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MuseLetter #211 / December 2009 by Richard Heinberg

1. Is "Clean Coal" a Dead End?

Note: this article is being featured in the first issue of the new magazine Solutions.

Many energy experts, politicians on both sides of the aisle, and representatives of the coal industry agree on the need to spend billions to develop technologies to capture and store the carbon from burning coal, thus making coal "clean" from a climate standpoint. President Obama has repeatedly endorsed the development of "clean coal," and in July Department of Energy Secretary Stephen Chu announced that $1 billion of stimulus package funds would go toward re-launching FutureGen, a stalled project intended to show how carbon dioxide can be captured on a large scale from coal-fired power plants. The Waxman-Markey climate bill earmarks another $60 billion for "clean coal" research and development.

The "clean coal" argument runs like this: America is brimming with cheap coal, which provides almost half our electricity and is the most carbon-intensive of the conventional fossil fuels. The nation will need an enormous amount of energy over the next few decades, but renewable sources just aren't ready to provide all—or even the bulk—of that energy. Meanwhile, preventing catastrophic climate change requires that we stop venting carbon dioxide into the atmosphere. It is possible to capture and store the CO_2 that would otherwise be emitted from burning coal, and elements of carbon capture and storage (CCS) technology are already in use on a small scale. Put all of these factors together and the case for government funding of research and development of "clean coal" seems strong.

However, several recent studies of US coal supplies suggest that much that we think we know about coal is wrong. If these studies are correct, the argument for investing in "clean coal" becomes tenuous on economic grounds alone. These studies call into question the one "fact" that both pro-coal and anti-coal lobbies have taken for granted: that the US has a virtually limitless supply of cheap coal.

How much coal?

Doubts were first raised in a book-length 2007 report by the National Academy of Sciences titled "Coal: Research and Development to Support National Energy Policy" (1), which noted that "Present estimates of coal reserves are based upon methods that have not

been reviewed or revised since — 1974," and concluded that a newer and better assessment "may substantially reduce the number of years' supply."

Also in 2007, an energy analytics organization founded by a member of the German Parliament, Energy Watch Group (2), released a study of US and world coal supplies concluding that global coal production will reach a peak and begin to decline sometime around 2025, and that US coal production will peak only slightly later—perhaps by 2030 or 2035.

Last December the USGS issued a report (3) on the nation's largest and most productive coalfield, in Wyoming, finding that, at current prices, only about six percent of the coal can be profitably mined; if coal prices soared, then more of the coal would be recoverable—but then coal wouldn't be economically competitive with other energy sources.

On what do these studies base their pessimistic assessments of coal's future?

America's coal resources are indeed vast—none of the studies claims otherwise. However, during the past century, coal *reserves* (the portion of total coal resources that can be mined profitably with existing technologies) shrank much faster than could be accounted for by the depletion of those resources through mining. That is because geologists are doing a better job now of taking into account "restrictions" that make most coal impractical to mine—factors having to do with location, depth, seam thickness, and coal quality. In recent years, some nations have reduced their booked coal reserves by 90 percent or more on the basis of new, more realistic surveys. The National Academy of Sciences report mentioned above is essentially a plea for an updated US national survey, and it offers abundant reasons for thinking that such a survey would almost certainly reveal a much smaller reserve base than the one on which current supply forecasts are founded.

Moreover, when it comes to forecasting future coal supplies the official agencies seem to have been asking the wrong question, namely, "When will the nation run out of coal?" The customary answer is, "Not for a couple of hundred years or more"—which is a sufficiently long period for current energy planning. But more relevant questions are, "When will it no longer be possible to increase the rate at which coal is being extracted?", and "When will coal cease to be an economically competitive energy source?" These are addressed in the Energy Watch Group study, which reasons that, long before the nation runs out of coal, production will peak and start to decline due to the depletion of easily accessible, high-quality deposits. Already some of America's most important coal regions are long past their glory days, and recent field surveys by the USGS (including the one cited above) suggest that the capacities of even the most abundant coalfields in the nation have been over-estimated.

No cheap coal, no "clean coal"

How would the prospect for "peak coal" sometime in the next two or three decades impact the debate over the development of carbon

capture and storage? As we are about to see, the enormous investments that will be required to make coal "clean" only make sense if coal continues to be abundant and cheap.

The basic elements of carbon capture and storage technology already exist. Capturing carbon is relatively easy in coal gasification (IGCC) power plants, and such plants have been shown to be technically feasible. In such plants, coal, air, and water are brought together under high pressure and temperature, yielding "syngas," a mixture of carbon monoxide and hydrogen (along with solid waste byproducts); the hydrogen can be burned to turn a turbine to produce electricity, while the carbon monoxide is transformed into carbon dioxide—which can then potentially be piped to an underground sequestration site for permanent storage. IGCC power plants are efficient, using about a third less coal to produce a similar amount of electricity, and can also capture other pollutants from coal. However, nearly all existing US coal power plants are of an older, simpler type in which coal is burned directly, so replacing these with expensive-to-build plants in which the coal is first gasified will itself require enormous investment and decades of work.

We also know how to store carbon: the petroleum services industry routinely injects CO_2 into old oil wells to make it easier to extract the remaining crude. But the quantities of carbon dioxide sequestered this way are trivial when compared with the amounts spewed from coal-burning power plants annually. Gathering and storing two or three billion tons of carbon each year from hundreds of geographically scattered coal power plants will require the construction of an enormous system of pipelines, compressors, and pumps. A 2007 MIT study, "The Future of Coal" (4), found that if just 60 percent of the CO_2 from US coal-fired power plants were to be captured and compressed to a liquid, its daily volume would equal the amount of oil Americans consume each day (about 20 million barrels). The study also concluded that a huge increase in investment in industrial-scale demonstration plants would be required now even to know in 10 or 15 years if the technology can work at a meaningful scale. All of this underscores the basic fact that carbon capture and storage is going to be very expensive—if it is even possible to accomplish on the scale that is being proposed.

Yet there is a subtler but possibly even more decisive price tag for "clean coal": the energy cost. According to the most recent estimate (from Harvard University's Belfer Center (5), at least 30 percent of the energy produced by burning coal will be needed to run the system for capturing, compressing, pumping, and burying CO_2. Therefore any efficiency benefit from gasifying coal at IGCC power plants would be canceled out.

But already the average quality of coal being mined is declining—that is, we get less energy for each ton of coal burned today than we did ten years ago. This is a natural consequence of the "low-hanging-fruit" principle of resource extraction, in which we tend to consume the highest-quality, most easily accessed resources first.

So as time goes on, the US will need to burn more coal, while the coal itself will be more scarce and costly. And the technology used

will be far more expensive and complex, both to build and to operate, than the system of power plants we have today. Taken together, these factors read like a recipe for cost overruns and spiraling electricity rates.

How high could coal-based electricity prices go? During the period from 2006 to 2008, prices for some grades of US coal doubled. This year the economic crisis has lowered demand for electricity and thus for coal, and so prices have softened. However, recent experience shows that, even in the absence of serious shortages, coal prices are increasingly subject to dramatic swings. Thus, taking higher coal prices into account, it is reasonable to assume coal-based electricity costs two to five times current rates by 2030. The current average generation cost of coal electricity is from 2 to 5 cents per kilowatt-hour; compare that to the current average cost for wind electricity of 3.5 to 7 cents per kWh (not counting tax credits), or about 12 cents per kWh for solar thermal electricity, or 25 cents per kWh for solar photovoltaic electricity, and the vulnerability of coal's economic dominance becomes apparent.

Imagine a scenario in which the US goes ahead with the attempt to develop "clean coal" technologies. During the coming decade tens of billions of dollars (mostly from government) would likely need to be invested in research and the construction of demonstration projects. By 2020, the price of coal will already have begun to rise, as supply problems multiply, yet "clean coal" technology won't be ready to deploy widely (the most ambitious proposals don't see that happening until after 2025). Even if renewable energy doesn't get cheaper due to technological advances (and most analysts assume it will), at some point along this timeline the "clean coal" bandwagon will almost certainly grind to a stop because it is simply too expensive to keep going.

What, then, are our options?

The most likely course for the Obama Administration and Congress is to continue developing "clean coal" based on current market conditions, and to change course only as market conditions evolve. The problem with doing so is that large infrastructure investments require long-range planning, and the success of those investments depends upon an accurate forecast of future resource prices and demand for product. Decisions made now on the basis of assumptions about future coal prices that are wildly wrong could waste enormous sums of money and foreclose opportunities to invest in ways that would leave society much better off two or three decades from now.

Some environmental organizations, such as National Resources Defense Council (NRDC) and Environmental Defense Fund (EDF), argue that the nation will almost certainly continue burning coal in any case, and since we cannot allow the resulting carbon dioxide to exacerbate climate change, "clean coal" technology is worth the investment.

But what sort of energy policy could force "clean coal" into existence? Government could legislate that all new coal power plants must capture and store carbon. But then, for reasons already explained,

few new plants would probably get built—other than demonstration sites operating with public subsidies—and the nation would be stuck with its old, inefficient, and highly polluting coal plants. Alternatively, the government could mandate that, after a certain date, *all* coal power plants must capture and store carbon dioxide. Yet what would happen in the overwhelmingly likely event that the specified date arrived and most coal plants simply weren't ready? Would regulators shut down non-compliant plants, reducing the nation's electricity supply by a substantial percentage? Or would the utility operators face stiff fines—which they would quickly pass along to consumers in the form of higher rates? Or would the government simply push the date for compliance back — and back — and back?

Meanwhile, leading climate scientists are warning that we need to reduce CO_2 in the atmosphere below current levels; how high will CO_2 levels rise while we wait for "clean coal" technology to come online?

It might also be argued that partial deployment of carbon capture and storage technology would be better than nothing—at least some carbon emissions would be avoided. However, there is a problem there, too. The research and development costs for limited implementation are likely to be almost as high as for universal deployment (since the technology has to be made to work on a small scale before it can be built out on a large scale). This would represent an enormous investment in an energy source and a technology with a limited future. And that investment will be needed elsewhere.

Coal gasification plants without carbon capture would be less polluting and more efficient than current power plants, but, once again, the up-front costs are very high (and this is why several potential IGCC projects have been canceled or rejected in recent years).

The ongoing, relentless depletion of our nation's—and the world's—coal, oil, and natural gas resources will force us to depend increasingly upon renewable energy. By the end of this century, America will have an essentially all-renewable economy, whether or not we have planned for it. Over the short term, more electricity could come from natural gas, but it is unclear how long the current gas glut will last, given that the new, unconventional sources responsible for it (especially shale gas) are proving expensive to develop and quick to deplete. Building new nuclear plants will be costly and slow—and controversial. And uranium is itself a depleting, non-renewable resource.

But renewable energy sources are not without problems of their own. Their current share of total energy produced is relatively tiny, and a rapid build-up of capacity will require subsidies of some kind. Also, wind and solar power are intermittent, and the times of greatest abundance of sunshine and breeze do not always coincide with times of greatest electricity demand. This is a problem that can probably be solved, but not without an enormous upgrade to the nation's electricity grid. Still other investments in national transport, food-system, and housing infrastructure will be needed to get us to a low-

consuming, renewable energy future.

Altogether, it is hard to avoid the conclusion that the years ahead are likely to see increasingly expensive electricity, if not actual shortages. By mid-century, renewables must be ready to provide a substantial majority of energy consumed, or energy shortages could be rampant. An even faster transition will be needed if the nation's goal is (as it should be) to reduce atmospheric carbon dioxide to 350 parts per million, as climate scientist James Hansen says is necessary (currently, we're at 387 ppm, and rising by over 2 ppm per year).

Given a depleting resource base and the likelihood of soaring coal prices, the "clean coal" debate hinges on the question, *Can we afford to do it all?* That is, can we spend tens or hundreds of billions of dollars mitigating the impacts from burning increasingly expensive, depleting coal using expensive coal gasification power plants and unproven carbon capture and storage technologies, while at the same time spending hundreds of billions to develop an entirely different energy infrastructure that we will eventually be forced to rely upon as coal runs out? It would be nice to think so, but the harsh reality is that time and capital are both limited.

Abandoning "clean coal" need not be seen as a retreat in the effort to reduce carbon dioxide emissions. As a nation, we could simply halt the construction of new coal power plants. We could tax carbon. We could cap carbon emissions and ration or sell emissions permits. We could discourage coal mining by enforcing reasonable environmental regulations. None of these strategies would require substantial new investments by the government, just tough policy decisions.

There are other strong arguments against "clean coal." The mining of coal results in environmental, social, and economic ruin for communities in coal regions—witness the travesty of "mountaintop removal" mining practices in Appalachia. Capturing and storing the carbon from coal would do nothing to address that concern. Also, some doubt whether the carbon dioxide that is sequestered underground will really stay there.

While these arguments may be valid, they are unlikely to be decisive in the "clean coal" debate. That debate will be won or lost on the hard, practical basis of cost. And on that basis, the case for "clean coal" may have just fallen apart.

Tough energy choices

What would be a sound energy policy from both an energy supply and a climate standpoint? Unfortunately, there are no easy answers. Given the need for rapid reduction in the use of carbon fuels and the expense of building renewable energy infrastructure, energy conservation will almost certainly have to be the basis of our national strategy. This means finding ways to do more with less through increased energy efficiency—but it also means identifying and simply curtailing non-essential current energy consumption. Our climate and energy problems would become much easier to solve if America were to go on an energy diet so that it required only half, a third, or even a quarter of the energy it currently uses. Such demand reductions are certainly possible, but they would require fundamental changes in

citizens' habits and expectations, as well as massive investments in efficient technologies—from household gadgets to power plants and transport systems.

Investment will also be required in renewable energy sources, many of which are not currently cost-competitive with fossil fuels. If we wait for market signals to change so that alternative energy is cheaper in every instance (either because fossil fuels have depleted or renewable technology has advanced), we will have waited too long. It will take decades to fully replace the energy systems that power our society. Unless we begin now, the lights may begin to go out in a couple of decades—at about the same time we may be facing climate catastrophe.

All we have to do to realize that horrific future is to continue doing what we are doing now.

Notes

1. **Coal: Research and Development to Support National Energy Policy**
2. **Coal: Resources and Future Production**
3. **Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming**
4. **The Future of Coal**
5. **Making Carbon Capture and Storage Work**

This article is based on my book 'Blackout: Coal, Climate and the Last Energy Crisis' (New Society Publishers).

2. Just Tell Us the Truth

At last we know...sort of. An article in the UK newspaper *The Guardian* for November 9, titled "**Key Oil Figures Were Distorted by US Pressure, Says Whistleblower**," reveals what hundreds of analysts have been trying to convey to world leaders for years: The global oil supply situation is critical and getting worse, and vested interests are playing key roles in covering up this devastatingly inconvenient truth.

Over a decade ago, when I began following the Peak Oil story, the main sources were a few highly-placed petroleum geologists with experience in oilfields around the globe. At that time, these brave scientists were saying that world oil production would peak sometime around 2010, and that the global economy would be hammered as a result. Since it will take decades to develop alternative energy sources to replace petroleum (if adequate replacements are even available), the consequences for transport, trade, and agriculture will be almost too awful to contemplate.

In the past few years these lone voices of warning have garnered the backing of a million-voice chorus: investment banks, oil analytics firms, and investigative journalists have joined the geologists in pointing out that oil production limits are within sight, and in calling for more transparency in official data reporting and forecasting.

But the **International Energy Agency** has stubbornly refused to come clean. And this is important: while financial analysts and investors are free to draw their own conclusions about Peak Oil (and a great many of them have seen the writing on the wall—hence recent run-ups in oil futures prices), national and local governments must rely on officially sanctioned fuel supply and price projections for all their planning. Energy policy, transport planning, agriculture policy, economic forecasting, and much more depend upon the august pronouncements of the Paris-based IEA.

There are always folks who are glad to tell us what we want to hear. Indeed, the presentation of plausible excuses for the denial of serious problems offers an attractive career track. Prominent oil optimists like Daniel Yergin and Michael C. Lynch find open doors at the New York Times and other major media outlets, and wealthy clients for their consulting services, because they reassure markets that all will be well.

Nevertheless, denial leads to complacency, not problem-solving. And the end of cheap, abundant oil is a problem that could cripple the global economy not just for another year or two, but more or less permanently.

This is not to say that the recently released IEA "World Energy Outlook 2009" is worthless: the current iteration of the agency's annual report makes many excellent points (for example, that "Falling energy investment [resulting from the worldwide financial crisis] will have far-reaching consequences"). But, as the whistleblower quoted in the recent *Guardian* article notes, agency forecasts for future world oil production are still profoundly unrealistic:

> *Many inside the organisation believe that maintaining oil supplies at even 90 [million] to 95m barrels a day would be impossible but there are fears that panic could spread on the financial markets if the figures were brought down further. And the Americans fear the end of oil supremacy because it would threaten their power over access to oil resources.*

Sooner or later, we must face reality. If we do it sooner, our chances of adapting successfully are far better than if we wait and deny just a little longer.

On one hand, careers are at stake if IEA officials step forward and tell us the truth. On the other hand, the global economy is as risk if they don't.

There is evidently a quiet battle raging within the agency, and within the consciences of many of its officials. So far, we are all the losers in that battle.