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Carbon Sequestration -- A Sierra Club View

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I want to begin by thanking those of you working to develop the innovative new techniques that will be needed if carbon sequestration is to make a serious contribution to solving the world's global climate change problems. This is the kind of work about which you can and should feel proud. This work is in some sense akin to cathedral building. Both are grand projects on multi-generational, multi-century time scales.

That said, I must deliver a cautionary message. Carbon sequestration has a place in a basic energy research portfolio. Sequestration has no near term relevance, and should not be used as a diversionary tactic to avoid doing what should be done vigorously now: implementing energy efficiency and bringing on renewables. Though all fossil fuel combustion emits carbon dioxide, coal is a particularly bad actor, so my emphasis will be there.

This is a pretty good starting point for the understanding the views of the people I work with. However, I don't want you to conclude that no dialog is possible. I do want to leave you with a good understanding that little useful conversation is likely when the coal industry seems to be doing everything it can to degrade environmental regulations. When the coal industry resists advanced pollution control technology. When the coal industry aggressively lobbies against international agreements to address global warming.

There can be no doubt that bringing global warming under control is a monumental task. The world energy system is huge, capital intensive, and environmentally disruptive. Since the industrial revolution, global fuel mixes have taken about a half-century to change. Over the next half-century typical forecasts suggest global energy use may grow by 50% -100% from today's roughly 400 quadrillion BTU/year (quads/year) (1). Simultaneously most of the existing energy systems and infrastructure will have to be replaced.

Most of the growth is expected to occur in developing nations. Today's global energy system releases about 6.5 billion metric tonnes of carbon equivalent per year. Coal provides 20% of the world's commercial energy, but emits 38% of the carbon-dioxide (2). The release rate in 2050 and beyond is, of course, what this meeting is all about. Combating global warming will require installing new technology and replacing most of the existing systems. The capital investment will be enormous.

Princeton University Professor Rob Socolow has characterized the needs in terms of "slices". The term refers to the process by which new energy system will grow over time

and become slices of the 2050 energy supply pie-chart. A handy definition of a "slice" is 10% of total current world energy use. That is, 40 quads per year. For reference, current world coal consumption amounts to a little more than twice this – two slices.

10% of total world energy use is an enormous amount of energy. It's roughly 40% of the energy the US uses now (100 quads/year). To meet 2050 world energy needs will required something like 10 of these "slices".

Slices could come from new supply or from demand reduction. Example: One slice corresponds to increasing the fuel efficiency of a billion cars from 20 to 40 mpg. Example: One slice corresponds to 500 one-Gigawatt carbon-free generating plants operating in base-load mode.

What about sequestration. A sequestration slice is daunting. Sequestration of one "slice" of coal – less than half of the 3.8 billion metric tonnes of coal the world currently uses each year -- would require doing something permanent with a continuous stream of carbon-dioxide moving at 60 miles-per-hour through a pipe the area of a football field. That's a football-field size pipe with a continuous gale-force wind, every bit of it put away somewhere, forever. That's just one "slice". We need many. The challenge is immense in every dimension. There's a reason why I'm skeptical.

This calculation breathes some life into a casual remark by one of my colleagues, who said-- only partly facetiously: "sure; we believe in sequestration -- we believe that carbon is safely sequestered right now, underground where nature formed it. Lets keep it there".

The technology mix in 2050 is enormously uncertain. Technology forecasting in general and energy forecasting in particular has a horrible record. There is no reason to think forecasts will be better in the future (3, 4). The extreme uncertainty means it makes sense to explore many options. Sequestration of fossil fuels should be one of those options.

Clearly, if global warming is to be minimized, fossil fuel must either be kept in the ground, or effluent must be captured. Thus it makes sense to do long-term exploratory research on sequestration, just as it makes sense to explore other approaches -- fusion is a famous example -- which just might change the nature of the game. But one shouldn't be overly optimistic. Sequestration is a long shot.

Nor should we let CO2 issue cause us to lose sight of the massive environmental and mine worker issues with coal. Land use problems; water problems; air problems; social disruption problems; worker accidents; black lung disease. These are immediate issues. They are the source of most of our tension with the coal industry. They need to be resolved if sequestration is to have a chance.

Some sequestration concepts call for massive environmental engineering. Ocean carbon-dioxide-dumping is a particularly egregious example. At the technical level, understanding of oceans is exceedingly poor. Macroengineering runs the risk of disturbing oceanic processes in ways that might prove unstable, leading to consequences

potentially worse than the damage avoided by sequestration. At the social level, oceans are international territory considered so sacred by many peoples of the world that international treaties to protect them have been enacted. The same kind of reasoning that makes oceans off-limits for nuclear waste disposal makes them off-limits to many for carbon sequestration.

Although sequestration research is appropriate in principle, it is inappropriate if it is used as a substitute for doing what ought to be done now. The industry and the Administration have a clear record of opposition to action on global warming. The Administration is cutting back research on efficiency and renewables. Artifices like fuel-cell research are seen for what they are -- excuses for inaction. Sequestration in biomass has at best minor relevance on time scales of a century or more -- and is therefore properly seen as a diversion from the real issues.

Fundamental research on sequestration makes sense. Even fundamental research, however, is unacceptable if it takes dollars away from efficiency and renewables programs. There is one proper source for coal R&D dollars: existing coal subsidies. Details of how excuses play out in the Administration energy budget has been documented extensively by David Hawkins of NRDC, and others.

It may be helpful to frame the discussion in terms of "externalities". Coal is cheap when environmental costs are ignored. When they're included, the social cost of coal combustion makes it at a minimum problematic, and at worst unacceptable. Whether new technologies can overcome the environmental costs is unknown, and is certainly worthy of research.

A vigorous research program might make coal burning acceptable. But it might not. R&D offers the industry its best chance of playing a role in the latter part of the world's twenty-first century energy mix. The industry should develop research capability of world-class stature. Environmentally acceptable technologies are a long shot -- but the only shot.

The coal industry's present approach of lobbying to weaken environmental laws, using sequestration research as a cover for inaction is near-sighted and is doomed to ultimate failure. Don't expect people who care about the environment to pay much attention. Don't expect us to allow our time to be distracted from more important endeavors. Don't even expect the government to be forever distracted from addressing global warming.

I'd love to see the coal industry mount a serious effort to combust coal cleanly. The US needs it; the world needs it. I don't see this happening now, and I'm not holding my breath about the future. A quarter century ago I participated in "The National Coal Policy Project." This was a major industry-environmental effort seeing common ground (5). The project, supported by dozens of businesses, has been described as an experiment in "cooperative pluralism" (6). It took a lot of time and lead to some interesting suggestions. Ultimately the divide was too great; nothing came of it.

A new cooperative venture would make sense only if there exist significant areas of potential agreement and the potential for real change. Without that, people like me will conclude we should invest our time and energy elsewhere.

Global warming is not a problem of years, but one of decades, centuries, and generations. Global warming will be an issue when the present Administration is long gone. In my optimistic moments I imagine a situation where the coal industry sees itself as a part of a solution to environmental problems. It would appreciate and capitalize on advanced, low pollution technology. Rather than seeking to weaken environmental regulations, it would seek to strengthen them. Rather than fighting international agreements, it would encourage them. It's motivation for so doing would be long-term survival. The industry would recognize that if it can't combust coal in a sound manner, social pressure may keep the coal underground forever. Is that a plausible future? I don't know. If I were in the coal industry I'd want to hedge my bets.

To conclude: Basic sequestration research makes sense. Funding should not be taken from high-value efficiency and renewables research. Subsidies to coal are anathema. The coal industry should implement existing advanced technologies that offer higher efficiency while polluting less. These exist. Install them.

And remember – to meet less than 10% of global energy needs in 2050 using sequestration would require the equivalent a pipe the area of a football field carrying carbon dioxide at gale-force speed off to someplace or other – from which it will never – repeat never – emerge.

For those of you in the research community, your challenge is to figure out how to start filling that gigantic pipe. Some challenge! As I observed at the outset, this is a challenge you can be proud to work on.

I appreciate the opportunity to be here today to describe the sequestration scene as I see it. I'll be pleased to answer any questions.

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3. Craig, P.P., A. Gadgil, and J.G. Koomey, *What Can History Teach Us? A Retrospective Examination Of Long-Term Energy Forecasts For The United States*. *Annu. Rev. Energy Environ.*, 2002. **27**(1): p. 83-118.
4. Landsberg, H.H., *Energy in Transition: A View from 1960*. *The Energy Journal*, 1985. **6**: p. 1-18.
5. Murray, F.X., ed. *Where We Agree : Report Of The National Coal Policy Project*. Vol. 2v. 1978, Westview Press: Boulder, CO.

6. McFarland, A.S., *Cooperative Pluralism : the National Coal Policy Experiment*. 1993, Lawrence, Kan: University Press of Kansas,. pp219.

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