NATURAL RESOURCES DEFENSE COUNCIL

Policies to Promote Carbon-less Energy Systems

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Abstract

Several studies have shown that very large amounts of zero-carbon-emitting energy resources ("carbon-less energy") must be deployed in the next few decades if humans are to grow in number and wealth, while avoiding a doubling of carbon dioxide (CO2) concentrations in the atmosphere. One such study estimates that stabilizing CO2 at 450 ppm would require that approximately 22 of the forecasted 30 terawatts (TW) of primary power demand in 2050 be from carbon-less energy resources. Despite the technical community's recognition of the magnitude of change required, there has been little discussion of the policies needed to pursue such a path among public and private sector officials whose actions will determine whether such a stabilization objective can or will be met.

Two issues have dominated the discussion that has occurred: what are the relative roles of "new" and "current" technologies in building an carbon-less energy system and what policies are appropriate to stimulate deployment of such technologies.

This paper contends first, that it is likely infeasible to deliver 22 TW of carbon-less power by 2050 by relying solely on "new" technologies. Given the lead-time associated with deploying large quantities of carbon-less energy, it will be necessary to pursue a strategy that combines two initiatives: first, expanded use of "current" technologies, such as energy efficiency, renewable energy sources like wind, solar, and biomass, and technologies that capture CO2 from fossil-fueled stationary sources for geologic disposal and second, adoption of policies designed to develop and deploy "new" technologies.

In the policy arena, limited debate has centered on whether a regulatory program, such a cap and trade system, or increased financial support for carbon-less energy RD&D programs will be more effective. This paper argues that, at least in the U.S. context, political realities are likely to prevent either a pure regulatory approach or a pure advanced technology RD&D effort from being adopted and implemented at the requisite scale. While modest regulatory programs may well be adopted, the more ambitious programs needed to stimulate massive deployment of carbon-less energy resources are likely to be blocked by coalitions of industries that perceive themselves as losers under such programs. Similarly, absent the driver of a regulatory target, RD&D programs are not likely to attract adequate amounts of either public or private resources.

A more successful strategy is likely to involve a hybrid program that combines a schedule of binding limits on global warming emissions over time with a major increase in financial support for "current" carbon-less energy technologies, including nearly commercial systems like carbon capture and storage for fossil energy facilities. Such a program could engage a broad coalition of support from a variety of

interests. Environmental groups might be persuaded this approach will likely achieve larger reductions sooner than alternatives. Renewable energy and agricultural interests would likely support due to increased business opportunities. Fossil energy interests may support if they are convinced that such a program is needed to provide them with a viable business future. Finally, in many countries, deployment of carbon-less energy resources may reduce dependence on imported energy resources. Recognition of these "ancillary benefits" could lead to increased international cooperation to promote carbon-less energy. Carbon-less energy systems will benefit all countries by averting dangerous interference with the climate, they can provide domestic economic benefits, and they can help avoid a dangerous over-dependence on imported sources of energy.

Introduction

Forecasts of future greenhouse gas (GHG) concentrations in the atmosphere conclude that with "business as usual" (BAU) assumptions about growth in population, economic activity and energy use, we will more than double pre-industrial concentrations before the end of this century[1]. Various analyses have shown that that quite large changes in BAU energy paths will be required in order to stabilize concentrations at less elevated levels, such as 450 or 550 ppm.[2] Hoffert, *et al.*, conclude that if global primary power demand reaches 30 terawatts (TW) by 2050, that approximately 22 TW of that demand would have to be met with non-carbon-emitting energy resources in order to stabilize atmospheric CO2 concentration at 450 ppm.[3] If we are to preserve our ability to stabilize concentrations at levels close to 450 ppm, a key issue facing public and private decision-makers will be what strategies to use to stimulate the deployment of such large amounts of what I will call "carbon-less" energy resources.

A vigorous debate continues over two issues. First, how far toward stabilization can we get using known technologies and how much should we rely on the development of radically new technologies?[4] Second, what policies and programs are required to stimulate deployment of carbon-less energy resources not yet developed or in wide-spread use?[5]

Role of "new" technologies

Hoffert, *et al.*, argue that energy technologies that are currently operational or at the pilot plant stage are not capable of producing 10 to 30 TW of carbon-less power[6] and that accordingly a suite of new technologies must be developed and deployed. In the U.S., business interests have cited this paper to justify their opposition to binding measures to limit greenhouse gas emissions: "Simply put, no matter how strong any...mandate, the technology needed to stabilize global atmospheric levels of CO2 does not exist."[7]

In effect, the U.S. business lobby is arguing that adoption of binding measures to limit greenhouse gas emissions must wait until after we have developed new energy technologies. An implicit corollary of the argument is that waiting for the development of such new energy is a viable strategy for stabilizing greenhouse gases; that the new technologies will arrive in time to enable stabilization at some prudent level. While the Chamber of Commerce cites the Hoffert, *et al.*, paper as implicitly supporting their view, it does not; nor do other objective analyses.

Most analyses, including those by Hoffert *et al.*, demonstrate that to stabilize concentrations at 550 ppm or below we will have to make major reductions from BAU emissions during the next 20 to 30 years.

When the inertia inherent in energy development and deployment cycles is accounted for, it is difficult to conclude that "new" energy technologies are likely to be able to play a major role in that timeframe. Such "new" technologies are likely to be needed in this century but in the next several decades it will be essential to rely on improved versions of current technologies to provide the bulk of new carbon-less energy resources if we are to stabilize concentrations at levels less than or equal to twice pre-industrial values.

As mentioned, Hoffert, *et al.*, (1998) estimate that 22 TW of zero-carbon-emitting ("carbon-less") power would need to be in place by 2050 to stabilize concentrations at 450 ppm, using mid-range climate sensitivity parameters. In the scenario analyzed by the authors, about 10 TW of this carbon-less energy would be provided by an expansion of nuclear and renewable energy resources and about 12 TW by "generic carbon-free" resources.[8] The authors are not explicit about how much of the generic resources would be from "new" technologies but it appears that most if not all of the 12 TW is assumed to come from such "new" resources.

How plausible is it that "new" technologies could contribute something approaching 12 TW of power by 2050? By truly "new" technologies Hoffert, *et al.*, appear to mean systems that have not yet advanced to the pilot stage today. In their paper they assume that the "generic carbon-free" energy resources begin to deploy in the year 2000 and ramp up nearly linearly over the 50 year period, reaching about 2, 4, and 12 TW in 2010, 2020, and 2050 respectively.

While this assumed penetration rate may be reasonable for technologies that are commercially demonstrated and economically viable today, it is an extremely questionable assumption for new resources that have not yet progressed even to the pilot scale phase. Technologies at such an early development stage are not likely to be developed to the point of wide commercial deployment until two, three, or more decades have passed, if prior energy technology paths are any guide. [9] Let us assume optimistically, that some unspecified set of "new" technologies could be ready for significant deployment in 25 years (the year 2030).

In the year 2030 such hypothetical new resources will be competing for market share in a world that is even more heavily dependent on high-carbon emitting energy resources, absent a concerted program to alter BAU forecasts. The International Energy Agency (IEA) forecasts that by 2030 over 1400 gigawatts (GW) of new coal-fired electric generating plants, over 2000 GW of natural gas-fired plants, and over 200 GW of oil-fired plants will be built under their reference case scenario.[10] Between 2000 and 2030 total primary energy use will grow in the IEA forecast by 6088 million tons of oil equivalent (Mtoe), from 9179 Mtoe in 2000 to 15267 Mtoe in 2030. But 91% of that increase in primary energy use is forecast by IEA to be supplied by fossil fuels.

Without major programs to alter this BAU path between now and 2030, by the time "new" technologies are ready to perform at significant scale, our ability to stabilize CO2 concentrations below 550 ppm will have disappeared. If BAU patterns persist until 2030, IEA forecasts that global carbon emissions from energy use will have reached 10.4 billion tonnes (Gt) a year -- a "burn rate" 4 Gt higher than the 6 Gt per year limit consistent with stabilization at 450 ppm.[11]

For "new" technologies by themselves to get the world back on a 450 ppm stabilization path after another 25 years of BAU, several heroic (impossible?) performance challenges would have to be overcome. Emissions would have to stop growing immediately and then turn down very rapidly. For "new" carbon-free technologies to accomplish this, they would have to be deployed at an annual rate high enough to accommodate growth in demand and to replace existing high-emitting energy resources on a schedule capable of meeting the cumulative carbon budget consistent with a 450 ppm stabilization objective.

Failure to reduce emissions and deploy lower carbon-emitting resources before 2030 makes both of these tasks much more demanding.

Under the IEA reference case, in 2030 primary energy demand will be growing at about 0.3 TW per year, compared to about 0.2 TW per year over the past three decades.[12] If emissions are not deflected below the reference case before 2030, annual emission decreases of about 300 million tpy would be needed to limit cumulative emissions during the 21st century to levels consistent with 450 ppm stabilization.[13]. In the IEA reference case, carbon intensity of primary energy supply will be about 0.51 GtC/TW/yr,[14] implying a need to replace nearly 0.6 TW of existing supply per year to achieve the required emission reductions. Thus, to make stabilization at 450 ppm possible under this scenario, "new" energy technologies would have to be deployed at a rate approaching 0.9 TW per year starting in 2030. To this writer it does not seem plausible that we can rely on a suite of undefined and undeveloped "new" technologies to be deployed just 25 years from now at a rate more than four times the deployment rate of conventional energy resources during the past three decades.

While one could assume a somewhat earlier deployment date for these "new" technologies than 2030 and/or that the "dirtiest" existing resources in 2030 are replaced first, the conclusion would still be that enormous amounts of "new" technologies would have to be deployed very rapidly. One also could argue that the task might be manageable if the target were 550 rather than 450 ppm. But honesty would require an acknowledgement that further delay does mean eliminating options to stabilize at lower concentration values -- something the advocates of delay in the business community are not admitting.

None of this should be understood as an argument against a very large-scale effort to promote the accelerated development of "new" energy technologies. Such "new" technologies are likely to be required to provide the significant continuing reductions that will be required throughout the 21st century. Rather, the argument is that a realistic assessment of the potential deployment rates for such "new" technologies suggests that their major contribution will come after 2050. What we will need in addition to a "new" technology acceleration program is a major effort starting now to expand the use of the current carbon-less energy resources over the next several decades. If we do not do that, the problem will have grown so large that it will not be manageable with a suite of "new" technologies when they do emerge.

What can current technologies accomplish?

Fortunately, a number of analyses indicate that current technologies do have the capability to reduce emissions in the next few decades by very large amounts, thus enhancing the ability of our generation and those that follow to stabilize concentrations at levels as low as 450ppm. The "toolbox" of current lower carbon technologies is well-known: substantial reductions in energy consumption by vehicles, appliances, buildings and the megalopolises they form are achievable without any loss in services[15]; renewable resources like wind, solar and biomass are already cost-competitive in certain applications even though their lower CO2 emissions attributes is currently valued at zero in most markets -- and further cost reductions are likely; preferential use of lower carbon fossil fuels like natural gas is expanding; all of the elements of CO2 capture and geologic disposal techniques have been demonstrated at commercial scale in a number of countries. Some would add nuclear power to this toolbox while others would argue that the problems of waste disposal and proliferation risks are show-stoppers. Taken together, these current technologies can accomplish enormous amounts of CO2 emission abatement and fill the decades-long gap before undeveloped "new" energy resources are ready for large-scale deployment.

A July 2003 report for the Pew Center on Global Climate Change concludes that policies that promote deployment of currently available mitigation technologies could reduce U.S. CO2 emissions by 2035 to less than 970 million metric tonnes of carbon -- a 38% reduction below year 2000 levels and a reduction of between 46-59% below several alternative reference scenarios.[16] An analysis of an integrated energy and environmental policy in China found that advanced versions of current technologies could achieve a 33% reduction in cumulative carbon emissions by 2050 and a significant reduction in oil and gas imports, relative to base case forecasts, all at a lower overall cost than a policy that attempted only to limit sulfur dioxide emissions.[17] In February 2003, the British government released an Energy White Paper that concluded the U.K. could cut its CO2 emissions by 60% from current levels by the year 2050, using known technologies (including hydrogen for transport beginning after 2030), at a cost ranging from ½ to 2% of GDP in 2050 (when GDP is forecasted to have tripled from 2000 levels)[18] A recent analysis by Pacala and Socolow, presented in more detail at this conference, concludes that a suite of existing technologies are available to cut BAU emissions globally by enough to achieve stabilization at 500 ppm.[19]

Thus, the technical and policy choice is not whether to rely on current or "new" technologies to combat global warming. We need effective programs to employ both approaches -- current technologies now, and policies to accelerate the development of "new" technologies.

Making change happen

As with the debate about what to do, commentators are also divided on how to do it. Academic economists have argued what is required is a policy that imposes a price on carbon emissions: once an adequate price is established, the market will produce the required solutions. Of course, this prescription is a bit like the "assume a can opener" joke. In some countries, opponents of such policies still have sufficient political power to block such policies and there is reason to be concerned that even if such "carbon price" policies were adopted, they would initially be set at such a low level that they would not stimulate the required investments in low-emission energy technologies. While the power of such blocking coalitions is steadily eroding, a "war of attrition" approach to policy change runs the risk of action that comes too little and too late.

Others, notably the current U.S. administration and some business organizations, argue that we should promote "new" technology and employ nothing more than voluntary programs until the new technology arrives.[20] This approach is, intentionally or otherwise, a prescription for delay. A program to bring "new" technologies to market will not succeed unless both the public and private sectors commit significant resources to the effort. While the costs of bringing low-carbon current technologies and developing "new" technologies are modest from a macroeconomic standpoint, they can be quite large for individual firms. For those firms to commit significant investments in low-emitting technologies they must believe there are real needs and real opportunities at hand. To many private sector decision-makers a voluntary-only approach communicates a lack of seriousness and a lack of clarity, leading to a "wait and see" posture. This fact is acknowledged by many in industry. For example, the U.S. National Coal Council (a coal-industry industry dominated advisory body) had this to say about coal gasification's (IGCC) prospects relative to conventional coal (PC) and natural gas (NGCC) plants:

"IGCC may only become broadly competitive with PC and NGCC plants under a CO2-restricted scenario. Therefore, vendors currently do not have an adequate economic incentive to invest R&D dollars in IGCC advancement. Similarly, power companies are not likely to pay the premium to install today's IGCC designs in the absence of clear regulatory direction on the CO2 issue. Therefore, accelerating the

development of low-cost, low-CO2-emitting CCTs, such as IGCC, will require substantial cooperation and funding from both public and private sources." [21]

Yet, the U.S. coal industry as a whole continues to oppose any mandatory CO2 emission limits, apparently out of fear that it will be an economic loser under such a regime. Two trends may help to change this posture. First, a realization that at least in the U.S., the industry can not count on significant new coal plant construction to spur demand and that its existing customers will come under increasing pressure to address CO2 emissions, leading to at least modest fuel switching. Second, an understanding that it may be possible to craft a "grand bargain" that couples support for "carbon-free" energy resources, including coal technologies that capture carbon, with an achievable schedule of binding CO2 emission limits.

Prospects for breaking the U.S. policy impasse

The U.S. posture on global warming policy remains a significant obstacle to mounting the global effort that is required to stabilize greenhouse gas concentrations at prudent levels. Fortunately, many countries are moving ahead with some modest programs but the current U.S. position acts as a sea anchor impeding progress there and in the developing world. But this can change. Regardless of the outcome of this year's national elections in the U.S., the year 2005 presents an opportunity for a thorough reassessment of the approach taken by both the U.S. government and industry. A roadmap for progress is ready to be pieced together.

A viable framework is likely to include a flexible but mandatory schedule for capping and reducing greenhouse emissions over time (applied either to a major sector, such as electric generators, or to all major emitting sectors) combined with a very substantial program of financial support for deployment of low- and zero-emitting energy resources, including new coal plants that capture CO2 for geologic disposal. A financial support program could be structured to mitigate the impacts on those coal-dependent businesses that might be adversely affected by a pure "carbon price" approach.

Why would U.S. politicians support a proposal that both imposes new regulations and requires significant spending? First, there is a growing awareness that the problem of global warming cannot be made to go away. The consequences of continued increases in emissions are inexorable and delay will just make the solutions more costly and disruptive. Second, changing the energy system to operate with lower CO2 emissions can provide large benefits to a range of constituencies. A program that enhances efficiency, expands the use of renewable energy, and enables coal use without global warming emissions will, of course, provide enormous environmental and economic benefits by avoiding runaway changes in the climate. But the same measures will serve other strategic interests.

Increasing dependence on imported hydrocarbons, in the U.S. and in nearly all major trading nations, poses real threats of economic and political disruption. Efficiency, renewables, and coal without carbon emissions can reduce this import dependence in the U.S. and in every country that employs these methods. In the U.S., industrial gas users are increasingly damaged by price volatility due in part to the continued and growing demand for gas use in the electric sector. The trio of efficiency, renewables, and coal without carbon emissions can avoid a disruptively tight gas market. Agricultural interests will also gain. U.S. (and European) commodity producers have long enjoyed large subsidies for products like cotton and sugar. But these subsidies are now being challenged successfully before the World Trade Organization (WTO).[22] Renewable energy resources, particularly wind and biomass energy products,

promoted by a comprehensive climate protection program, have the promise of becoming a significant, WTO-legal source of new revenues.

Meeting the needs of these diverse interests will be a powerful motivator for elected officials regardless of their ideology on other matters. If these forces do come together then change could occur rapidly and establish a serious program that combines regulatory and drivers and financial incentives for deployment of low and carbon-free energy technologies, both current and "new."

Notes

1. R. T. Watson *et al*., *Climate Change 2001: Synthesis Report. Contribution to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge Univ. Press, Cambridge, UK, 2001).

2. M. I. Hoffert *et al.*, *Science* 298, 981 (2002); S. Pacala *et al.*, *Science* 305, 968 (2004).

3. M. I. Hoffert *et al.*, *Nature* 395, 881 (1998).

4. Hoffert, *note 2*; B.C. O'Neill *et al.*, *Science* 300, 581 (2003); Pacala, *note 2.*

5. *See, e.g.*, Resources for the Future, *Will Technology Save the Day?*, on-line forum at http://www.weathervane.rff.org/pop/pop3/index.html

6. Hoffert, *note 2*.

7. W. Kovacs, U.S. Chamber of Commerce, Why CO2 Mandates Won't Work, *The Washington Times*, May 7, 2003.

8. Hoffert, *note 3*.

9. O'Neill, *note4*.

10. International Energy Agency (IEA), *World Energy Outlook 2002* (2002).

11. *Ibid*; Hoffert, *note 3.*

12. IEA, *note 10.*

13. Based on a constant annual percentage reduction in emissions sufficient to stay within WRE century-long cumulative emission constraints for 450 ppm stabilization.

14. IEA, *note 10*.

15. U.S. Department of Energy, *Scenarios for a Clean Energy Future* (2000).

16. I. Mintzer, *et al.* 2004. *U.S. Energy Scenarios for the 21st Century.* Washington, D.C.: Pew Center on Global Climate Change.

17. E. D. Larson *et al.*, *Energy Policy* 31, 1189 (2003).

18. U.K. Department of Trade and Industry, *Energy White Paper, Our energy future-creating a low carbon economy* (TSO, London, UK, 2003).

19. Pacala, *note 2*.

20. Kovacs, *note7*.

21. J. B. Harvey *et al.*, *Coal-Related Greenhouse Gas Management Issues* at 65 (National Coal Council, Washington, D.C., USA, 2003).

22. Benson, Todd 2004. W.T.O. Rules for Brazil in Sugar Dispute, *New York Times*, August 5, Business section; Meller, Paul and Becker, Elizabeth 2004. U.S. Loses Trade Cases and Faces Penalties, *New York Times*, September 1, Business section.