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From Climate Culprit to Solution

*Richard K. Morse*

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# Cleaning Up Coal

## From Climate Culprit to Solution

*Richard K. Morse*

COAL, THE rock that fueled the industrial age, is once again remaking the global energy landscape. Over the past decade, while most of the world stood transfixed by the gyrations of the oil markets, the promise of alternative energy, and the boom in cheap natural gas, coal left all other forms of energy in its dust, contributing nearly as much total energy to the global economy as every other source combined.

That explosive increase in coal use came not from the developed world, where demand is plateauing, but from the developing world, where the fuel remains the cheapest, most reliable source of electricity. This year, the market in globally traded coal used to generate electricity is expected to reach 850 megatons—twice the total in 2000. If current trends continue, according to the International Energy Agency (IEA), China and India alone will drive 75 percent of the growth in coal demand before 2035, and coal will become the world's single largest source of energy before 2030.

But just as coal is remaking energy markets, it is also remaking the climate. Coal combustion is the world's largest source of carbon dioxide emissions, responsible for almost 13 billion tons per year. (By comparison, oil and natural gas account for 11 billion tons and 6 billion tons, respectively.) With demand for coal ballooning in Asia, between 2010 and 2035, fully half the total increase in global carbon dioxide emissions from fossil-fuel use will come from coal use in the region. The climate problem, in other words, is a coal problem.

For the last two decades, economists and diplomats have tended to favor one solution to that problem: putting a price on carbon dioxide

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emissions, which would allow markets to find the cheapest route to a cooler climate. But so far, doing what may be economically optimal has proved politically infeasible in most economies. Another strategy, promoting renewable power, is a necessary part of solving the climate problem but will not be enough on its own. Developing economies are adding new coal plants on a scale that still dwarfs the contribution of renewable energy, and those plants will continue churning out more and more emissions for decades to come.

Coal, despite the proliferation of clean-energy policies, is not going away anytime soon. As of 2010 (the most recent year with available data), 30 percent of the energy used in the world came from coal, second only to oil, at 34 percent. Most of this coal is used in the power sector, where it accounts for more than 40 percent of global generation capacity—a larger share than any other form of energy.

Given how dominant coal is, one of the most promising ways to fight global warming is to make it emit less carbon dioxide, a solution that is less elusive than commonly thought. Merely installing the best available technologies in coal plants in the developing world could slash the volume of carbon dioxide released by billions of tons per year, doing more to reduce emissions on an annual basis than all the world's wind, solar, and geothermal power combined do today. And advanced technologies now in the works could someday allow coal to be burned without releasing any carbon dioxide into the atmosphere.

In order for these innovations to materialize, multilateral banks will have to offer financing, and individual governments will have to fund research and encourage private investment. Efforts to clean up coal should not replace a more comprehensive climate policy that includes putting a price on carbon and promoting renewable energy. But absent the unlikely event of a sudden global consensus on pricing carbon dioxide, they are one of the most practical ways to make immediate progress in the fight against global warming.

### COAL FEVER

IN ORDER to confront the coal problem, it is important to understand how the fuel became so popular in the first place. Although coal is often cast as an environmental villain today, just four decades ago, it

seemed the obvious answer to some of the developed world's most pressing political and economic challenges. The oil crises of the 1970s showed industrialized countries that disruptions in the supply of petroleum could send shockwaves not only through their transportation systems but, because much electricity was generated by burning oil products, through their power sectors, too. So they rushed to replace cartel-controlled oil with abundant, cheap coal.

Between 1980 and 2000, countries that were members of the Organization for Economic Cooperation and Development (OECD) increased the use of coal in electricity generation by 61 percent and reduced the use of oil in that sector by 41 percent. Formerly dispersed in niche regional markets, the international trade in coal grew into a sophisticated global commodities exchange and quadrupled in size. Stable, diversified networks of suppliers offered coal-importing countries low energy costs and enhanced energy security. No longer were electricity prices vulnerable to instability in the Middle East. Swapping oil for coal paid handsome dividends.

By the 1990s, however, natural gas had emerged as a competitive alternative for generating electricity in the developed world, and the coal fever that had been gripping Western capitals started cooling off. Between 2000 and 2008, the use of coal for power generation in OECD countries grew by only four percent, while the use of natural gas increased by 55 percent. Coal's future in the developed world looks bleaker every year. Today, experts predict that coal demand in the OECD countries will remain flat, and may even shrink, from now until 2035. In the United States, coal is losing market share thanks to newly cheap natural gas (a consequence of the shale gas boom) and tighter federal pollution regulations. In Europe, the main threat to coal comes from environmental policies. The capstone of the EU's climate policy, the EU Emissions Trading System, which was launched in 2005, has caused countries to shift to cleaner natural gas. Renewable-energy mandates, meanwhile, have also started pushing coal out of the market.

The rest of the world is racing in the opposite direction. Whereas industrialized countries once embraced coal to diversify their energy supplies, by the 1990s, the developing world was turning to it to answer a different problem: poverty. Rapidly growing economies needed more and more electricity, and coal was the cheapest and most practical way to



REUTERS

*Dirty rock: a coal miner showering, Shanxi, China, May 2009*

get it. It was not the cleanest energy source, to be sure, but developing countries saw pollution as a cost worth incurring in order to obtain the benefits of a modern economy. As the Indian economist Rajendra Pachauri, chair of the Intergovernmental Panel on Climate Change, has asked, “Can you imagine 400 million people who do not have a light bulb in their homes?” He continued, “You cannot, in a democracy, ignore some of these realities. . . . We really don’t have any choice but to use coal.”

As the developing world keeps growing, coal will remain its fuel of choice. The IEA expects coal demand in non-OECD countries to nearly double by 2035 if current policies continue, with Chinese and Indian demand alone accounting for more than 80 percent of that growth. Indonesia, Vietnam, and much of the rest of Asia are also rapidly building new coal plants. The coal markets of Asia are thus at the heart of the global-warming problem.

The case of China, the world’s biggest carbon emitter, demonstrates just how hard it is to give up the fuel. The country’s reliance on coal is becoming increasingly costly. Over the last five years, as demand for coal has risen while supply has struggled to keep up, Chinese coal prices have skyrocketed. Meanwhile, tightly regulated electricity prices have not been allowed to rise in parallel. Pricing has become so distorted that at many points, a ton of coal has cost more than the value of the

electricity it could create. China's dependence on coal is not only an expensive habit but also an environmental hazard. In addition to emitting carbon dioxide and sulfur dioxide, coal combustion creates mountains of toxic ash that are swept up in storms and blanket cities with particulate poison. That pollution is increasingly drawing the ire of the Chinese public and has even sparked protests.

Beijing is making every effort to kick its coal habit. The government has set a target of deriving 15 percent of the country's energy from nonfossil fuels by 2020 (the current figure is eight percent), with nuclear and hydroelectric power likely to make up most of the difference in the electricity sector. It has given generous subsidies to wind and solar power, industries that have made strong gains in recent years. Beijing is also focusing on improving the efficiency of coal-fired power generation by funding state-of-the-art engineering research and shutting down older, dirtier coal plants. As a result, the average Chinese coal plant is already far more efficient than the average American one.

These policies have started to curb China's coal addiction, but they are fighting an uphill battle against ever-increasing energy demand. Coal's share of new electricity capacity in China dropped from 81 percent in 2007 to 64 percent in 2010, but the figure rose to 65 percent in 2011, proving that the march toward alternative sources of energy will not be linear. Last year, droughts reduced hydroelectric output and caused severe power shortages. China's central planners no doubt see coal plants as the only available way to maintain the stability of the electrical grid, especially as the country relies more on wind and solar power, the outputs of which are intermittent.

Moreover, new technologies that can convert coal into more valuable liquid fuels, natural gas, and chemicals could stymie progress toward a coal-free future. When oil prices have been high, China has flirted with large-scale investments in these technologies. Although the resulting fuels can be less environmentally friendly than gasoline, in a world of \$100-a-barrel crude oil, the economics get more tempting every year.

If China keeps up its efforts at diversifying its energy supply, coal's share of total electricity capacity there might drop one to three percent each year before 2020. After that, it could fall faster as nuclear power and natural gas gain a stronger foothold. But even then, it will be difficult for China to get less than 50 percent of its electricity from

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coal by 2030. Like it or not, coal will remain the dominant fuel in China and the other emerging Asian economies for quite some time.

### EFFICIENT ELECTRICITY

FORTUNATELY, a coal-fired future can be made cleaner. In order to prevent emissions from rising as fast as the demand for coal, developing countries need to install advanced clean-coal technologies on a large scale. To do so, they will need help from the developed world. The countries of the OECD should work with international institutions such as the IEA and the World Bank to provide expertise on the latest clean-coal technologies and the financing to pay for them. In the short run, they should focus on helping the developing world upgrade its existing coal plants and build more efficient new ones.

The world's existing coal plants are the low-hanging fruit. Simply improving basic maintenance and replacing old turbine blades can make coal plants two percent more efficient and emit four to six percent less carbon dioxide. Those reductions can add up. If China were to make just its least-efficient coal plants two percent more efficient, the country would slash emissions by an estimated 120 megatons annually—nearly as much as the United Kingdom emits every year.

Opportunities for simple upgrades are ripe across most of Asia, and such improvements typically take little time to pay for themselves. To put them in place, all that developing countries need from the rest of the world is engineering know-how and modest financing. International organizations such as the IEA Clean Coal Center, a research institute that offers expertise on how to affordably reduce coal-plant emissions, ought to be expanded. Developed countries should consider such efforts part of their foreign aid strategy.

The next big opportunity is to change the type of new coal plants that get built. Much of the world is still constructing what the industry calls “subcritical” plants, which operate at low pressures and temperatures and are thus inefficient. As a result, the average efficiency of the world's coal plants is around 30 percent, meaning that 70 percent of the potential energy in the coal is lost as it gets converted into electricity. More efficient “supercritical” coal plants, which burn at higher temperatures, can achieve efficiency levels of

around 40 to 41 percent; even hotter “ultra-supercritical” plants can reach levels of 42 to 44 percent. Within ten years, advanced plants that can operate at still higher temperatures will hit the market with efficiency levels approaching 50 percent. So, too, will new plants that boost efficiency by gasifying coal before burning it.

Replacing old coal plants with state-of-the-art ones would cut carbon dioxide emissions drastically, since every one percent gain in efficiency translates into a two to three percent reduction in carbon dioxide emissions. Given how much of the world’s electricity is generated at outdated coal plants, collectively, those gains would be massive. If the average efficiency of all coal plants in the world were boosted to 50 percent, emissions from coal-fired power would fall by a whopping 40 percent. At current emission levels, that amounts to three billion fewer tons of carbon dioxide annually, equivalent to more than half of what the United States releases every year.

More efficient plants make long-term economic sense. Although a 750-megawatt ultra-supercritical plant costs around \$200 million more to build than does a subcritical plant of the same size, by saving coal, power companies can recoup these expenses over the lifetime of the plant. The economics are such that the carbon dioxide reductions end up paying for themselves; if one were to calculate the abatement cost, it would come out to around -\$10 per ton. As a point of comparison, under California’s cap-and-trade system, companies have to pay around \$15 to emit one ton of carbon dioxide.

The problem, however, is that cash-strapped utilities in the developing world don’t have the funds on hand to realize these gains over the course of several decades. Multilateral development banks do, and so they should step in to finance the additional capital costs of building highly efficient coal plants. The increased revenues that result from wasting less coal could more than cover the loan payments.

If development banks are unwilling to finance new plants, utilities could turn to the market for help. Their additional revenue streams could be packaged into tradable “green” securities and sold to private investors, functioning like bonds. Investors would loan capital up-front to pay for more efficient plants that generate higher profit margins. In return, when long-term power sales agreements for the plant are structured, investors would receive a portion of that extra profit. In order

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to maximize the environmental gains, any loan program should not finance anything less efficient than ultra-supercritical plants.

Critics may argue that financing any kind of coal is bad environmental policy. The calculus, however, is more complicated, and it depends on counterfactuals. In places where financing coal power would crowd out cleaner sources of energy, development banks should refrain from doing so. But much of the developing world, constrained by tight budgets and limited alternatives for large-scale power generation, faces a choice not between coal and renewable energy but between inefficient coal plants and efficient ones. In those places, it makes sense to finance more efficient coal plants because they would reduce emissions substantially. In other cases, the reality will lie somewhere in between, and development banks should finance packages of renewable sources alongside cleaner coal. That is precisely the arrangement the World Bank reached in South Africa in 2010, when the country was experiencing crippling electricity shortages.

A push for efficiency can bring the economic and environmental interests of the developing world into alignment. Although China is already aggressively replacing its outdated plants with world-class ones, many other countries have been unable to overcome the scientific and financial hurdles to boosting efficiency. That lack of progress represents a massive opportunity to prevent billions of tons of carbon dioxide from polluting the atmosphere.

### COAL WITHOUT CARBON

EVENTUALLY, as the world's coal plants reach the limits of efficiency and the economics of renewable energy grow more favorable, advanced coal plants will yield diminishing returns. But because coal is so cheap and plentiful, it will remain a major part of the world energy mix for some time to come. In the long run, then, the goal should be to develop the capability to produce electricity from coal without releasing any emissions at all. Technologies that offer that possibility are beginning to emerge. Yet in order to become commercially viable, they will need financial and regulatory support from governments.

One of the leading clean-coal technologies is carbon capture and sequestration (ccs), whereby carbon dioxide is siphoned off from a power

plant's emissions and pumped underground. Right now, the process is prohibitively expensive, costing roughly \$50 to \$100 for every ton of carbon dioxide stored. But since carbon dioxide from coal plants is

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Emerging technologies could eventually allow electricity to be produced from coal without releasing any emissions at all.

one of the largest sources of emissions, it is worth trying to bring these costs down. To do so, governments that already sponsor ccs research, including those of Australia, China, the European Union, and the United States, need to ramp up funding. (So far, the sum of global public support for ccs demonstration projects has reached only \$23 billion.) Countries should coordinate their efforts more closely so as to accelerate innovation in ccs, planning demonstration efforts in places,

such as China, that offer lower costs and fewer regulatory hurdles. Additionally, governments should fast-track regulatory approval for projects that use captured carbon dioxide to revive old oil reservoirs, a practice that would make the economics of ccs more attractive.

A more revolutionary clean-coal technology allows energy companies to capture coal's energy without ever bringing the coal itself aboveground. Underground coal gasification (ucg) involves igniting coal seams deep below the earth's surface, which transforms them into a gas that can then be piped aboveground to fuel electrical generators or create diesel substitutes. The technology is experiencing a wave of new investment thanks to new advances in drilling and computer modeling that are bringing down costs. Ucg leaves most of the pollution associated with burning coal belowground, especially when the process is combined with ccs.

Ucg technology is not yet widely commercially viable, but pilot projects across the globe are allowing engineers to perfect their drilling and combustion techniques so that the costs can eventually come down. The Lawrence Livermore National Laboratory estimates that the gas created by ucg could be environmentally equivalent to natural gas and cost around \$6 to \$8 per million BTUs. That range far exceeds current U.S. natural gas prices, which hover between \$2 and \$3, but it is roughly half of what China and India pay for natural gas on world markets. The gas from ucg would also be cheaper than oil per unit of energy and could be turned into transportation fuel to compete directly with it.

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Governments should bankroll more research into this promising technology, which could yield huge environmental and energy security benefits. Companies in Australia and China are already pursuing advanced UCG projects. According to scientists at the Lawrence Livermore National Laboratory, if the U.S. government spent \$122 million on a domestic UCG research program, the country would have a shot at developing commercially viable technology.

In a time of fiscal austerity, these worthy emissions-reducing innovations are unlikely to get much government funding, at least not enough for them to become commercially viable. So innovators will have to attract some of the \$1 trillion managed by private equity groups and venture capital firms. Smart tax policies can make that task easier. In the United States, Congress should create a new tax category for private equity and venture capital funds that invest in energy innovation. Then it should offer investors, such as pensions and endowments, tax credits for funneling capital into these funds. The result would be the creation of an entire asset class that would allow markets to seek out the energy innovations that will deliver both the greatest environmental benefits and the greatest profits.

### A CLEANER, COOLER FUTURE

THE GROWTH of demand for coal in the developing world is simply a replay of the developed world's own industrial past. Once-poor societies are now clamoring for the same opportunities and luxuries their richer counterparts have enjoyed for decades, and they are turning to coal, dirty as it may be, to fuel that expansion. As one Chinese energy official put it during an energy conference at Stanford University in 2011, the average man in Guangzhou "would rather choke than starve."

Cleaner alternative energy sources are beginning to sate the developing world's appetite for coal, but it will be decades before they can meaningfully displace coal's dominant share of the global electricity mix. Any energy and climate strategy for the future must accept that fact. Indulging in quixotic visions of a coal-free world is an incoherent and inadequate response to the problem of global warming.

No matter what one thinks about coal, this much is clear: cleaning it up has to be a central part of any climate strategy. If the governments,

multilateral institutions, and financial markets of the industrialized world helped the developing world upgrade its existing coal plants and ensured that only the cleanest coal plants were built, the effect on the climate would be profound. All told, smarter policies could lower the volume of carbon dioxide emissions per megawatt of coal-fired electricity by more than 40 percent before 2050. And if CCS or UCG can be made commercially viable, that volume could be reduced even further.

Ultimately, these transformations will cost money, and most of it will have to be spent in the developing world, where emissions are rising the fastest. The best way to pay for that would be to assign a market-based price to carbon—through a cap-and-trade program, tax policies, or other alternatives—and then allow the market to finance the cheapest sources of carbon dioxide reductions. But as the aftermath of the Kyoto Protocol negotiations has demonstrated, getting countries to agree on that idea is immensely difficult. The good thing about a strategy to make coal cleaner is that it doesn't require a price on carbon or a global climate deal.

The lack of a price on carbon will make it harder to finance some clean-coal technologies, and it will affect which strategies hold the most near-term promise. In particular, the profitability of CCS technology depends on governments assigning a price to carbon dioxide; otherwise, there is little incentive to capture a gas with almost no value. But other strategies to deal with coal use in the developing world—namely, highly efficient coal plants and UCG technologies—can still be successful because they are aligned with developing countries' own incentives to deliver cheap and secure energy. Slashing emissions from coal doesn't require a price on carbon, and there is no reason to wait for one.

As demand for coal climbs to new heights and as global temperatures keep rising, the world cannot afford to pass up the opportunity to make the fuel cleaner. This strategy represents a pragmatic way to cut carbon dioxide emissions by billions of tons each year. Humanity has come a long way since the Industrial Revolution, when sooty skies signaled economic progress. As the developing world industrializes, it is time to reenvision coal, not just as the leading cause of climate change but also as a leading opportunity to fight it. 🌍

