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COAL AND SUSTAINABLE DEVELOPMENT

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Abstract

Sustainable development depends upon electrification and infrastructure, and these in turn are reliant on coal. In recorded world history, more electricity has been derived from coal than any other fuel source. It remains so and by 2040, coal is forecasted to account for 40% of generated electricity worldwide, ahead of natural gas, nuclear, petroleum, and all renewable sources. A byproduct of coal combustion is coal ash, the properties of which are useful to civil, commercial, and residential construction. This manuscript challenges the notion that coal should be discouraged as a fuel source. Instead, it should be encouraged to continue the rise in global sustainable development indicators as well as to increase the capacity for research and innovation.

Keywords: *Coal, Sustainable Development, Climate Change, Carbon*

1. Introduction

Worldwide sustainable development depends on access to energy. Much of the world's energy policy is guided by the premise that the use of coal to generate electricity is contributing to global climate change and as such should be reduced as soon as possible. Government regulation, litigation, academic research, and popular media all align with this narrative. Advocacy groups discourage investments in companies which buy, sell, or otherwise use coal, and seek to block coal-fired power plant construction in the U.S. and in U.S.-financed projects in the developing world. The objective of this paper is to critically evaluate this anti-coal premise in the context of sustainable development, using considerations of benefits, costs, and uncertainty to suggest an alternative perspective.

2. Background

In government, achieving policy objectives typically requires influencing public opinion, financial incentives, laws/regulations or combinations thereof. Environmental policy in particular has been driven primarily by regulation, the benefits of which are widely appreciated in terms of clean air, water, and soil that collectively support human and ecological health. In developed countries, virtually all measurable contaminant indicators in air, water, or soil have either been reduced to levels for which direct exposure yields no measurable risk or have been contained to specific locations to which exposure routes are controlled (e.g., risk-based corrective action at legacy industrial waste sites). For example, the U.S. Environmental Protection Agency (EPA) uses 30 parts per billion (ppb) of sulfur dioxide (average annual value) as a federal standard for healthy air. As of 2013, the EPA estimates that more than 90% of U.S. locations have levels that are less than 5 ppb, a value that continues to decrease [1].

The air has never been cleaner. So the next frontier in environmental policy is focused on regulating carbon dioxide (CO_2) as part of an effort to reduce its presence in the atmosphere from its current level 0.040% to 0.035% [2]. In the U.S., for example, more regulations aimed specifically at reducing coal use have been promulgated in the past six years than in the preceding century. These regulations cover all aspects of coal exploration, mining, processing, transport, combustion, and disposal. While cumulatively significant, many of these regulations are individually incremental in nature, with the exception of the EPA's proposed rules entitled "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," [3] and "Standards of Performance for Greenhouse Gas Emissions From New Stationary Sources: Electric Utility Generating Units" [4]. These two regulations address current and future coal-fired electric generating units in the U.S. In terms of current generation, proposed rules would require nationwide idling of current units to result in an approximately 30% reduction in CO_2 emission. For future

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generation, the regulation eliminates coal as a viable fuel source unless carbon capture technology is utilized. Specifically, the rule for future generation limits CO_2 emission to a standard of 1,100 lb CO_2/MWh (500 kg CO_2/MWh), while current coal fired plants generate 2249 lb CO_2/MWh (1021 kg CO_2/MWh) on average. That difference can only be achieved by carbon capture and storage (CCS) technology, which has not been viably demonstrated on a commercial scale.

By statute, the EPA is required to consider the benefits and costs of any proposed regulation. The extent and basis of benefit/cost consideration was recently debated for a rule entitled "National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial- Institutional Steam Generating Units" [5], known in its abbreviated form as the Mercury and Air Toxics Standard (MATS). As the shorter title implies, the rules were intended to reduce emission of mercury and other constituents from coal-fired power plants. For this particular rule, EPA asserted that it did not have to consider compliance costs. It did however provide an estimate in the amount of US$9.6 billion/year. The estimated monetized benefits varied depending on how indirect effects were considered. Direct benefits of reducing the emission of mercury and other elements was estimated to be three orders of magnitude less than compliance costs, at US$4-6 million/year. However a byproduct of meeting these reduced emissions would also have been to lower exceedingly fine particulate matter, e.g., those particles with diameters less than 2.5 µm (PM2.5). The reduction in PM 2.5 particulate matter was not the intent of the rule however its removal was estimated to yield health benefits, primarily in the form of reduced premature mortality, in the amount of US$37-90 billion/year. While EPA asserted that costs should not be considered, it included these "co-benefits" to conclude that overall benefits outweighed the costs in any case. The state of Michigan sued the EPA for this rule and on June 29, 2015, the U.S. Supreme Court ruled against the EPA [6]. In writing for the majority, Justice Antonin Scalia wrote "The Agency must consider cost—including, most importantly, cost of compliance—before deciding whether regulation is appropriate and necessary."

3. Coal's Role in Sustainable Development

The foregoing discussion on benefits and costs illustrates an inherent challenge to sustainable development, what some authors have referred to as the "energy-economy-environment dilemma" [7]. Simply put, we need low-cost energy to meet basic human needs, however the provision and use of such energy is thought to prevent these needs from being met. The Intergovernmental Panel on Climate Change (IPCC) notes that the largest known human contribution to climate change comes from the burning of fossil fuels, accounting for 78% of the total increase in greenhouse gas emissions from 1970-2010 [8]. And yet, sustainable development depends upon electrification and infrastructure, and these in turn depend on coal. In recorded world history, more electricity has been derived from coal than any other fuel source. Figure 1 presents data for the India, the U.S. and the world for the past forty years.

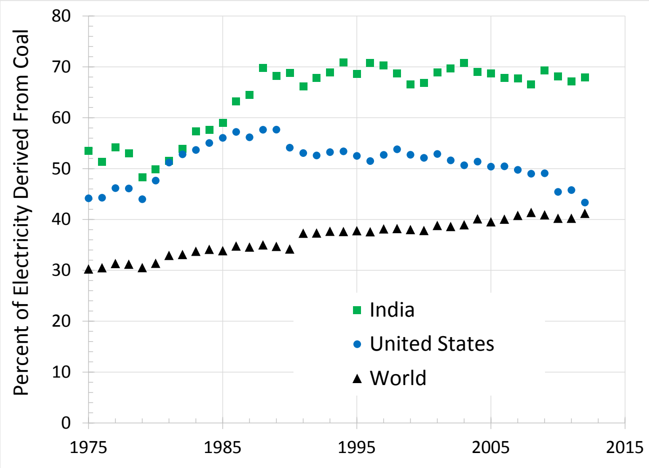

Figure 1. Percent of electricity derived from coal from 1975-2015; data from the International Energy Agency [9]

Worldwide, coal use continues to rise, accounting for more than 40% of electricity generation [9]. In India, approximately 70% of electricity is generated through coal combustion. In the U.S., the percent of electricity generated from coal has decreased significantly in the past five years because of regulation, anti-coal advocacy, and the widespread availability of natural gas. Hydraulic fracturing technology in particular has enabled natural gas supplies to increase twenty-fold in the past decade [10], as shown in Figure 2.

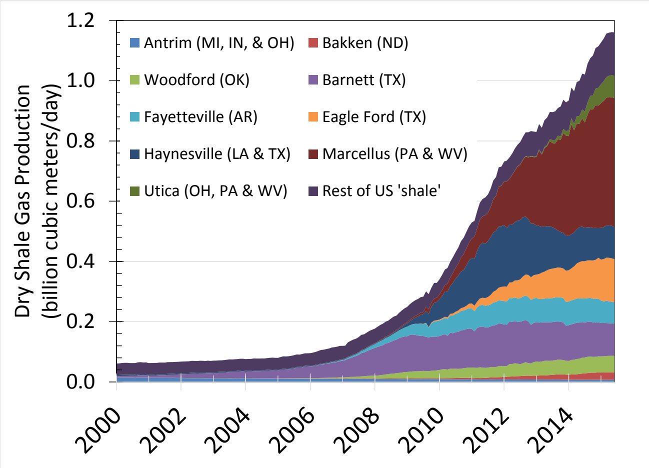

Figure 2. Increase in shale gas production in the U.S. since 2000; data from Energy Information Administration [10]

Despite these factors and as with the rest of the world, coal is forecasted to be the dominant fuel source in the U.S. through 2040, accounting for 36% of generated electricity, ahead of natural gas, nuclear, petroleum, and all renewable sources, as shown in Figure 3 [11].

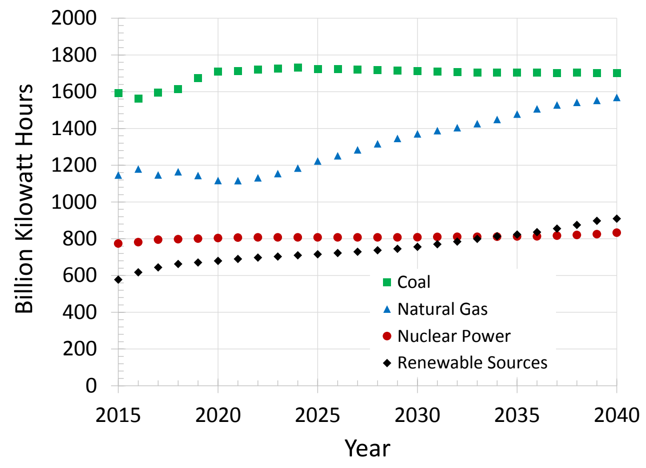

Figure 3. Forecasted sources of electricity in the U.S. through 2040, data from the Energy Information Administration [11]

Increased electrification contributes to multiple indicators of sustainable development, including greater gross domestic product, increased life expectancy, and reduced infant/toddler mortality. Specifically, electrification is a prerequisite for providing supplies of clean water, functional medical facilities, and refrigerated vaccines [12]. The correlation between low-cost coal-fired electricity and global health measures has been presented by the author [13] and others [14]. For example, Figure 4 provides data on the under-age five mortality in India, the U.S., and the world [15].

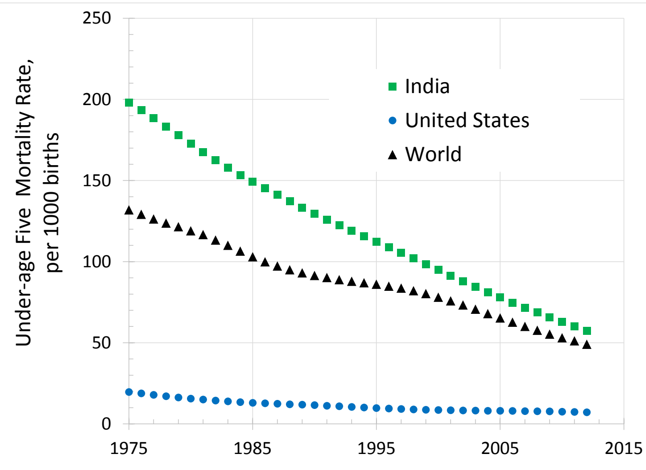

Figure 4. Under age five mortality rate for India, the U.S., and the World; data from [15]

In addition to facilitating a globally rising standard of living, low-cost sources of electricity such as coal provide the capacity to make investments in the research required to develop an engineering-level understanding of climate change, mitigation strategies, and cost-effective renewable sources of energy [13]. This is because energy costs have a direct effect on a country's gross domestic product (GDP). Increasing energy costs reduces the GDP and decreases the ability for investments in any other activity, including research and development (R&D). It is a reinforcing cycle in the sense that investments in R&D can, in turn, yield advances which improve GDP [16,17].

4. Benefits, Costs, and Uncertainty

So in returning to the energy-economy-environmental dilemma, we note that we need low cost sources of electricity despite their environmental concerns. While seemingly utilitarian, a cost-benefit approach provides useful context in which to consider uncertainty and social considerations. Such an approach can be observed in the evolution of air emission control policies, from gross particulate matter control, to nitrogen/sulfur oxides, to the currently proposed regulation of CO_2. The first coal fired power plant in North Carolina was constructed in 1926. There was no provision to remove the particulate matter and for decades it simply emanated from tall flue gas chimneys in the form of coal fly ash. By the 1970s, particulate control technology was relatively common, achieved through electrostatic precipitators or baghouse filters. Similarly, since 1990, a significant fraction of coal-fired power plants have been constructed or retrofitted to reduce emissions from nitrogen oxides through selective catalytic reduction and from sulfur oxides through flue gas desulfurization. In comparison to carbon capture and storage, the costs of these changes were relatively small in comparison to either the U.S. gross domestic product or the revenue of a given utility. For its part, the U.S. EPA estimated that between 1970 and 1990, the Clean Air Act (CAA) legislation of 1970 resulted in a variety of health-related benefits valued in the range of US$ 6-50 trillion dollars. Compliance with this legislation was estimated at US$ 520 billion [18] and these costs were absorbed during a time in which the GDP grew by a factor of five.

In the case of CO_2 regulation, there is a significant difference in the benefits, costs, and associated uncertainty of the calculations. This is illustrated conceptually in Figure 5.

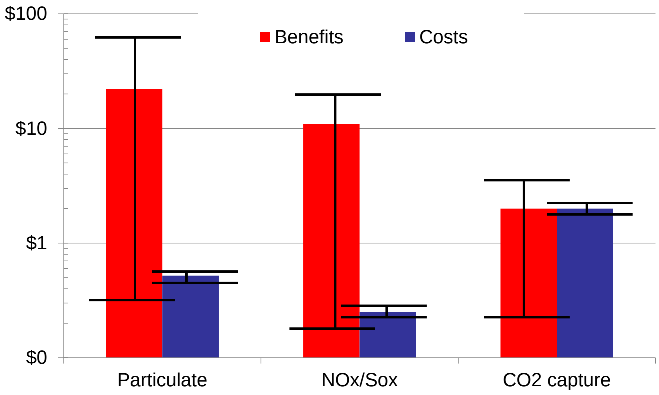

Figure 5. Conceptual comparison benefits and costs for the removal of particulate matter (e.g., 1970s), nitrogen/sulfur oxides (e.g., 1990s) and carbon dioxide capture (e.g., currently proposed).

As shown, the benefits of cleaner air from removing large particulate matter (e.g., coal fly ash) as well as nitrogen and sulfur oxides are demonstrably larger than the costs. That said, we can estimate compliance costs with far greater precision than we can benefits, given that the former can be readily estimated with actual equipment costs and the latter derive from macro-level correlations with subjective assumptions. The cost to build or retrofit a power plant is far more predictable, as is its effect on the economy. In the case of CO_2 capture, the benefits are even more nebulous. Efforts are made to assign a monetary value to the presumed ability of coal fired power plants to contribute to climate change. This is referred to as the “social cost of carbon” (SCC) and includes predicted reductions in agricultural productivity, reductions in human health, property damage from increased floods, and reduced functioning of ecosystems.

To enlarge the combined uncertainty, these correlations and assumptions are linked in series to another suite of correlations and assumptions that connect carbon dioxide with weather patterns and temperature. For example, although the IPCC and others have widely reported that there has been a “hiatus” in warming for the past 17 years (e.g., no correlation between carbon dioxide and global temperatures), a recent publication [19] has demonstrated that perhaps this hiatus is actually a function of data biases. The authors employ a series of correlations, corrections, and assumptions to ultimately conclude that warming has indeed been occurring after all. In reality, there is no validated equation that can relate a given or proposed coal fired power plant to its effect on global sea level rise nor with the frequency, severity, or location of extreme weather, e.g., tornados, hurricanes, droughts, and floods. Moreover, many such forecasts, when monetized, presume credit for an entire storm’s worth of damage, not merely the increase beyond that which is naturally occurring.

The result is that there is less precision when using CO_2 emission data to project a cost on society in comparison to the direct benefits we observe from electrification (e.g., Figure 4). Similarly, a comparison of GDP data with energy costs reveals a strong, predictable correlation that has not been decoupled in developed economies in which the service sector has disproportionately increased [20]. Nevertheless, using a modeling approach with a varying suite of assumptions [21] the EPA predicts a range of SCC values from US$13 to US$138 per ton of carbon dioxide. The bulk of these costs are forecasted to occur at some point in the future.

Carbon capture is not a mature technology and as such a requirement to use it would make electricity more expensive. In its proposed rules to regulate existing and proposed coal-fired power plants, the EPA asserts that, actually, there are no costs. This claim is made because their modeling [4,21] presumes that from a pragmatic perspective, no utility will build a coal-fired power plant regardless of the proposed rules, largely because natural gas has become so readily available. This logic aside, there are other estimates of the incremental cost of requiring carbon capture for coal fired power plants. David and Herzog [22] note that requiring carbon capture would add more than US$0.03/kilowatt-hour. According to the U.S. Energy Information Administration, North Carolina’s price is approximately US$0.09/kilowatt-hour, thus this would increase prices by at least 33%. Similarly, the Electric Power Institute has generated the following comparison of prices [23]:

Table 1. Comparison of cost for carbon capture technology with coal vs. natural gas combined cycle [23]

Type	**Project Name**	**Total Plant Output (MW)**	**Cost/kW (US$)**
Natural Gas Combined Cycle	Panda Sherman Plant, Sherman, Texas, USA	758	$1,100
Coal with Carbon Capture	SaskPower Boundary Dam Estevan, Saskatchewan, Canada	110	$11,800
Coal with Carbon Capture	Southern Company Kemper County, Mississippi, USA	524	$8,800

As shown in Table 1, implementing carbon capture, as would be necessary to comply with proposed regulation of CO_2 at 1,100 lb CO_2/ MWh (500 kg CO_2/ MWh), increases the cost by an order of magnitude. In either case, these costs are known with far greater accuracy (smaller standard error bars) than any benefit (or cost) of climate change. Moreover, such increases impact the poorest countries in the world and poorest citizens of a given country.

5. Conclusion

Coal fired power has been the primary source of fuel for much of the world’s history and it is forecasted to remain so for the foreseeable future. Its use correlates with a growing economy in both developing and developed countries as well as with multiple indicators of sustainable development. The benefits and costs of coal fired power can be computed with greater precision than the putative benefits of eliminating coal as a fuel source.

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