A Future for Fossil Fuel

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The cost of heat energy from coal is $1-$2 per million BTUs, compared to $6-$8 for natural gas and $8-$12 for oil. Where it is plentiful therefore -- as in the United States and China -- coal is the economic fuel of choice for new, electricity-generating power plants at today's fuel prices.

What about coal as a substitute for imported oil? Coal can be converted into liquid fuel suitable for transportation use; engineering estimates of the cost of deriving this synthetic fuel from coal (or shale oil) vary from $50 to $80 per barrel of oil equivalent. If world oil prices, currently in this price range, persist, this synfuel might become an attractive option.

Chad Crowe

So what is the problem? The environmental impact.

Here there is some good news: The so-called "criteria air pollutants" (sulfur oxides, nitrogen oxides and particulate matter) emitted from power plants have been effectively controlled at an affordable incremental cost. More recently, the EPA has placed restrictions on mercury emissions; it is not yet clear how well or how cheaply power plants will be able to meet this new constraint. However, on balance, we've achieved much "cleaner" generation of electricity from coal since the Clean Air Act of 1970.

Global warming is another matter. Coal combustion contributes about 40% of the global emissions of carbon dioxide, the major greenhouse gas; and most qualified scientists believe human-generated greenhouse gas emissions are causing global warming. Oil contributes another 40% and coal-derived substitute fuels would roughly double the carbon dioxide emissions per gallon.

The scale of the emissions is enormous. About two pounds of CO2 are emitted for every kilowatt-hour of electricity produced from coal combustion. A modern 1000 megawatt coal plant emits over 20,000 metric tons of carbon dioxide per day. Thus the urgent need to find practical and economic technologies and policies that permit the continued use of coal without increasing CO2 emissions into the environment. This need motivated "The Future of Coal: Options for a Carbon-Constrained World," an MIT study released yesterday.

The most effective way to reduce the atmospheric concentration of greenhouse gases is to place a significant charge on the emission of CO2 and other greenhouse gases. The charge can be an emission tax or the price of an emission "allowance" obtained in a cap-and-trade system.

The charge will raise the price of energy, and of electricity in particular, and the market will respond in three ways: (1) the demand for electricity will fall from the adoption of more efficient generating and end-use technologies, (2) nuclear power and renewables will become more attractive for investment in new electricity-generating capacity; and (3) new technology to reduce C02 emissions from coal combustion will become economic.

The leading technological option for reducing CO2 emissions from coal into the atmosphere is sequestration: This involves capturing the gas produced by coal combustion and burying it in deep geological formations, such as saline aquifers. This can be done in today's coal combustion plants, but it is currently very expensive.

In the U.S., much of industry and many environmental groups believe that the best method for sequestration is IGCC -- the acronym for coal gasification integrated in a combined cycle with combustion and steam turbines. Coal is partially burned with oxygen (not air, to avoid wastefully heating up nitrogen) to form a gas that is subsequently "shifted" to a mixture of carbon dioxide and hydrogen by the addition of steam. The CO2 is separated before combustion, compressed and transported to the site for injection into the aquifer; the hydrogen is sent to a combustion turbine to produce electricity.

This IGCC system can remove 90% of the CO2, but as it is a more complex process than conventional coal electricity production, it will add about 50% to the cost. This translates into about a 25% increase of the cost of electricity to the consumer, a substantial but not crippling increase for developed economies. With current technology and with additional experience, this appears to be the lowest cost option.

Europe is following a different technology path: oxygen-fired supercritical pulverized coal combustion (as well as a process called fluidized bed combustion, suitable for low-quality coal). The "oxy-fired" plant is, like IGCC, designed for coal combustion in oxygen rather than air, and the CO2 is also captured for sequestration, but after combustion. The advantage of the pulverized coal combustion process is simplicity; the disadvantage is the increased cost, as more oxygen is required to burn all the coal to carbon dioxide.

This cost disadvantage could be reversed if a cheaper way is found to separate oxygen from air -- a challenging but entirely plausible technical prospect. And the pulverized coal/fluidized bed technologies more easily accommodate a diversity of coal types.

Which technology path is better? We do not have enough engineering knowledge and operating experience to answer that question for a variety of coals and local conditions. Indeed, we need a great deal more technical development to demonstrate the commercial promise of these and other options.

But neither government nor industry will make the required level of technology investment -- so long as the current administration does not adopt serious carbon reduction policies in a timely fashion. Instead, the absence of administration leadership

invites Congress to adopt half-measures insufficient to achieve the needed innovations. For example, the 2005 Energy Act provided significant incentives for new coal plants, but without requiring carbon capture and sequestration -- perhaps under the dubious assumption that these plants could be easily retrofitted for CO2 capture in the future.

Taxpayer dollars should be focused on stimulating the introduction of technologies that look promising for commercial deployment when a CO2 emissions charge is introduced. Congress should also reduce uncertainty in private-sector decision making by signaling that new plants of any type will not be "grandfathered" from such future pricing. Uncertainty about CO2 emissions is not good news for the coal industry since, absent a strong policy, industry has no clear signal upon which to base investment. But if strong emission constraints are adopted without a successful technology for avoiding these emissions, the future use of coal will fall dramatically.

However, the MIT study outlines a scenario where large scale carbon dioxide capture and sequestration (CCS) is developed and demonstrated rigorously and promptly, so that even with a significant emission charge, say $30 per ton of CO2 within the next decade (and growing thereafter), coal use will increase but CO2 emissions at mid-century are no higher than today.

The scale is daunting; a 1000 MW coal plant that captures much of the CO2 would sequester over a *billion* barrels of pressurized gas over a 50-year lifetime; many hundreds of such plants would be needed world-wide to significantly affect global warming. Thus the government should support multiple sequestration efforts, with the instrumentation needed to support regulatory requirements, at the earliest possible date. The coal industry should support large-scale demonstration of CCS, because it offers a practical option for continuing to burn coal competitively in a carbon-constrained world.

Today, there is no coal electricity generating plant operating in the U.S. with CO2 capture, let alone one that would demonstrate at commercial scale the integrated operation of the entire clean coal system: electricity generation, CO2 capture, transportation and sequestration. Importantly, neither do we have a proposed regulatory regime that would define the selection of sites for sequestration, the injection operation, and a robust system of measurement and monitoring to verify the integrity of CO2 storage.

The Department of Energy has an ambitious project, called FutureGen, designed to implement an integrated clean coal system based on IGCC technology, but it is proceeding slowly and has too many chefs in the kitchen. If the project can be focused on commercial demonstration and freed from government controls, it could be an important step forward. If not, alternative "quasi-governmental" approaches to the needed demonstrations with carbon capture should be explored. But the few CO2 sequestration projects that exist or are planned around the world are insufficiently instrumented and unconnected to building the needed regulatory regime.

Without proven technology and a regulatory regime, we may not have the option for large-scale CO2 capture and sequestration when a strong emissions control policy is adopted in the future. But in the meanwhile, one can only marvel at the discussions in Washington that debate hypothetical policy options under the false assumption that today CCS is a demonstrated and available technology for very large scale sequestration.

A properly designed DOE demonstration program should immediately be launched for three to five well-instrumented sequestration projects, at a scale of one million tons of carbon dioxide per year for many years. Launching sequestration today at this scale is low risk; failing to do so is high risk for future coal use in a carbon-constrained future.

Substantial global warming won't be avoided unless all countries reduce greenhouse gas emissions. Yet emerging economies such as China and India are deploying enormous additional coal-fired electricity generation capacity without any carbon emission constraint. Last year, for example, China reportedly put about 80 gigawatts of coal-fired electricity generating capacity on line -- the rough equivalent to all the electricity capacity of the United Kingdom. At present there is no indication the emerging economies will accept the higher cost required to accommodate emission constraints because of urgent competing infrastructure needs.

The way forward requires more than a call for government leaders to seek consensus, or for a thin menu of demonstration projects and technology exchange agreements. Prudence calls for early action.

The U.S. must be prepared to adopt serious carbon emission constraints, and, along with Europe and developed countries in Asia, to offer significant financial incentives to emerging economies to adopt carbon emission constraints, on a step-by-step basis.

It is by no means certain that agreement will be reached, so that absent serious reductions in emissions, substantial global warming will occur. At some point, nations would then face accepting the high economic cost and social disruption of adapting to climate change or the more problematic prospect of geo-engineering the climate by active measures. We believe it less risky and ultimately less costly for the U.S. to lead the way for the world to adopt emission constraints today.

Messrs. Deutch and Moniz, both former undersecretaries of the Department of Energy, are co-chairs of the MIT study on which this essay is based.