partial. Limit to generation and indigenous resource extractions.
Pollutants	All.	Priority pollutants from screening, e.g., PM2.5 and GHGs.
Emissions factors	Specific technologies and facility characteristics.	Representative technologies for each generation type.
Pollution distribution and transformation	Best available models.	Borrow from other studies or assume generic distance decay function for each pollutant estimated from other studies.
Unit Impacts	Use modeling framework default or use country-specific studies.	Implicitly using impact relationships in donor study.
Population	Actual/projected.	Actual/projected; use to adjust BT estimates.
Population parameters (e.g., death rates)	Actual/projected.	Actual/projected; use to adjust BT estimates.
Valuation of in-country effects	Use modeling framework default or use country-specific studies.	Use value relationships in donor study; possibly scale for elasticity of willingness to pay of income.
Valuation of climate effects	Use nationally identified value.	Use nationally identified value or borrow value from donor study. Possibly scale for elasticity of willingness to pay of income.
Treatment of uncertainty	Full, including Monte Carlo and expert elicitation methods. Use uncertainty to advance understanding of policymakers.	Best estimates and scenario analysis; expert elicitation methods.
Mapping damages to externalities	Full, except in labor markets and where there is liability.	Full, unless labor markets competitive.

With these differing contexts in mind, the choices that might be made in these two settings are illustrated. Country A may want to do a complete screening of every plausible external cost and examine multiple real-world geographical locations, with specific technology characteristics, such as stack heights and boiler design. It might also use the best available models of pollution distribution and transformation and apply them to each specific location, and it may have original valuation studies to apply in estimating the monetary damages from pollution.

Country B, meanwhile, may choose to limit its screening to a small number of high profile issues and to where data are available—for example, emphasizing priority pollutants such as PM2.5 and greenhouse gases. It may focus on a single, r epresentative site and representative generation technologies. Country B may also borrow pollution distribution models from other studies or assume generic decay rates for the effects of pollution over distance and time. And, it may borrow value relationships from another study, and may want to scale those values according to the income or preferences of its population.

It is clear that Country A's findings will be more robust and accurate, specifically suited to its own needs. However, both approaches will leave policymakers and investors better informed about the true costs of their power generation choices than if they had done no analysis—and this information is important in making better decisions about the appropriate investments and planning.

This report provides the background for stakeholders and analysts to begin a process. The ultimate results of an analysis should prove extremely valuable to sustainable energy development. However, the process of the analysis and stakeholder discussion can be just as important as the final results in providing guidance to decisionmakers. These methods, and the consideration of true costs, should be a component of decisionmaking for all energy investment worldwide.

These studies and the broader literature support a rank order of fossil fuels, wherein the coal fuel cycle is more damaging than the oil fuel cycle and the oil fuel cycle is more damaging than the natural gas fuel cycle.

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