

NATIONAL COMMISSION ON ENERGY POLICY
Design Issues in Market-based Greenhouse
Gas Reduction Strategies

Washington Court Hotel
525 New Jersey Ave., NW
Washington, DC 20001

Workshop 4: November 9, 2005
Incentives for Technology Innovation and Deployment

FINAL AGENDA

Welcome—Jason Grumet, National Commission on Energy Policy (NCEP)

Introductions—Robert LaCount, Cambridge Energy Research Associates, Inc. (CERA)

Global Emissions Pathways—Tom Wilson, EPRI

Technology Options and Timing—Robert Socolow, Carbon Mitigation Initiative and Princeton University

Policy Approaches for Stimulating Technology Innovation and Deployment—Anne Smith, CRA International; David Doniger, Natural Resources Defense Council; John Holdren, National Commission on Energy Policy, Woods Hole Research Center, and Harvard University

Moderated discussion, led by CERA

ADMINISTRATIVE ITEMS

All workshop presentations are posted on the NCEP Web site (<http://www.energycommission.org>). This was the final workshop scheduled for this series. CERA will be releasing a final document that highlights the critical issues discussed throughout the workshops and the range of opinions expressed on the various topics.

MODERATED DISCUSSION

Robert LaCount posed the following three questions to frame the discussion.

- Would a price signal established through a greenhouse gas (GHG) trading market adequately encourage private sector investment in lower emitting technologies and accelerate development of additional technology options? To what extent should additional policies, including investment in public research, development, and deployment (RD&D), be used to support these technology goals?
- To the extent that additional policies are recommended for encouraging technology investments, what are the most effective methods to invest additional funds to support technology RD&D? How should funding be prioritized for basic research and

development (R&D), demonstration projects, and deployment of proven but perhaps still expensive technologies?

- A GHG trading program provides a variety of mechanisms, including auctions, allocations, and safety valves, to generate funds that could be used to support technology investments. What mechanisms are recommended for generating funds under a GHG allowance trading market to support technology deployment and development goals?

The three panelists began with opening statements that summarized their views regarding the material discussed during the morning presentations and the three questions posed by the moderator. The following summary categorizes the main comments made by the panelists and workshop participants during the discussion.

Overarching Policy Issues

- The objective of cap-and-trade programs is to provide incentives to make least-cost investments to reduce emissions. The design of the system will determine the nature and scale of investments and how quickly they happen. Forty percent of the generation capacity that will be available in 2020 has yet to be built. This implies the need to do something today in developing countries as well as in developed economies. Perhaps the best policy is to have a cap-and-trade program implemented in conjunction with incentives for technological development. In both cases, government should be responsible for setting the rules, while the private sector should drive innovation and develop the solutions.
- The best way to optimize the effectiveness of R&D is to create a real market for the technologies within the private sector. For example, markets created by renewable portfolio standards have driven the development of wind technologies. A distinction needs to be made between research and development. Government will need to be the primary driver of research dollars, but markets and the private sector provide the most effective means to drive the development of the technologies. Applying a cap on emissions is a necessary step to motivating the private sector to develop the needed technologies.
- Carbon prices that are politically feasible will not be adequate to accomplish everything that needs to be done to address climate changes risks and energy security concerns. For this reason, it is important to develop a suite of policies to drive the energy investments and R&D that we will need in the future. The carbon price signal does have an important role in driving cost-effective reductions that are currently available. However, we cannot do it all with a price signal. We also need a vigorous government-funded R&D program for long-term, high-risk projects.
- Investment decisions for new technologies are driven by more than just costs. Energy security and social concerns are examples of other factors that influence investments. Some of these concerns can be leveraged to drive energy investments that also produce less GHG emissions.

- We need to find a way to fund the deployment of midterm technologies that will not solve all of our problems but are much cleaner than current conventional technologies. These midterm technologies will provide important carbon benefits because we will be living with these near-term capital investments for many years into the future.
- The coverage of a program needs to be as broad and as flexible as possible. Modeling used to study future changes in the energy sector as it shifts to low-emissions technologies shows that segments of the industry will change dramatically. It does not make sense for regulators to try to revise standards for each sector as this transformation occurs. We need to let these changes occur within the competitive forces of a market.
- When you place a cap-and-trade program on the whole energy system, the program has broad economic implications. This has led many people to think about refined versions of command-and-control regulations. In this way, targeted standards could be used to deploy existing technologies quickly and to focus R&D on next generation technologies. Gasoline price increases have been described as a blunt instrument for bringing about fuel efficiency for the vehicle fleet. If we know we need more efficient vehicles, why not develop a focused program to get vehicle fuel efficiency to where we think it should be and then gradually integrate this sector into the overall GHG market? This approach may be more cost-effective than solely using a cap-and-trade program for reducing emissions from the transportation sector. The same type of program can be envisioned for the electric power system. We need to think about developing a portfolio of carbon policies rather than having a single cap-and-trade program or pure government R&D.
- We have a lot of challenges to getting low-carbon technologies widely deployed. The challenges include the economics of many of the technologies, along with other practical barriers such as current regulatory structures. Regardless of the future level of global GHG emissions considered appropriate to mitigate climate change, there is general agreement that we need many of these nonemitting technologies to be available very soon. We need to address the challenges aggressively.
- There is concern within the environmental community and now more broadly about the urgent need to deal with global warming. Impacts of climate change are now evident, including the melting of polar ice caps and increased severity of hurricanes. In a world where we think we see impacts resulting from current global carbon dioxide (CO₂) concentrations, the policies that we consider must acknowledge the risks associated with going to higher concentrations and costs associated with losing the option of staying at lower concentrations.
- For power generation, the use of portfolio standards may be an effective way to stimulate the adoption of low carbon technologies such as integrated gasification combined-cycle plants with carbon capture and storage. Under this approach, carbon-emitting power generators would have to have a specified percentage of low carbon-emitting plants. If the initial targets for the standards were relatively low, then multiple companies could invest in a single low carbon-emitting plant. In this way multiple parties receive credits, and the companies share the risk associated with being a first mover.

Emissions Pathways

- There is a lot of variation among different analyses that project future GHG emissions under “business as usual” cases. The analyses have different assumptions regarding the rate of adoption of different technologies as well as the economic growth and structural changes that will occur within different economies. We should stop talking about what the right baseline is—because this is an unknowable proposition. We should focus on policies and incentives that encourage the use of technologies that will reduce emissions below whatever baseline we have.
- We need to send a policy signal that will stop and reverse carbon growth, not just slow it. Starting with a policy that is too weak to generate action would be a big mistake given the severity of the problem.
- The question we are here to address is not whether we should stabilize emissions but how we should do it. To state that the right price of carbon is the one that starts to stabilize emissions right now ignores the reality that there are many ways to get to stabilization. Additionally, the idea that a policy may establish a high price in the near term and would eventually fall misses a critical point about what it takes to make a viable climate change policy. The policy must be affordable if we expect to implement it. If it is not affordable, it is unlikely that the policy will receive the necessary political support. Starting the policy with a high price for carbon also fails to recognize that climate change is a cumulative GHG emissions problem. We can take advantage of the fact that it is the cumulative emissions that we must address rather than the discrete emissions from any specific year. There are many paths we can use to reduce GHG emissions and stabilize concentrations of CO₂. The question is which one is most appropriate.
- Under an international program to reduce GHG emissions, the United States and other developed nations would probably have to bear a higher proportion of the cost. The magnitude of the costs that would fall on the United States is probably not politically viable, and more importantly, it is not necessary. The optimal path for stabilizing emissions is one that minimizes the cost of getting there. We can spend less now and gradually increase prices following a price path that will increase at the private sector discount rate. This would be, by definition, the most affordable path. The question then becomes, What would society be willing to pay for reductions once we have robust options for zero-emitting technologies? This might carry a cost of approximately \$100 per ton of carbon reduction, but this doesn’t have to happen today. It has to happen in time to stabilize emissions—maybe 50 years from now. If that is the future cost target, this suggests that the right amount to spend now, on a present value basis, is on the order of \$10 to \$25 per ton of carbon (\$3 to \$7 per ton of CO₂).
- The proposition that climate change is a cumulative emissions problem neglects the idea of growth rates and long-lived assets. For example, many coal-fired power plants will be built in China and elsewhere around the world in the near future. These plants will run for 50 to 60 years. If these plants are pulverized coal technology and are not easily retrofitted for CO₂ capture, the emissions from these plants will be huge. We need to figure out how we can build plants over the next 20 years with technologies

that can at least be economically retrofitted to capture and sequester carbon. To do this, we need a policy that reflects the expectation that society will have decided within the next 20 years that we need to pay the price for carbon capture and sequestration. Given the public's interest in having the option to capture and sequester carbon, perhaps the government could pay some of the difference between a conventional coal-burning plant and one that is capable of carbon capture and storage.

- We can manage the cost of a CO₂ program if it is gradually implemented rather than requiring a significant reduction in emissions in the near term.
- A problem with delaying significant emissions reductions into the future when we think costs will be less is that we don't know what level of reductions is needed. If it turns out that we need to stabilize CO₂ concentrations at 450 parts per million (ppm) rather than 500–550 ppm, we lose this option if the delay is extended. This could be a very high price to pay. Many scientists that study this problem think it is imprudent to believe that 550 ppm will work.
- Figuring out the right price signal for carbon should be a second step after we first determine what can be achieved through technology innovation and after we articulate our long-term emissions reduction goals.

Economics of Technologies

- Transportation technologies currently available can help to significantly reduce CO₂ emissions from the transportation sector. When evaluating these technologies, people tend to only look at the up-front cost, which makes new technologies look very expensive. However, these technologies look much more competitive if one includes the large benefits they provide for fuel savings. Unlike in other sectors, lower carbon technologies in the transportation sector can provide a net savings to consumers. Few economic analyses adequately capture the fuel savings associated with the new technologies. There are practical challenges to deploying these technologies, but because of the net savings that they can provide to consumers, their potential should not be overlooked.
- When evaluating future policies and low-emissions technologies, we tend to focus on the up-front costs associated with the various climate change mitigation options. Who is looking at the increased societal costs we will experience if we do not mitigate climatic change? Many of these costs can have feedback loops affecting the specific technologies that we are evaluating, such as the availability of cooling water for power plants or increased electricity load due to more air conditioning. We need to bring these considerations into the analysis when evaluating the total costs and benefits of various policies and technologies.
- We have enough analyses and modeling that evaluate climate change and related policies. It is now time for action. The appropriate price for carbon is the price that makes things happen in the current marketplace. The appropriate price to do this may actually fall over time as we improve our technologies and learn by doing.

- Many of the available economic analyses do not significantly differ on the costs of low-emitting technologies. Many of the analyses performed on policies intended to stabilize emissions come up with costs of about \$100 per ton of carbon reduction. The critical question relates to what the cost projections actually mean. Some people argue that the analyses are wrong and that the costs will be much less than \$100 per ton carbon, while others argue that society will never agree to pay that much for carbon reductions in the near term. This is the current political reality.

Role for Technology R&D

- How do we achieve zero-emissions technologies? The best way is probably not to learn by doing with the technologies currently available. Current technologies will not get us to zero emissions. To stabilize CO₂ concentrations, we need revolutionary technologies, not evolutionary ones. We must determine how to make the technology revolution happen.
- Some believe that we can develop unforeseen technology breakthroughs if we place an appropriate emphasis on technology R&D. This is not the way the R&D community really operates. The real goal of R&D is to increase the amount of technology options that we have at competitive costs rather than to dramatically lower current costs. By increasing our options, we may prevent prices from rising dramatically in the future, but we should not rely on these options to dramatically reduce costs in the future.
- R&D should be considered as a way to increase options for carbon-free energy at a given cost. New nuclear plants are currently more expensive than new conventional coal plants. If we don't have a carbon tax to drive the cost of coal up, then we need to do something to drive down the cost of nuclear. The same could be said about wind. We should not lose sight of the role of R&D in improving the economics of our technology options.
- Markets are essential to drive the deployment of new technologies. Developing a price for carbon is a good mechanism to get existing technologies into the marketplace. However, to effectively address the need to stabilize emissions, we will need big breakthroughs in new technologies. A near-term price signal will not motivate these technology breakthroughs. We need focused R&D efforts to create the breakthroughs. A near-term price signal can be effective to drive cost-effective reductions that are currently available. However, these options add up to a relatively small number of reductions compared to what will be necessary in the future.
- There appears to be general agreement that current technologies provide some options for lowering emissions but that we will need more advanced technologies that will require significant R&D. The question is how to encourage investments in current technologies and in R&D.

Funding Technology R&D

- Allowances distributed within a GHG market also provide a revenue source to encourage low carbon-emitting technologies. Allowances could be directly allocated to companies that invest in state-of-the-art technologies. This option internalizes the incentives for rapid deployment of new technologies within the GHG market rather than relying on other federal policies that would create additional costs for tax payers.
- R&D is cheap. If we raise the federal tax on gasoline and diesel fuel by 1 cent per gallon, we would raise \$1.8 billion per year. This is the total annual expenditure on all applied energy technology R&D performed by the US government. A tax equaling 0.1 cent per kilowatt-hour would raise \$4 billion a year. This would triple applied energy R&D. The real challenge is not how to raise money, but whether we have the will to invest the money into R&D.
- It is very difficult to ensure that R&D receives sustained funding over an extended period because Congress decides where funding ultimately goes regardless of how the monies have been budgeted. FutureGen provides a perfect example: it has been very difficult to get funding for this program. Is there a way to secure funding for these projects? Without a sustained financial commitment, technology development will not progress at the necessary pace. We should also evaluate whether there is a way to provide more incentives for the private sector to do more of this research.
- We should consider whether we can ring-fence revenues that are generated within a GHG. This funding could be earmarked solely for supporting energy R&D. We have too many examples where a program was put in place but the appropriations never followed, such as with Yucca Mountain.
- It is a mistake to assume that the only way to fund energy R&D within a GHG market-based program is through proceeds generated by selling allowances. Perhaps the best way to ring-fence monies for R&D is to never turn the funds into cash but instead leverage the value of CO₂ allowances by allocating them to investors that build and operate low-carbon emitting technologies. Then the recipients can turn the allowances into cash within the allowance marketplace. In this way, the financial incentives never pass through the Treasury. This model was drafted in Senator Jim Jeffords' proposed legislation. Another example is Senator John McCain and Senator Joseph Lieberman's proposed legislation that would create a nongovernmental entity called the Climate Change Credit Corporation (CCCC). The CCCC would receive a fraction of the available allowances from the federal government and would convert them into cash that could be used for grants or would give the allowances directly to third parties that could convert them into cash. These are ways to depoliticize the process of financial incentives.

Managing R&D Efforts

- We must address how we should design government R&D programs that produce valuable knowledge instead of pork barrel projects. We have had a tendency to misuse energy R&D and particularly demonstration projects. There have been alternative proposals for how we should organize our R&D. This is an important topic to address in this process.
- We should consider whether we need to strengthen patent and trademark rights to further encourage energy R&D. Do we need longer patents? Also, if a consortium of companies is funding basic research, should the consortium be guaranteed a patent or trademark on the products that result from the effort? This is an especially important issue in international markets.
- We should ensure that future policies enable investors to receive financial benefits from their low-carbon investments. For example, what regulatory regimes will ensure that utilities can profit by increasing the amount of power that their customers conserve?
- It would be useful to consider having R&D funds administered by the private sector. Although governmental and academic institutions should also be involved with the R&D process, we should consider having it predominantly managed by private sector representatives. Greater participation by the private sector would help to make R&D efforts more effective because it is the private sector that will ultimately decide what technologies to use in the future.
- Inefficient use of government R&D budgets is a big problem in the United States, but it is not unique to energy R&D. We should work to improve the effectiveness of the budgets, but some residual waste is the cost of doing business. One way to improve the effectiveness of the research is to increase the level of partnerships with the private sector. This is particularly important for applied research and development.
- The value of low carbon R&D is ultimately created through a GHG policy decision. The most important issue for encouraging R&D is not necessarily intellectual property rights. Even if the innovator has the property rights, the R&D investment will not be recovered if the future CO₂ price is below initial expectations. The future price and, therefore, the value of the technologies will ultimately be a policy outcome. It is also difficult to create R&D incentives by focusing on patent rights because future technologies will rely on the combination of many smaller technological advances rather than on a single technology breakthrough created by a single inventor.
- One way to create value for technological advances is by creating technology prizes that would be awarded to successful inventors. These programs have been used to create incentives for other research areas. The question is whether they can be effectively used for the development of low carbon-emitting technologies.

Carbon Price Signal

- There is not a specific threshold for establishing a carbon price that encourages actions to reduce emissions. There is a supply curve for carbon reductions similar to that for other commodities and services available in the marketplace. There is a quantitative question concerning how much action will happen at different prices of carbon, but there is not a price at which nothing happens. The lesson from the sulfur dioxide trading program is that the price to get emissions reductions may be smaller than what everyone initially assumes.
- There is not a way to have a price signal announced years in advance of when it would be implemented that would adequately motivate R&D in the private sector. It is not credible to think that society will bear the costs of a very high CO₂ price signal if the technology breakthroughs do not happen in the future. Therefore, the private sector has nothing to lose if the technology breakthroughs do not happen. On the other hand, the private sector may absorb significant costs if companies do aggressively invest in R&D. Under this scenario, government will attempt to minimize future costs by setting the CO₂ price signal at the minimal level necessary to encourage the deployment of the new technologies. These prices are not likely to be high enough to fully pay back the fixed costs for the companies that aggressively invested in R&D. The private sector is aware of these pitfalls and will be cautious regarding R&D investments. Therefore, simply establishing a future CO₂ price signal will not provide a sufficient incentive for technology R&D. We must develop other policies that encourage the appropriate level of R&D.
- There is a tension in finding an appropriate price level. Aiming too low means that not enough happens, and aiming too high may result in nothing happening because the program will not be politically viable. We need to have a mechanism with parameters that will be revisited over time. The National Commission on Energy Policy proposed a policy that limits near-term carbon prices while providing mechanisms to adjust the price signal over time.
- It is not difficult to provide incentives for private R&D. History shows that in competitive markets, innovators will invest in new opportunities as soon as the market places a value on something. Many companies are ready to make investments as soon as they see the financial opportunities. There is a continuous supply curve for carbon reductions. Investors will evaluate and invest in options along the supply curve that correspond with the current carbon price and the expectations for future prices.
- The only efficient way to get reductions is to have a common price of carbon across the economy.
- When thinking about a price signal, it is important to understand how these numbers will work. If the price of carbon is too low, industries, such as the coal industry, will look at the price simply as an additional cost of doing business. This will not lead to significant emissions reductions. We need to have a carbon price that will alter the economics of how different industries operate. US policies that are designed to encourage wind, biofuels, and nuclear power cost the equivalent of \$100 per ton of carbon removed. So \$100 per ton is not a high tax. Europe also has a CO₂ market that is currently sending a price signal of approximately \$100 per ton of carbon.

- Policies used to encourage solar, wind, and nuclear technologies in the recent Energy Bill may be equivalent to costing \$100 per ton of carbon reduction; however, this is not an appropriate comparison. Although the unit costs may be similar, the cost of these targeted incentives is clearly much smaller than placing a \$100 per ton carbon tax on all energy consumed within the world or the United States. Also with respect to current carbon prices in the EU Emissions Trading Scheme, prices are currently at about \$100 per ton of carbon. However, these prices are causing political problems right now. A number of governments are considering re-regulating the electricity industry, partly because of the effects of the carbon prices.
- Putting a price on carbon that generates revenue for the government does three things. First, it shifts the consumer and producer choice to low carbon technology options that already exist in the marketplace. Second, the price increases incentives for private sector R&D that will eventually increase our options for low carbon technologies. Third, it generates revenue that the government can use to pay for publicly funded R&D that can complement the private sector R&D. This is especially important for longer-term and higher-risk opportunities such as fusion. All of these benefits of having a price on carbon are important.

Cap-and-trade Programs

- There is a problem with the view that a CO₂ cap and a tax are functionally the same. We will not know the right price for achieving the desired level of emissions reductions until the program is actually operating. For this reason, we should establish a gradually declining emissions cap on the appropriate sectors of the economy. The cap will set the price of carbon and drive the appropriate level of investment. This approach can include an economic relief mechanism that controls the pace at which the cap tightens and the price of carbon rises. We can create an effective economic incentive that avoids the endless debate over establishing the “right” price for carbon. The forcing function of a cap provides a very different incentive than that provided by a tax. More innovation takes place if companies are forced to comply with a cap rather than being able to pay a tax to achieve compliance.
- A GHG market cannot be designed on the fly. Many important design variables are interrelated. Every time a cap-and-trade system is developed, it is necessary to make important choices. The initial price of carbon within the market may not be the most important variable to address. However, we do need a program that sets a credible ramp for reducing emissions over an extended period.
- Designing a cap-and-trade program requires many important decisions that must be carefully considered. However, it is also important to have some provisions that can be modified over time, such as the price for a safety valve or the rate at which the caps decline over time.
- It is important to have independently funded R&D to support the big technologies that we will need in the future. However, big technologies aren’t going to solve the problem on their own without a parallel demand for the technologies. You cannot say that we will wait to develop all of the technology before we start the cap-and-trade program because the technology will not develop without demand.

International Considerations

- There is an option value for having the right technologies employed as we make near-term capital investments. It's not clear what this option value is, but we need to study this. However, when discussing near-term investments we must think internationally in scope. Much of the new investment is happening outside of the United States in places such as China and India.
- This discussion has focused on a potential domestic US program, but climate change is a global problem. Some have argued that there is little prospect for implementing a cap-and-trade program that large developing countries would be willing to join. The success of any climate change policy relies on broad participation. A program implemented solely within the United States will not get us to where we need to go. So what is the purpose of all this domestic talk if we don't have a good prospect in getting rapidly developing economies involved with significant emissions limitations? It is also important to note that without emissions limitations in these countries, you can rule out the use of carbon capture and storage technologies. This technology does not compete in the absence of emissions controls.
- We need to remember that there is a continuous supply curve of GHG emissions reductions. It is easy to get scared about the costs of emissions reductions when we jump to carbon capture and storage technologies. The supply curve starts at a much lower level than the costs of carbon capture and storage. We need to exploit lower-cost options that may include opportunities such as efficiency, hybrid vehicles, and biological sequestration. One back-of-the-envelope calculation suggests that if we could increase the efficiency of existing coal units in China and India, we would reduce more greenhouse gas emissions through 2012 than what is possible under the Kyoto Protocol. This example would not necessarily involve reductions at US coal plants, and it would not require an international cap-and-trade program. However, it would require international collaboration that focuses on how to get the maximum GHG reduction benefits from limited resources. The United States may need to be more engaged on this issue internationally, but it cannot put itself at risk by focusing on only domestic programs. We must think about how to leverage the domestic changes that we need to make with the most cost-effective solutions that are available internationally.
- The whole idea behind the Kyoto Protocol is to create value for carbon reductions that could be generated within developing countries. This is enabled through the Kyoto Protocol's Clean Development Mechanism (CDM). One reason that CDM hasn't taken off is a lack of demand resulting from the United States' rejection of this accord. If the United States had its own GHG market that connected with the international market or if it joined the next phase of the international agreements, we would have an international regime that would create strong incentives for implementing emissions reductions in developing countries. These are the right structures to get greater cooperation within the international community.
- The CDM is not working, but it is not because of a lack of global demand for the credits. Many of the problems for this program result from the flaws in the mechanism's design features.

- The Chinese and Indian governments are further along in their thinking about the implication of climate change than many realize. They have performed their own studies using their own models. They have found that they are vulnerable to the effects of climate change, but they are waiting for the United States to move first on this issue. The United States would benefit by working with these countries because they provide an opportunity to demonstrate new low carbon–emitting technologies through joint ventures. China and India will hesitate to deploy new technologies such as carbon capture and storage until the United States demonstrates that it is committed to investing in these technologies.
- The United States is still in a position to lead the demonstration of future technologies. However, the window of opportunity for this leadership position is limited, as other countries are moving forward in this area.
- Numerous studies show that the least-cost opportunities for reducing GHG emissions are in developing countries. We should be thinking about how to leverage these opportunities through our energy research. For example, in addition to improving carbon capture and storage technologies and the fuel efficiency of vehicles sold in North America, we should also think about how to improve the efficiency of the cars sold in China or India.