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It Is Time to Clean up Coal Extraction

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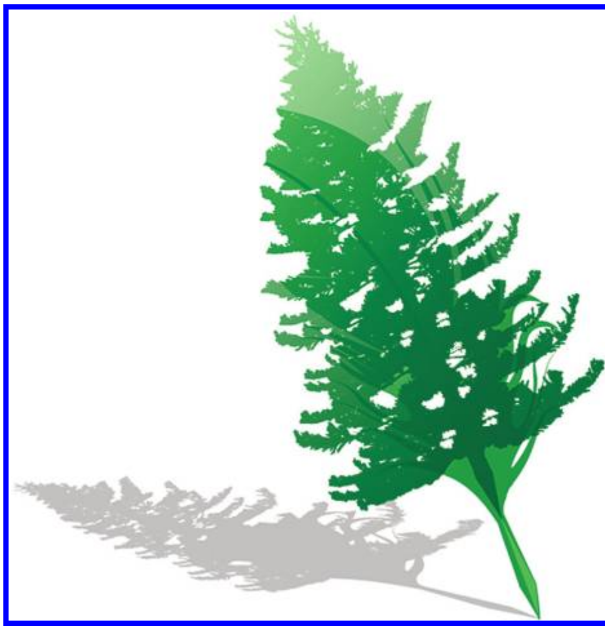
Author's Viewpoint



RHONDA SAUNDERS

Last spring the walls of the Metro in Washington, DC.were plastered with advertisements asserting, "there is no such thing as clean coal." That is true, but in the future it need not be.

While talk has been plentiful, and action painfully slow, commercial-scale systems to capture CO_2 and sequester it in deep underground will soon be built in the U.S., EU, Australia, and China. With experience, costs should fall sufficiently to make CCS a major part of any cost-effective portfolio for CO_2 emission reduction (*1*). However, CCS plants alone will not change the fact that the Metro ads will *still* be correct because coal mining is still dirty.

Today coal mining causes ecosystem damage, soil erosion, dust and air pollution from surface activities, landscape disruption from surface mining, interruption of streams and aquifers with impacts on water availability, acidified water, subsidence and land instability from underground mining, and emissions of methane and other greenhouse gases.

Using available coal resource data, one of us built a model that estimates the environmental impacts and economic cost of future extraction (*2*). If future extraction uses current technology and practice, between now and 2020 to meet the business-as-usual demand projected in the 2007 Energy Information Administration's *Annual Energy Outlook (3)*, the U.S. will incur cumulative damages of 300 billion tonnes of acid in our waters, disrupt 379 000 km^2 of land, erode 11 thousand tonnes of soil, emit 10 million tonnes of PM, 5 million tonnes of NO_x, 5 million tonnes of SO_2, 17 thousand tonnes of CO, and 561 million tonnes of CO_2 equivalent by 2020.

A good start on cleaning up could be achieved by better enforcement of the Federal Surface Mining Control and Reclamation Act (SMCRA) and the Clean Water Act (CWA). Past enforcement has often been lax, agencies have conflicting objectives, and variances are common. For example, the Army Corps of Engineers may permit a mine to dispose of its spoil in a stream, while the state's environmental agency is responsible for maintaining that stream's water quality. SMCRA allows subsidence, which can disrupt surface wetlands, this can conflict with the CWA goal of wetland preservation. The SMCRA mandates that surface mines must be filled to "approximate original contour" after surface mining. However, that contour is almost impossible to achieve in mountainous terrain such as West Virginia. Variances have frequently been granted allowing overburden from mountain seams to be placed in neighboring valleys, a practice known as "mountaintop removal." Although EPA and West Virginia have recently indicated they are becoming stricter, variances were still being approved last summer (*4*).

We used our model to estimate the cost of three scenarios: (1) conventional practice and enforcement; (2) extraction using best current technology and practice in order to achieve hypothetical strict enforcement of the SMCRA; and (3) extraction using a set of hypothetical improved technologies and abatement strategies to meet hypothetical stringent enforcement of the SMCRA, CWA, Clean Air Act, and a greenhouse gas restriction.

We estimate that strict enforcement of existing SMCRA regulations would result in only a modest increase in the mine-mouth cost of coal through 2020 (see left plot in Figure 1). Under this scenario, lowest cost coal mines are located in the west. All cost estimates are at the mine-mouth and do not include transportation costs. Cost of coal transport by rail is approximately \$0.01/tonne-km (*5*). In this scenario, the costs of using sealants to avoid acid mine drainage, backfill to reduce subsidence, soil replacement and revegetation to repair surface mine pits yields a mine-mouth cost of approximately 10 $\$_{2005}$/tonne in the Colorado Plateau region through 2018. Costs increase by 10% until 2035. If only existing methods are used, we estimate that costs would increase through 2060 to about 22 $\$_{2005}$/tonne, but the cheapest coal would still come from western coal basins. At this point, costs from strict SMCRA enforcement could almost double from business-as-usual projections.

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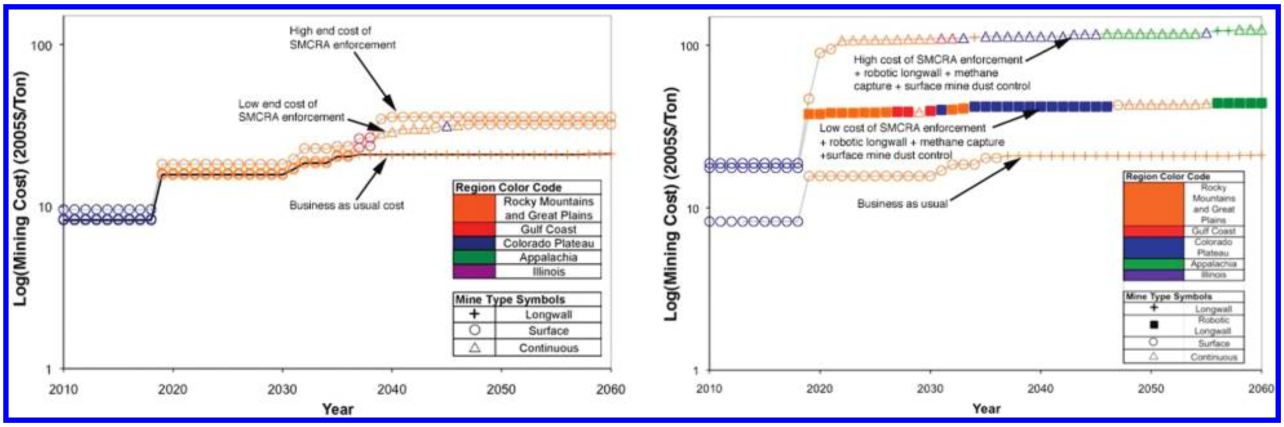

FIGURE 1. Modeled minimum coal extraction cost for the period 2010−2060. Curves on the left compare estimated lowest cost mine-mouth coal supply for extraction using present methods *with* upper and lower cost estimates of full enforcement of SMCRA that involves adding the control strategies that are, or could be made, available in the near future, as discussed in the text. These include technologies that control acid formation (coating or sealing the seams after mining), and those that control subsidence (backfilling). Color codes indicate mining regions: orange = Rocky Mountains and Great Plains; red = Gulf Coast; blue = Colorado Plateau; Green = Appalachia; Purple = Illinois. Curves on the right show the same result with the addition that all but the shallowest surface mines are converted to underground, all underground mines are run robotically, coal-bed methane is captured, and dust control is applied to remaining surface mines. A vigorous program of research could be expected to reduce these costs.

But, we can do better. There has been remarkably little U.S. research in the last 20 years on technologies and strategies to reduce the environmental impacts of coal extraction. A much more serious and sustained research program is urgently needed. To estimate what might be feasible, we have performed a series of order-of-magnitude cost estimates, drawing where possible from practice and experience in other countries and industries.

To eliminate subsidence, the hardrock mining industry backfills mine voids with waste material mixed with a binding agent (often cement or paste). This strategy has been modified for longwall coal mining in Germany and by the CSIRO in Australia. Before backfilling, cements and other coatings can be sprayed on to exposed coal surfaces to minimize future contact with air and water, and reduce the formation of acid.

Today, to avoid explosive risks, some mine operations drill holes to release a portion of methane from methane-rich underground seams, only sometimes capturing it. With additional research, more methane could be extracted, and marginally economic coalbed methane resources could become less expensive to extract. This would both mitigate methane emissions from coal mining while perhaps also increasing safety in underground operations.

To avoid the need for mountaintop removal in Appalachia where thin or deep seams and unstable overburden can make underground mining too hazardous for human operations, robotic methods hold promise. Again, CSIRO in Australia has pioneered such methods, although they have not addressed the problem of operations in thin seams.

The curves in the right side of Figure 1 report our estimates of the cost of adding robotic mining to eliminate surface mining. By replacing all but the shallowest surface mines with robotic underground longwall systems, using backfill to mitigate subsidence, and grouting to reduce acid formation, it is possible to operate high yield coalmines without incurring the damages associated with surface mines. The result would be a reduction of erosion and dust in western coal seams, and the elimination of mountain top removal in eastern mountain seams. This scenario includes coal-bed methane development before and during mining to reduce greenhouse gas emissions. Our estimates suggest that cost could increase 2−6 times over business as usual mining practice. However, a serious program of research should be able to substantially reduce such costs.

Today, half of the nation's electricity comes from coal. Sources of electricity defined in most legislation as renewable together accounted for 1.1%, with wind at 0.77%, geothermal 0.36% and solar 0.01% (*3*). We see no way to achieve an 80% reduction in CO_2 emissions by midcentury without coal continuing as part of a portfolio of energy technologies. But, it does not have to be dirty.

To put the lie to the advertisements on the walls of the Washington Metro, three things must happen: 1. Start strictly enforcing existing rules to limit the environmental consequences of coal extraction; 2. Make a major investment in developing and demonstrating strategies and technologies that can extract coal from the earth in a cost-effective manner without leaving a mess behind; 3. By 2015, develop and enforce a new set of rules that require the use of those strategies and technologies for all future coal extraction.

Acknowledgments

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