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***Symposium Summary:
Greenhouse Gas
Reduction Programs &
Technologies***

Robert Slott, editor

December 2002

MIT LFEE 2002-004 RP

*Sponsored by the MIT Laboratory for Energy and the Environment
7-8 August 2002
Endicott House
Dedham, Massachusetts*

*Massachusetts Institute of Technology
Laboratory for Energy and the Environment
77 Massachusetts Avenue
Cambridge, MA 02139-4307*

*<http://fee.mit.edu/publications/>
Publication No. LFEE 2002-004 RP*

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Sponsored by the American Chemistry Council, American Petroleum Institute, California Air Resources Board, Health Effects Institute, MIT "Integrated Program on Urban, Regional and Global Air Pollution: Mexico City Case Study," MIT Laboratory For Energy and the Environment, Northeast States for Coordinated Air Use Management, PG&E National Energy Group, PSEG Services Corporation, United States Department of Transportation, and the United States Environmental Protection Agency.

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Greenhouse Gas Reduction Programs and Technologies

Endicott House, Dedham MA, August 7 and 8, 2002

Chair Robert Slott, MIT. Co-chair Praveen Amar, NESCAUM.

Wednesday, August 7, 2002

- 8:15 AM Henry Jacoby, MIT, Introduction
- 8:35 AM John Reilly, MIT, Non-CO₂ Greenhouse Gases
- 8:55 AM Andy Keeler, University of Georgia, National Policies
- 9:15 AM Discussion
- 9:35 AM Break
- 10:05 AM City Programs, Melissa Royael, ICLEI
- 10:25 AM Susan Anderson, Portland and Oregon's GHG Reduction Programs
- 10:45 AM Doug Howell, Seattle City Light, Greenhouse Gas Reduction Programs and Technologies
- 11:05 AM Discussion
- 11:35 AM State Programs, Praveen Amar, NESCAUM
- 11:40 AM Pierre DuVair, California Energy Commission, California
- 12 noon Lunch
- 1:10 PM Caroline Garber, Wisconsin
- 1:30 PM Sonia Hamel, Massachusetts
- 1:50 PM Mike Winka, New Jersey
- 2:10 PM Bill Lyons, U.S. DOT/Volpe National Transportation Systems Center
- 2:30 PM Discussion
- 3:00 PM Break
- 3:30 PM Industry Panel, Judi Greenwald, Pew Center for Global Climate Change
- 3:45 PM Bill Senior, BP
- 4:05 PM Mark Carney, PGE National Energy Group
- 4:25 PM Tom Jacob, Dupont
- 4:45 PM Discussion
- 5:15 PM Adrián Fernández Bremauntz, INE, GHG Mitigation Actions in Mexico
- 5:35 PM Discussion
- 5:45 PM End of 1st Day
- 6:30 PM Dinner and Reception

Greenhouse Gas Reduction Programs and Technologies

Endicott House, Dedham MA, August 7 and 8, 2002

Chair Robert Slott, MIT. Co-chair Praveen Amar, NESCAUM.

Thursday, August 8, 2002

- 8:15 AM Technology Panel, Nancy Brown, LBNL, Energy Efficiency Programs
- 8:35 AM Howie Herzog, MIT, CO₂ Sequestration
- 8:55 AM Marty Hoffert, NYU, Power Generation for a Sustainable Earth
- 9:15 AM Discussion
- 9:45 AM Break
- 10:15 AM Auto Panel, John Heywood, MIT
- 10:25 AM Paul Blumberg, Consultant, Light Duty Automotive Technology and Strategy Options
- 10:45 AM Klaus-Peter Schindler, VW, Fuel economy and the ACEA agreement
- 11:05 AM Philip Sharp, Harvard, NRC CAFE report
- 11:25 AM Alan Lloyd, ARB, AB1493,
- 11:35 AM Discussion
- 12:05 PM Lunch
- 1:15 PM Health Effects, Dan Greenbaum, HEI
- 1:30 PM Tee L. Guidotti, George Washington University
- 1:50 PM Jonathan Patz, Johns Hopkins
- 2:10 PM Discussion
- 2:30 PM Break
- 3:00 PM Henry Jacoby, MIT, Moderator of the Panel: Where do we go from here?
- 3:10 PM Eric Washburn, Office of Senator Daschle
- 3:30 PM Andrew Wheeler, Staff Member, Senate Committee on Environment and Public Works
- 3:50 PM Tim Profeta, Office of Senator Joseph I. Lieberman
- 4:10 PM Larisa Dobriansky, DOE
- 4:30 PM Vicki Arroyo Cochran, Pew Center for Global Climate Change
- 4:50 PM Ken Colburn, NESCAUM
- 5:10 PM Discussion
- 5:40 PM End of Conference

Henry Jacoby, MIT, *Introduction*

There are several broad points to keep in mind when working on climate policy. The first is to understand the implications of climate change over the next century. To do this, we need to understand uncertainty and the risk tradeoffs we are making. There is a climate roulette wheel – there is a chance that there will be less than 2 degrees of warming, and a chance that there will be more than 4 degrees – how much are we willing to gamble? The second point is what gases and sources matter. Transport and power each contribute a third of CO₂ emissions, but there are other important sectors and gases. A complex relationship exists between different compounds, both in terms of climate effects and other environmental impacts (Aerosols impact temperature and acid rain, tropospheric ozone is both a pollutant and a greenhouse gas). There are also large uncertainties involved in effects such as indirect aerosol forcing and biomass burning. The third point is realizing the scale of the task we face: we need to reduce global per capita emissions, but LDCs (lesser developed countries) need to increase their emissions in order to improve their standard of living, and persuading developed nations to reduce emissions is very difficult. The solution may be a combination of technology and wealth transfer. And we need to understand the history of climate policy. With the US withdrawal, Kyoto has become a policy that no longer imposes significant restraints on its signatories, even if Russia and Poland ratify to bring it into force. The US GDP linked target constraint is also lost in the noise. In summary, nations in Kyoto will do what they want, while in the US domestic fragmentation occurs as states, firms, and sectors each create their own plans. However, weak but broad climate policies may open the door to future control regimes, and tying emissions to growth may turn out to be a good idea. The final recommendation is to examine short-term actions and ask whether they are helping or hindering long-term substantial, coherent goals.

John Reilly, MIT, *Non-CO₂ Greenhouse Gases*

There are a host of climatically important substances other than CO₂. These range from the other greenhouse gases to ozone precursors to black carbon and sulfur compounds. The question becomes how to determine their relative importance in order to incorporate them into future policies? Global Warming Potentials (GWPs) are a way to compare different gases on a per ton basis, but suffer from the changing lifetimes of reactive gases like CH₄ and the cut off of 100 years for integration. Non-CO₂ gases turn out to be very important for reducing cost of policies (they account for 18% of emissions but reduce costs by 40% because of low cost abatement opportunities), and yield a large near-term reduction in temperature. Very long-lived gases can also be reduced cheaply. Other issues include the potential explosion in HFC usage in the coming decades, and the close correlation between methane and N₂O emissions and food production in developing countries, which would make reduction in those emissions politically difficult without significant cooperation from the developed world. In summary, including other gases in reduction policy is important for cost reduction and for effective temperature reduction.

Andy Keeler, University of Georgia, *National Policies*

Withdrawal from Kyoto has led to a focus on national GHG reduction programs. However, the voluntary standards proposed by the Bush administration leave a lot of regulatory uncertainty, and therefore registry systems are being developed to ensure that early action is not penalized. The two approaches being used are baseline certification and early action credits. Secretary Abraham has proposed a transferable credit system, but without any defined purpose. In any early action program, the devil is in the details: reduction credits can be simpler because they can be more easily certified. Baseline determination has to take into account "additionality" (does emission reduction to meet state regulations or non-GHG substances reduce an individual source's GHG baseline?), whether it provide incentives for numbers manipulation, and how to properly certify company wide emissions. But baseline determination is key for allocation measures based on grandfathering – politically the most likely approach. Economists favor auctions, or some system that allocates allowances based on an industry- or output-specific benchmark, both of which avoid the wasted effort and potential manipulation of baselines while ensuring that early action is not punished. These more logical regulatory forms may be more difficult to implement.

Discussion

There are some key decisions involved in designing a CO₂ cap and trade program: should a cap be utility specific or economy wide? Should it be placed down-stream or upstream? Upstream (where the fossil fuel enters the system), economy wide regulation is the most efficient option.

There are technical problems in monitoring CH₄ and N₂O reduction because emissions are not point sources. Sinks are also difficult to monitor. The MIT economic model addresses these difficulties by only abating where

measurement is available. E.g. N₂O abatement relies on elasticity of substitution for nitrogen fertilizer. Given that this is a blunt, poor instrument, it may be hoped that there will be superior alternatives in the real world.

Given that states historically took the lead on many environmental programs such as reformulated gasoline and acid rain, will that approach serve as a model for climate change policy? The major difference is that CO₂ is inextricably linked to energy use throughout the economy. Abatement is very difficult (though conservation and fuel switching is feasible). In the long term, an economy wide federal program is necessary to address the root issues. However, states can prod the federal government, by creating a patchwork of regulation that will encourage industry to lobby for a unified federal policy.

City Programs

Melissa Royael, ICLEI, *Local Governments and Climate Change*

The International Council for Local Environmental Initiatives (ICLEI) is an international association of local governments dedicated to the prevention and solution of local, regional and global environmental problems through cumulative local action. ICLEI's largest program is the Cities for Climate Protection (CCP) campaign, which includes 530 participants worldwide, 130 in the US. The list of US participants has skyrocketed to include a diverse range of cities, from the main players in environmental issues to small locales. When joining the CCP campaign, cities commit to five voluntary milestones: (1) conducting an emissions inventory, (2) setting a target for emissions reduction, (3) drafting a local action plan for meeting the target, (4) implementing the action plan, and (5) monitoring and reporting on progress. Local government policies and practices affect the major sources of global warming pollution, therefore local governments can make major advances in GHG reductions by improving their own municipal energy use, making their planning process more effective for transportation and land use, and better managing solid waste, and working with the residential, commercial and industrial sectors. While not every city is motivated by climate change, the multiple co-benefits can range from improved air quality and public health to reduced municipal operating costs. For example, LED traffic signals have saved Philadelphia \$800,000 a year by reducing energy usage. In Tucson, AZ, the reflective "cool roof" coatings applied to the municipal service center has become a best practice in Tucson. Many of these programs have had rapid payback times and large quantifiable benefits in cost savings, however, many impacts are beyond quantifiable, as people involved share their experiences and spread the message to their colleagues.

Susan Anderson, City of Portland's Office of Sustainable Development, *Portland and Oregon's GHG Reduction Programs*

Motivated by the wealth of natural resources in the area, Portland was one of the first cities to develop a local action plan to address environmental issues such as global warming. In 1993, the City of Portland published the Carbon Dioxide Reduction Strategy. The revised 2001 Local Action Plan on Global Warming assesses progress and adds emphasis on education. There is both an important technical as well as public relations side to these programs. Selling climate change actions to the community requires highlighting improvements in the quality of life, air and water quality, reduced traffic congestion, saving money for residents and businesses, and economic development. For example, in the northwest and other states such as Colorado and Utah, where winter recreation is an important local concern, focusing on reductions in snowfall can draw in a much wider constituency.

Looking at the results of these initiatives, per capita CO₂ emissions in Portland have decreased 7% since 1990 (compared to the 1% increase in the national average). These reductions took place during a period of robust economic growth. According to Anderson, Portland's environmental regulations did not dissuade businesses from coming, but instead encouraged businesses to move to Portland. Businesses value stability. As an early adopter of environmental regulations, Portland could offer not only regulatory stability, but also the quality of life that employees desire. These successes have come from transportation, energy efficiency in homes and buildings, and the availability of retail green power. In transportation, transit ridership has increased 65% since 1990. Streets have been made friendlier for pedestrian and bicyclists. Energy efficiency in buildings has saved the city \$2 million annually, representing 22% of total energy costs. People are not necessarily motivated by climate and energy issues, but they will care about a more vibrant city center, high performance buildings, and cost savings. Overall, it is all the other co-benefits that are going to sell programs related to energy and climate. In the long run, we need federal solutions. Nevertheless, over the next 10-15 years we need real action at the local level or change is simply not going to happen in the short run.

Doug Howell, Seattle City Light, *Greenhouse Gas Reduction Programs and Technologies*

The possible impacts of climate change in the Northwest have led to strong responses by the Seattle mayor and city council. The city's mandate to Seattle City Light (SCL) is to meet all load growth with energy efficiency and renewable energy. In addition, for all remaining emissions, SCL is to achieve zero net GHG emissions through mitigation. SCL is mostly a hydro utility with resources it owns and buys. It has about 1,700 average megawatts in total resources with GHG emissions coming from power purchases and lesser amounts coming from operations. GHG emissions are estimated to be about 380,000 metric tons with about 10 percent coming from upstream emissions. The emissions estimates have been reviewed by third-party verification and will continue to be reviewed because of ever-changing assumptions about what constitutes emissions liability.

Regarding mitigation, SCL gives a priority to displacing fossil fuels. SCL also seeks to have mitigation projects happen sooner as actual emission reductions. In addition, SCL will discount the value of mitigation projects that take place over multiple decades to help emphasize the need to displace or avoid emissions now, rather than waiting for decades when the climate change problem has only worsened. Current mitigation projects include increasing energy efficiency both by displacement and avoidance, and material substitution for displacement. Possibilities for future local projects include biogas, biodiesel, methane, sequestration, cement substitutes, and transportation. The ideal mitigation projects are approximately \$2-5 per metric ton of carbon dioxide equivalent. Mitigation expenditures are a small portion of SCL's overall effort to combat climate change. The majority of funding will continue to go to conservation and renewable energy. Total spending for conservation, renewables and mitigation is equal to approximately 10 percent of total revenues. SCL believes that other utilities should follow this example and direct the majority of funding to conservation and renewables to help ensure that the utility industry is investing in solutions that correct the fundamental problem: the burning of fossil fuel.

Discussion

Regarding co-benefits, Mario Molina inquired whether there have been cases in which there were not co-benefits and action required tradeoffs between air quality and climate impacts. For example, what are the air quality impacts of switching from gasoline to diesel buses in order to lower CO₂ emissions? Melissa Royael noted that these tradeoffs cannot be neglected. In ICLEI's case, they are in the process of improving their carbon emissions calculation software to include criteria pollutants so that they can better understand these tradeoffs.

A participant raised the issue of whether states or companies can "embarrass" others into action by being at the forefront of making these changes. For example, perhaps Seattle City Light's mitigation programs could serve as an example for other utilities to show that it can be done.

How do you better make this link between economic growth and environmental projects for reduced emissions? Susan Anderson replied that in Oregon, the Economic Development Department has actually started to realize the market value of a "green city" and exploring the possibility of developing an export industry based upon the technologies developed for local emissions reductions. The hope is that by being early adopters of technologies, such as wind turbines, a state can bring in the producers of these technologies and therefore generate economic growth and jobs.

Greg McRae noted that the idea of co-benefits has not been part of the discussion at the higher level of the global climate debate. As observed by Tip O'Neil, "all politics is local." How do we enrich the Kyoto debate to include the co-benefits of improvements in the quality of life in the urban environment? Royael suggested that because the Kyoto process is based on heavy quantification, cities have a difficult time entering into the debate in this area. It is hard to accurately quantify the impact of very local policies such as land use plans.

Marty Hoffert noted that he sees a major disconnect between global problems and local and individual efforts. From his teaching experiences at NYU, his students want to know what they can do to become active. Royael replied that as a first step, many colleges have implemented GHG reduction efforts on their own campus. Jonathan Patz emphasized that we need to quantify the co-benefits of improved air quality, but less direct co-benefits such as reducing transportation infrastructure, and the subsequent effects on heat islands, runoff from roads, and other impacts, are nearly impossible to measure.

John Heywood asked how ICLEI stayed up-to-date with rapidly changing technology. For example, whether diesel or natural gas is "better" is a very subtle issue depending on which pollutant is being considered, the maintenance of the vehicles, and a host of other factors. Royael emphasized the need to only be in touch with the experts, but also get information from the more progressive cities. There can be technology transfer of best practices between cities by bringing them together. While ICLEI does try to keep a certain level of expertise on their staff, but they do not

hold themselves as the experts, but try to keep up-to-date with the experts themselves, and the “experts” within individual cities.

State Programs

Praveen Amar, NESCAUM, Summary of State GHG Reduction Programs

Amar described the processes of environmental regulation and technology innovation as a learning curve from experimentation, regulation, and innovation to implementation. State programs are in the experimentation part of the curve, as dynamic laboratories in policy innovation. Many of the US state-level policy initiatives could achieve significant reductions in GHG emissions, and a growing number of state government policies are redefining a more “decentralized” climate change policy. Decentralization has its advantages, however, it also has significant limits. States can take the lead and push federal action to occur, but federal leadership needs to emerge quickly to bring overall efficiency and consistency to these efforts. Current state policy initiatives involve programs in pollution prevention, technology sharing, cross-boundary collaboration, agriculture, transportation, waste management, and forestry management.

Pierre DuVair, California Energy Commission, California

California has been conducting a top-down inventory approach. Gasoline is taxed, and so easy to track (though when bunker fuel was taxed it led to ships refueling in Mexico). The inventories show that despite a 10% increase in state population in the 1990s, and a 28% increase in state products, carbon emissions increased only slightly from 426 to 429 MMT CO₂. 58% of those emissions are from the transport sector. Carbon emission control has been due in large part to an improvement in carbon intensity of 19% during the decade, which means the Bush proposal is “business as usual” for the state. In order to track corporate inventories and project-based reductions the California Registry will be launched in September. It will allow companies to select 5% of their total emissions to be de minimis (not tracked), in order to simplify accounting. Many cities in California are members of ICLEI, and will therefore hopefully join the state registry. The legislature also wants to reduce petroleum dependence after the gas price spikes. The state also has a renewable energy target of 17% by 2006 (from 12% now, not including large hydro). Public Interest Energy Research (PIER) is funded by a surcharge on the deregulated electricity sector. In addition to inventories and efficiency increases, adaptation also needs to be prepared for – water resources and sea level rise especially. Snowpacks, a major source of water for the state, are melting appreciably earlier in the year.

Caroline Garber, Wisconsin

Two GHG programs are being addressed – both an inventory and a reductions registry. Starting in 1993, mandatory emissions reporting requirements were imposed on stationary sources and CO₂ was included as one of the 500+ emissions in the inventory. By 2000, 30 MMT were being reported by 184 sources. In 1994 a Climate Change committee was created which developed an action plan in 1998 to address triple “E” benefits: energy, environment, and economy. They wanted to take advantage of co-benefits with non-GHG reductions and ensure that early actors were not penalized. Innovative, non command-and-control regulations were encouraged, as was a balance between a robust, accurate registry and broad participation. “Anyway tons” (additionality) will be registered in order to encourage multi-pollutant approaches. The final registry system is very open – industry wanted more flexibility and fewer requirements. The registrant has the responsibility for credibility, but the tools are being provided – good guidance leads to good quality. There are a few pioneer companies indicating interest in this registry – communication will be a valuable tool in encouraging more companies to join. This work will provide tremendous value in encouraging measurement and tracking, and providing tools to medium and small companies which would not have the resources to do this on their own.

Sonia Hamel, Massachusetts

Compared to the rest of the U.S., Massachusetts has fairly low per capita emissions because it is fairly densely populated. Nevertheless, its emissions are the equivalent of whole countries such as Austria, Egypt or Greece. In Massachusetts, 78% of the population believes that global warming is happening, and 59% is worried about it. In addition, Massachusetts has many companies that could benefit from a worldwide market for energy and environmental technology; fewer energy-intensive companies are located in Massachusetts than in many other states.

The State will be releasing a Climate Change Action Plan which will seek to reduce emissions back to 1990 levels by 2015 (currently 7% above), will reduce emissions by 10% by 2020 and then seek to have all state sources no longer have a warming impact on the climate. These goals are the same as those adopted by the groundbreaking New England Governors and Eastern Canadian Premiers Plan, which was adopted in 2001. The Governors Plan recognizes that in the long term, it will be necessary to bring emissions to a point where they are no longer warming the climate and current science believes that this will require cuts on the order of 75 to 85% from current levels. Furthermore, the states have adopted a 2012 reduction target for state buildings and facilities of 25%. There are many opportunities for saving money through energy conservation, better tracking of energy costs, renewables, and green buildings. The state has adopted a four-pollutant regulation for its power plants to make significant reductions in NO_x, mercury, sulfur, and CO₂ so that companies can make decisions on all four pollutants simultaneously. The DEP is working on proposed rules for CO₂ involving a 10% reduction from the start of the regulation, with on site reductions or purchased credits. The New England Governors are considering a second global warming resolution to continue and reinforce their work, and will vote on specific work plans, goals and projects at their August meeting in Quebec City. There are also 15 cities and towns in MA that are developing climate protection plans.

Mike Winka, New Jersey

New Jersey, which won a Climate Protection Award from the EPA in 2002, keeps a rough inventory dating back to 1960. The state realizes that it has billions of dollars worth of infrastructure near the shoreline that could be vulnerable to sea level rise. In 1990 NJ implemented its Demand Side Management (DSM) program which has saved 100 million megawatt hours since 1990. Examining emissions by sector, it appeared that industrial energy use had already become efficient, and while transportation use is increasing, it is the commercial side where the most reduction per dollar can be achieved. The near term goal for the state is 3.5% below 1990 by 2005. To achieve that a NJDEP sustainability covenant has been crafted for commercial entities and for colleges and universities. There is a 4 pollutant agreement with PSEG including a 15% reduction in lbs/MWh by 2006. A set aside of \$2 million a year for purchasing green power has been created. The NJ Treasury department now approves of this set aside because of the avoided emissions and water conservation. And requiring all schools to maximize energy efficiency through the USGBC LEED guidelines (www.usgbc.org) will get builders used to working on energy efficient buildings starting at the design phase.

William Lyons, U.S. DOT/Volpe National Transportation Systems Center

The U.S. DOT Center for Climate Change and Environmental Forecasting conducts research on transportation and climate change, including a project on innovative efforts by states and local areas to incorporate goals to reduce GHG emissions through transportation planning. Transportation planning has major impacts on transportation decisions, which in turn influence travel patterns, energy consumption, and ultimately, GHG emissions. The traditional transportation planning process, described in the federal transportation law (TEA -21), is led by state Departments of Transportation (DOTs) and metropolitan planning organizations (MPOs). The GHG plans are typically initiated by state energy or environment agencies or city planning departments, and often originate in smart growth or energy initiatives. Transportation is prominent both as a major source of GHG emissions and of reduction strategies. The transportation strategies in the plans stress actions controlled by sponsors – fleet composition and employee trips – and broad policies with implementation to be determined.

Extensive state and local planning is underway to reduce GHG emissions: 40 states have completed GHG inventories, 25 have begun or completed GHG Plans, 130 cities and counties participate in the ICLEI Cities for Climate Protection Program, and many have developed or are developing GHG Plans. “Champions” are usually governors or mayors. Links to traditional transportation planning are considered essential but “a tough nut to crack.” Although climate change goals have not appeared in State DOT and MPO long range plans, many areas are expanding links to traditional transportation planning. Further progress will take sustained leadership by champions; outreach to elected boards, planners, and citizens to demonstrate links between transportation and GHG emissions; and peer examples to demonstrate that GHG goals can complement goals such as air quality improvement and traffic relief. Linkages can be established incrementally at critical stages of transportation planning: as a goal in strategic vision plans, in public involvement, and in technical studies. These smaller steps may be necessary before reduction of GHG emissions is considered as a possible criterion among others in selection of transportation projects.

Discussion

While states are working on their own plans, they would appreciate a good national registry. Unfortunately, while state legislators recognize climate change, it doesn't seem to be on the national screen for Congressional legislators. In California, the Congressional legislators sometimes only talk to Sacramento once every 10 years (when reapportionment comes up).

All the effort spent on developing inventories for downstream emissions will be wasted if an upstream tax or regulation is passed because of the direct relationship between CO₂ emissions and fossil fuel sales. Would this effort be better spent on downstream methane inventories instead?

TRI (Toxic Release Inventory) is not quality assured, but it has changed public policy. TRI serves as a good way to "shame" companies at the top of the list, who want to move down, but it is not good for baseline protection. Maybe public documentation of GHG reductions would be more appropriate than a TRI system. Transport is also a harder nut for TRI to crack because vehicle mix, personal behavior, and land use all play a part.

Industry Panel

Judi Greenwald, Pew Center for Global Climate Change, Chair

The Pew Center is difficult to categorize as an organization. It operates as a think tank and an NGO and also works closely with businesses through its Business Environmental Leadership Council. The Pew Center produces information through reports, other kinds of publications, and workshops; all under the assumption that information can indeed drive rational policymaking. The Pew Center's Business Environment Leadership Council (BELC) includes 38 companies, which are generally large companies that are part of the global warming problem and that want to be part of the solution. The BELC supports the design of rational public policies to address global warming; and each company is taking action to manage its own greenhouse gas emissions. In order to join the BELC, companies must agree to four principles: (1) enough is known about climate change to act, (2) businesses can and should take steps now to mitigate climate change, (3) the Kyoto Agreement is a first step, but more must be done in order to find a global solution, and (4) the United States can make progress in addressing climate change and maintaining economic growth by adopting reasonable policies, programs, and transition strategies. The Pew Center works with the BELC in three ways: (1) to educate opinion leaders and others about climate change policy and business activities; (2) to promote peer learning among businesses on greenhouse gas management, and (3) to use participating businesses as subjects of studies. All of the companies represented on this panel today belong to the Business Environmental Leadership Council.

Bill Senior, Group Environmental Technology, BP, *Managing Our GHG Emissions*

Currently supplying 3% of the world's oil and gas, BP is now a major energy company supplying, producing, and refining oil and gas. BP's involvement in the climate change agenda started in 1997, when the BP leadership saw the need for progressive action, making BP the first in the industry to address the climate issue. Looking at the GHG emissions from own operations, the majority of BP's emissions (80.5 million tons CO₂ equivalent in 2001) come from the manufacturing-related processes of exploration and production (39%) and refining (41%). In 1998, BP set a target of 10% emissions reductions from a 1990 baseline, although they did not have a firm idea of how this would be achieved. Notwithstanding, it was recently announced that this target has been reached, with reductions of 10 million tons from 1990 levels.

The leadership and vision of the CEO and the board led to the formulation of climate policies at the group level, which were then translated into a firm reduction target. The target was then pushed down through the four core business streams to reach the 100 or so business units throughout the world. Engaging the staff is necessary for success, but with 100,000 people, knowledge management becomes critical. The three main themes in BP's climate plan are: (1) improving BP's own energy and emissions efficiency, (2) the de-carbonization of fuels, and (3) a move toward renewable energy. Looking ahead, the next steps for BP's climate change agenda must include a combination of actions such as: improved energy efficiency, lower carbon fuels, and CO₂ capture and storage in the medium term. BP will set its own internal target to hold net emissions at 10% below 1990 through 2012, by a combination of 10–15% improvement in operational energy efficiency by 2012 and the use of flexible mechanisms such as GHG emissions trading and carbon credits.

Mark Carney, PG&E National Energy Group

PG&E National Energy Group (PG&E NEG), a North American competitive energy supplier, has two business segments, integrated energy and marketing, and natural gas pipelines. The company has become involved in GHG initiatives through several channels including: voluntary actions, including GHG emissions trading with other power generators; policy development, particularly the emerging GHG registries; and compliance with state requirements for offsets and mitigation. Regarding the voluntary GHG emissions trading, PG&E NEG have gained international contract experience through a sale of 817,446 metric tonnes of CO₂ equivalent, learning about buyer's issues such as the "buyer beware" principal, additionality and third party due diligence. In terms of policy development, PG&E NEG is involved in many emerging programs at the state level such as the California Registry and the Early Action Registry in Wisconsin. At the federal level, they are involved in legislation such as the Bush's Energy Bill and the multi-emissions legislation. Carney also described offset requirements in Oregon for the Hermiston Generating Plant and in Massachusetts for Millennium Power. For Millennium Power, they were required to spend \$305,000 for offsets, as well as develop a new project of landfill methane capture and destruction.

PG&E NEG is also exploring a wide range of offset opportunities, although more clarification in trading rules is needed prior to investment. Projects currently under review include sequestration, domestic energy conservation, renewable energy, as well as international projects in energy efficiency and renewable energy. According to Carney, one of the key issues for rulemaking is to deal with the geographic constraints. Companies should be able to offset for reductions anywhere in the globe. Looking ahead regarding trading, Carney emphasized that the Massachusetts' trading rules would drive the costs of GHG compliance and set the precedent for other state and regional programs. It is also important that this is not done on a state-by-state basis. Finally, PG&E NEG will also push for multi-emissions legislation at the federal level that deals with all four emissions, since the industry will have to deal with the "fourth emission" which is CO₂.

Tom Jacob, Dupont, *Preparing for a GHG-Constrained Future*

Dupont is an old company with a 200-year heritage of core values such as safety, ethics, and respect. The environment is a newer and evolving core value. In the early 1990s, DuPont defined a goal of zero for environmental insults. In 1991, having concluded there is cause for concern regarding climate change, they analyzed the entire company's emissions profile. They found not only large CO₂ emissions, despite decades of energy efficiency gains, but also heavy exposure in non-CO₂ GHGs, such as N₂O and HFC23. Thereafter, they started tackling their biggest points of exposure, focusing initially on N₂O abatement. There was also a renewed energy efficiency commitment. As a result, they have reduced global CO₂-equivalent emissions from operations by over 60% versus 1990 levels, and energy consumption remained flat during the 1990s, despite a 36% increase in production volume. One concern is whether credits will be awarded for these early reductions. As a mandatory reduction scheme is delayed, they continue to lose the potential for gaining credits. If their early action is not credited, it will result in a business liability by benefiting competing companies that have delayed in pursuing any reductions. Notwithstanding these concerns, DuPont has set firm goals to reduce the global carbon equivalent emissions over the next decade by 65% using 1990 as a base year, while also holding energy use flat as they move into more knowledge-intensive products.

There are two axes of concern that are relevant to climate change and industry: the perceived environmental risk and the perceived economic risk. Companies can be in either of the four quadrants. Most of global industry has until more recently fallen into the category of this being a non-issue on either axis. European industry has tended to see climate change as an environmental issue, while many US companies have viewed it primarily as an economic issue. Dupont actually agrees with both of them that this is a highly significant and complex issue with very high economic and environmental risks.

Discussion

According to Howell, one issue is whether industry is playing off state and federal legislative efforts, using each to undermine early moves by one or the other. Carney responded that they are not trying to undermine states' legislation, but the reality is that these problems are not unique to individual states. We can learn from state efforts, but we cannot let them all grow up into 50 separate and incompatible programs. According to Jacob, the sense at DuPont is that eventually there needs to be a national level program that begins addressing leakage and global competition, which are very important. However, they also have a keen awareness of the need for real action, and therefore support the broadening of action to the cities and the states. In terms of moving forward, it is necessary to broaden the involvement even as the Bush administration has killed the more global and national approach. We have to start somewhere, and state regulations may be a stepping stone rather than a final endpoint. For example, the toxic release inventory (TRI) list was initially called the California List. These state actions are developed and built-upon, not discarded when federal initiatives come online.

According to Heywood, we are disadvantaging all of our US businesses. If a company is better at making carbon reduction than the competition, they have a business advantage. For example, Japan and other automakers are running away with the markets for smaller and more efficient automobiles. The US is seriously disadvantaging its domestic industry by protecting it from a carbon-controlled reality and delaying the engagement of the US economy. Our indigenous industries simply do not have the pressure to innovate. Jacob added that by taking the largest markets out of the process, the US is delaying innovation on a more global basis. According to Greenwald, in the Pew Center's report on emissions targets, the companies they worked with recognized the long-term competitive advantage of being ahead of the curve. If carbon is not in the equation, then companies are not making the right decisions in their long-term business strategy.

Guidotti asked how BP is viewed within its own industry, and how much emphasis there is in there moving from BP (British Petroleum) to BE (British Energy). Senior replied that BP has seen many other companies responding to the changes that BP are making. For example, Shell is pursuing similar actions as BP regarding GHG emissions.

Adrián Fernández Bremauntz, INE/Semarnat, *Greenhouse Gas Mitigation Actions in Mexico, a non-Annex I Party to the UNFCCC*

Looking at Mexico's involvement in the UN Framework on Climate Change, Mexico signed the climate change protocol in 1992 and ratified it in 1993, then signed the Kyoto Protocol in 1998 and ratified it in 2000. As a Non-Annex-I party, Mexico has the following commitments under the UNFCCC: (1) develop and update GHG emissions inventories, (2) prepare and submit National Communications, and (3) develop GHG mitigation and adaptation programs. Looking at the current situation in Mexico, approximately 700 million tons of CO₂ equivalent are emitted annually (based on the 1996 inventory), with combustion and transportation being the top two sources. While several scenarios of economic growth have been considered, a medium growth scenario of 4.5% annual GDP growth from 1990 to 2010 will lead to a 70% increase in CO₂ emission, growing from 520 to 880 million tons CO₂. While the largest increase will be in the energy sector, transportation is believed to be the fastest growing source of emissions. Yet, there is a large potential for mitigation from nearly all sectors. Mexico seems to have decoupled its emissions from economic growth as energy intensity has fallen substantially since 1995. Regarding the global importance of Mexico's CO₂ emissions, Mexico is 13th in the world, 1st in Latin America and 70th in the world in per capita emissions. According to Fernández, Mexico has an identity crisis. While they have become members of OECD, this can be a mixed blessing. Sometimes Mexico wants to be in the developed world, but it can also be convenient to be a developing country when it comes to emissions reductions and trading opportunities.

Fernandez then reviewed a number of mitigation policies in the forestry area, the energy sector and transportation. Forest conservation programs include reforestation and reclaiming of agriculture lands for forestry production. In the energy sector, new energy efficiency standards are coming into place. There are also several renewable energy projects including wind power, rural electrification with small scale systems, water pumping systems, and methane production for landfills for electricity generation. In transportation, there is a wealth of opportunities and the government is attempting innovative strategies. Currently, the patterns of auto ownership and use are following the US patterns of motorization, including increased use of SUVs. A differential tax scheme is being designed to increase the average fuel efficiency of vehicles purchased by people. The high rate of motorization means that 50% of cars that will be in use in 2010 have not yet been manufactured. Finally, there are efforts to pursue joint control of urban air pollution and greenhouse gas emissions in Mexico City, since emissions reductions target for local air quality and global climate can be achieved less expensively if planned simultaneously. They are also trying to assess the co-benefits of emissions control measures.

Discussion

Henry Jacoby asked if Mexico, as a non-Annex I nation under Kyoto, but also working closely with the US, will be able to play in two fields simultaneously, using both the CDM as well as buying some credits. Fernández noted that the issue is complex, since there are three options for Mexico: emissions trading with the US, trading within the Kyoto framework, or reductions by their own initiative. He also noted that there is pressure to take on voluntary reduction commitments. Currently, there is not enough information for what is the best plan for Mexico.

Regarding Mexico's efforts to have more stringent regulations for new vehicles, a participant asked whether it would be better to hit the high emitters. Fernández replied that the reason why they are such high emitters is that these cars were born obsolete. The government therefore focused on getting the auto manufacturers in Mexico to catch up, in order to take care of the huge fleet that is just on the horizon.

The question was raised that whether in the face of significant health air quality problems, Mexico can justify a focus on long-term GHG reductions. According to Fernández, Mexico needs to look to where the co-benefits interface. One such example is sustainable transport.

Technology Panel

Nancy Brown, Lawrence Berkeley National Lab, *Energy Efficiency Programs*

Energy efficiency leads to environmental and economic benefits. A big success since the first oil crisis has been achieved through appliance energy efficiency standards, where advances are estimated to have saved \$5 billion (in 1990 dollars through 1995). As an example, 20% of residential energy used to be consumed by refrigerators – now the energy use of refrigerators in residences has been reduced by 75% of the 1973 value. LBNL and other national laboratories have developed a number of innovations in the area of energy conservation that have reduced energy costs and achieved corresponding reductions in carbon dioxide. At LBNL, the large effort in energy conservation research was started by two physicists, who each were visionaries. One of them is Art Rosenfeld, who has performed significant work in energy conservation in buildings, and who is now a Commissioner for the California Energy Commission. Art was instrumental in creating the DOE-2 software that contributes to energy efficient building design and has resulted in savings of \$2.5 billion (in 1990 dollars through 1995) and in spearheading significant other research as well. The second physicist, Sam Berman, performed innovative research in lighting that resulted in considerable reduction in energy costs (savings of \$1.2 Billion in 1990 dollars through 1995) and in corresponding carbon emissions. LBNL continues its innovative research in lighting. For example, energy efficient LBNL torchieres are both more energy efficient by 70 % and much safer than the halogen versions because surface temperatures are considerably less. Duct sealers, which decrease leaks in heating-ventilation-air-conditioning (HVAC) systems, save considerable energy, for example, \$ 1 billion per year in California alone. At LBNL, an ultra low emission combustion device, a premixed burner that can burn "fuel-lean" with low NO_x and CO emissions, is being commercialized for gas turbine and utility boiler applications. UV waterworks, another LBNL invention, can provide clean drinking water in LDCs for 2 US cents per metric ton of water, which is much less expensive and resource preserving than sanitizing water by boiling it and does not produce carbon dioxide. It is estimated that people use 3.0 kg of water a day, and boiling water over a biomass cookstove is the most reliable treatment method, but it demands labor and imposes high economic, environmental, and human health costs. Savings in biomass fuel to boil the water is significant if UV waterworks were used; however, UV waterworks has a \$1700 capital cost. A Federal executive order now requires 1 watt maximum standby power loss to deal with the problem that standby power accounts for 5 to 7% of residential power use. Low energy fume hoods use a better design to require less air movement (\$1000/year per hood in energy costs is usually required to pump the air). Recent advances in lighting have led to the development of the Berkeley lamp so that those working at a desk do not need overhead lighting, and this represents a significant energy savings as well... What is key in technology is overcoming two valleys of death. The first is associated with having the good idea moved from basic research to applied research and the second from applied research to development, or these very promising ideas and potential technologies will never make it to the marketplace.

Howie Herzog, MIT, *CO₂ Sequestration*

Carbon sequestration can remove carbon from the atmosphere, or divert and capture it from an emissions stream, and then store the carbon in a reservoir. These technologies fall into a long-term climate program between the "low hanging fruit" of energy efficiency and the final goal of zero carbon technologies. Economic modeling shows that

sequestration can be cost effective on the decade time scale, all the major components are proven, and choosing to develop sequestration recognizes the reality that trillions of dollars of carbon infrastructure will not disappear overnight. Examples of sequestration in progress include the Bellingham, MA power plant which sells the captured CO₂ into the market; the Sleipner project in Norway where a \$50/ton carbon tax has created incentives to inject CO₂ separated from natural gas into a briny aquifer; and the Weyburn project which used CO₂ byproduct from a synfuel plant for enhanced oil recovery but plans to seal and monitor the reservoir rather than blowing it down. The major market for CO₂ sequestration will eventually be the power industry: the problem is that at 15% of the flue gas (for coal – it is less for natural gas), it is expensive to capture the CO₂. For IGCC (integrated gasification combined cycle), the most advanced type of coal power plant, the additional cost of carbon capture will only be 1-2 cents/kilowatt-hour, comparable to wind power tax credits. Carbon sequestration will also be important for fuel decarbonization, if hydrogen fuel is made from hydrocarbons. Two major challenges remain for sequestration. The first is bringing the cost down (it is estimated that a tax of \$100 to \$300 per ton carbon would be necessary to make sequestration viable with current technology). The second is understanding the reservoir options. Each reservoir has issues of size, cost, permanence, and/or environmental effects.

Marty Hoffert, NYU, *Power Generation for a Sustainable Earth*

Given projected increases in power demands, and the necessity of eventually moving to carbon free technology in order to stabilize carbon dioxide levels, it is a good idea to look at the power generation options available. The business as usual case predicts 10 Terawatts of energy will come from carbon free sources by 2050. Today, nonfossil power is mostly hydro and nuclear with <1% of human energy consumption from other renewables (solar, wind, etc.). In order to achieve 550 ppm CO₂ stabilization, another 5 TW would be required by 2050, a total of 20 TW for 450 ppm stabilization, and 30 TW for 350 ppm stabilization (which would require additional energy to sequester carbon directly from the atmosphere). The question becomes where will this quantity of carbon-free energy come from? 10 TW of biomass energy would require cultivation of 10% of the earth's surface, equal to all of human agriculture, which would conflict with biodiversity and food production needs. Photovoltaics would require 220,000 km² area – which compares to 3 km² shipped between 1982 and 1998. Making hydrogen from PEM electrolyzers would require 30 times the world's annual platinum production for the catalysts. And nuclear plants using U-235 as feedstock would use up identified uranium ores within 6 to 30 years. Using sequestration to turn hydrocarbon energy into carbon free energy would require burying 5 to 10 GtC per year. There are still options – wind and solar together have promise, though transmission and storage considerations need to be addressed in order to deal with the intermittency and geographic limitations. Solar panels in space receive 10 times the solar flux, and power could be beamed to the surface with microwaves – especially attractive for LDCs without a power infrastructure. Fusion is a long term prospect, but in the short term could be used to breed "relatively benign" nuclear fuels from thorium. In summary, we need to think about where we're going and how we will transform our global energy system in a fundamental way. This is a hard problem, and needs massive R&D commitment, and the knowledgeable community should be making this statement forcefully to policymakers.

Discussion

To understand the scale of carbon sequestration, one must realize that total US power plant emissions are 1700 times the one million tons/year that the Sleipner project sequesters. One question is whether we will retrofit old plants, or only sequester from new plants – and if the latter, then they can be sited near to sequestration sites to reduce CO₂ transport costs. And despite a dearth of new coal fired plants today, we can expect eventual growth in the coal industry if natural gas prices rise.

Some researchers are working on serpentine as a sequestration medium because the process is exothermic. However, it is not a kinetically favorable reaction, and there is no commercially viable technique to pretreat the serpentine properly. Sequestration through mineralization would also require large amounts of materials handling.

LBNL works hard to get their new technologies into the market. They bring in people who work in facilities. There is an "A Team" who specialize in moving tech into the marketplace. And they use contacts in industry, the DOE, and the state of CA to help implement technologies (especially during energy crises). Ironically, several of the LBNL advances can't be used in CA – for example, CA OSHA has a minimum requirement for air flow in a fume hood that prevents use of the efficient LBNL hood. Heating and ventilation standards are currently a big fight, and 30% of peak summer demand in CA is air conditioning, so that is another potential area for efficiency increases.

Auto Panel

John Heywood, MIT, *Introduction to the Auto Panel*

To understand why the automobile sector is so different from the other sectors we have discussed thus far, and why this sector is so difficult to act upon, several characteristics of the automotive vehicle fleet should be emphasized. First, the worldwide vehicle fleet is vast. Cars and light trucks, with approximately 700 million light duty vehicles worldwide, dominate the fleet. As a result, vehicle and fuel purchasers and users are primarily private individuals. Second, the technology used to meeting transportation needs is nearly universal, with all forms dependent upon petroleum-based fuels, consuming 400 billions gallons of fuel annually. Third, while most of the policy focus is on passenger transportation, freight is also highly significant.

Because of the scale of the sector, introducing change takes substantial time. Even where proven technologies exist, the lead times for introduction of new technologies is 5-10 years, and the long lifetimes of vehicles, approximately 15 years, means that the time to replace the current fleet is decades. Yet, governments can and should push for change. An important example is the UK Government's recent report entitled "Powering Future Vehicles." The UK has set targets for low carbon-vehicles: 10% of new car sales should emit 100 gCO₂/km or less by 2012. This action sends strong signals to the markets about the government's priorities and indicates the focus of future government fiscal incentives.

Paul Blumberg, Consultant, *Light Duty Automotive Technology and Strategy Options: A North American Perspective*

There are many positive factors working in favor of automotive GHG reductions, ranging from the geopolitical need for less dependence on imported oil and growing consumer awareness of GHG emissions and fuel economy. There are, however, also many negative drivers for GHG reduction. A major barrier is the low cost of fuel in the US and the seeming political impossibility of changing fuel tax policy. In many cities, limited transportation alternatives mean that one must have a car to exist. Finally, there is no tradition (compared to Europe) of a reasonable balance between regulated emissions standards (i.e, those for toxic or smog forming pollutants) and technologies offering higher fuel economy, as reflected in the anti-diesel sentiment in the US.

The major paths to reduced GHG emissions could be a downward shift in the size of the vehicle fleet, new technologies applied to conventional vehicles, alternative fuels, and alternative powertrains. Technologies for conventional vehicles include improvements in IC engine powertrains and in the overall vehicle body and components. Looking at the range of options available, it is clear that there is no "silver bullet" as long as the primary fuel is fossil fuel, since no single plausible technology using fossil fuel is better for CO₂ reduction than any other by more than 15-20%. By 2010, a 35% reduction is achievable, but to go beyond that would require Draconian measures and/or would require long lead times and huge costs.

In order to achieve faster progress in improving fuel economy and CO₂ emissions, Blumberg offered the following recommendations. First, declare victory with respect to regulated air pollutant emissions at the Tier 2 level, so that resources can be better spent on CO₂ reductions. Second, harmonize emissions standards worldwide near the US Tier 2 and EU Stage V levels to reduce the manufacturers' workload of certifying to different standards. Third, ensure that emissions standards can allow high performance diesel as a significant option in the US. Finally, do not spend scarce resources on major development and fleet demonstrations (for example, fuel cell demonstrations) for technologies that still require scientific breakthroughs at the concept level.

Klaus-Peter Schindler, VW, *Fuel economy and the ACEA agreement*

There are several important Kyoto mechanisms that could be available to VW in meeting targets to CO₂ emissions reductions, including the EU "bubble" mechanism, Joint Implementation (JI), which VW could use with countries such as Hungary, and the Clean Development Mechanism (CDM), which can be used with developing countries such as China. Without any of these trading mechanisms, the cost for one ton of CO₂ would be roughly 200 Euros, while emissions trading would reduce the cost to 30 Euros. One major uncertainty, however, is how the politicians will intervene in the system and the impact that would have on the efficiency. In an agreement between ACEA (The Association of European Car Manufacturers) and the EU Commission, the members of ACEA will reduce GHG emissions from the fleet by 25% from 1995 to 2008 to reach 140 g/km. With a near term target of 165-170 g/km by 2003, the ACEA fleet is moving in a straight line toward its target. Some companies, including VW, are performing above the fleet average, while some are below the current ACEA fleet average, such as Porsche.

VW and other manufacturers are searching for CO₂ reductions along many different pathways. Modern diesel engines, for example, are very different from older diesel technologies, with high-pressure diesel injection, ceramic particulate traps, and NO_x storage catalytic converters. There are also many possibilities with combined combustion systems that join the advantages of diesel and gasoline systems. Future “mild hybrids” will have a flywheel starter generator and braking regeneration. A main problem is the weight of the vehicle. They need to reverse the “weight spiral” with lightweight construction, which increases upfront costs, but by reducing the volume and weight of the components, costs can be saved over time.

Philip Sharp, Harvard, *NRC Report on Corporate Average Fuel Economy (CAFE)*

To put the problem of GHG emissions in perspective, the US light duty automobile fleet is responsible for 5% of worldwide carbon emissions. Current trends are not reassuring. Average fuel economy in US is falling. After a peaking in 1987-88, fuel economy has fallen by 7%. The problem is the separation of fuel economy standards into light duty (LD) trucks and automobiles, with demand for LD trucks growing rapidly. While the NRC identified many new technological developments in the industry, these advances have improved attributes such as power, safety, and amenities, and not fuel economy. The consumer interest in fuel economy is simply not prominent in the marketplace.

The mandate to the NRC was to address the issue of why would we intervene in the marketplace. According to Sharp, the primary reason was climate change. The second reason was oil imports, an issue that resonated with Congress. CAFE clearly helped to bring down gasoline consumption, although it is unsure how much was caused by other factors such as rising gas prices and the perception that prices would continue to increase. In the 1970s and 1980s, CAFE was going in the same direction as the marketplace. According to the NRC report, 2.8 million barrels of oil per day are saved compared to what would have occurred without CAFE standards, representing 14% of current consumption.

Alan Lloyd, CARB, *AB 1493 (Pavley) Bill: Greenhouse Gas Reduction and Motor Vehicles*

Transportation contributes 58% of California’s total GHG emissions, the majority of those emissions being CO₂ with lower amounts of HFCs, nitrous oxide and methane. The Pavley Bill, or AB 1493 gives the California Air Resources Board (ARB) the direction to control GHG emissions from motor vehicles. While there were complaints about the bill as “too vague” to do anything meaningful, ARB views the bill as an opportunity to work with industry to shape something concrete and more meaningful.

According to the major provisions of AB 1493, by January 1, 2005, ARB is required to adopt regulations that achieve the maximum feasible and cost-effective reductions of GHG emissions from new passenger vehicles. In doing this, ARB must consider: technological feasibility, economic impacts, cost effectiveness and ensuring maximum flexibility, and consumer costs. ARB must submit regulations to the legislature for review by January 10, 2005 for a one-year examination period, and regulations may not take effect prior to January 1, 2006. The regulations, therefore, will not apply until the model year 2009. Under AB 1493, ARB is specifically prohibited from certain actions. ARB cannot do the following: (1) ban the sale of any vehicle category in the state, including SUVs and minivans; (2) impose additional fees and taxes on any motor vehicle, fuel, or vehicle miles traveled; (3) reduce vehicle weight, (4) place limitations or reductions on speed limits, or (5) otherwise limit vehicle miles traveled. Some of the possible technologies for reducing GHG emissions include off-the-shelf engine technologies and transmission technologies, as well as some emerging engine technologies. In fact, many technologies already in the market place are effective at reducing automobile GHG emissions.

Discussion

Diesel vehicles were discussed in several of the presentations. In the US, there was well-deserved negative sentiment in the US due to their impact on air quality and problems in the 1980s. However, diesel vehicles will almost certainly meet Tier II standards in the near future, as well as the new California legislation.

Given the significance of the California law at the national level, and the legal battles that have followed, the panelists were asked what they believed the outcome of this would be. Sharp suggested that through this bill, California will place enormous pressure on the agenda at the federal level. According to Alan Lloyd, there is more than a 50/50 chance that AB 1493 will stand up in the courts. The more important victory, however, may be that the initiative wins in the courts of public opinion, and people support these types of efforts.

A participant asked where the bias toward large vehicles originated, and whether this bias was influenced in part by advertising from the auto industry. Is industry creating a market, then complaining to the regulators that the market does not want better fuel economy? Blumberg replied that while one could argue that in part it is coming from the manufacturers, Americans have always had a love affair with the car, and seek performance, comfort and size.

It was emphasized that we should be careful trading off one environmental problem versus another. While some of the solutions sound attractive, we need to take a systemic perspective to see if we are pushing something else out of the tailpipe such as methane or formaldehyde that creates new problems as we try to resolve others. Heywood noted that this is a good word of caution. Unfortunately, the US has been unable to make these tradeoffs well. However, these tradeoffs do exist, and we need to lower the temperature of the debate to look for ways to make wise decisions.

Health Effects Panel

Dan Greenbaum, Health Effects Institute (HEI), Chair

The driver in the environmental arena has usually been human health, though there are one or two exceptions like DDT control for saving the bald eagle and wetland preservation for other factors. There exists a strong scientific consensus about climate change, but models still are not perfect predictors of temperature and climate changes, and the step from climate to air pollution and other health factors is also difficult. An absence of certainty should not impair progress, but at least analog analyses can estimate magnitudes of impacts.

Tee Guidotti, George Washington University and the Canadian Institute of Child Health, *Climate Change: The Implications for Child Health*

Global warming can be a misleading term – the problem with climate change is the increase in extreme and chaotic weather due to additional energy in the system. Humans adapt to temperature extremes, but not on short time scales, and less well to heat than to cold. This can be seen when heat wave mortalities occur at temperature thresholds that are much lower in northern cities, where individuals have not adapted to higher temperatures. After 3 or 4 days, mortality during heat waves levels off. These extremes are especially dangerous for vulnerable populations: the elderly, the sick, the poor, and children. The young have immature thermoregulatory mechanisms, their developing nervous system may be susceptible to hyperthermia, and they don't sense overheating and so may not compensate well for the increased temperatures. There are encephalopathic changes with heat – high fevers can cause seizures, thermal stress inhibits attention, judgment, learning, and sleep. Children are also vulnerable to socially mediated health effects, like refugee migration, and increases in family violence, all of which may be affected by climate change. Air quality is driven by weather, so all the problems associated with poor air (asthma sensitization, insults to developing lungs, and respiratory tract infections) can be associated with climate change. The Royal Society of Canada recognized 9 years ago that there were steps that could be taken to protect children: we've lost 9 years, but these opportunities still exist today.

Jonathan Patz, John Hopkins, *Climate Change and Variability: Human Health Case Studies*

Health can depend on a variety of factors, including agriculture, water resources, coastal zones, and biodiversity. Climate change will have impacts on heat waves, air pollution, vector and water-borne diseases, environmental refugees, and agricultural yields (agronomists claim CO₂ fertilization may reduce protein content in grains). Already, heat is a larger health factor than many realize – the 1995 Chicago heat wave led to 700 excess deaths. Climate is a confounder for air pollution mortality and cardiovascular deaths. It is possible to determine a temperature/mortality response function in order to calculate the lives that could be saved in an urban area by reducing temperatures. An air pollution model, MODELS-3, has been applied to the Mid-Atlantic region with success at predicting ozone under emissions and climate scenarios.

There is a relationship between climate change and diseases. Flooding leads to mold and fungal growth, which lead to respiratory disease. Ragweed and other allergenic plants release more pollen under high temperature and CO₂ conditions. Cold-blooded insects are sensitive to ambient conditions, and incubation periods for diseases like malaria are shorter in high heat so the mosquitoes can become infectious more quickly after they feed. Drought leads to good conditions for spreading encephalitis and the West Nile virus, as birds congregate near small standing water pools that are breeding grounds for mosquitoes. The good news is that according to the Hadley model, conditions may no longer be as good for Lyme disease and Rocky Mountain Spotted Fever. As a closing note, compare the price of gasoline to beer, milk, or water.

Discussion

Humans respond to crises. So in order to make health an issue in the climate change debate, we need to communicate findings such as the connection to the West Nile virus. Encouragingly, in the last several years, the media has been addressing these issues more frequently.

In addition to addressing emissions per capita, we also need to address population growth. Many health outcomes are related to overcrowding and population displacement, but it is a politically incorrect topic in the IPCC.

Emissions in the US are a consumption issue, but in the LDCs (less developed countries) it is a population issue. However, women in developing countries want access to better family planning – they just need the information.

There are many confounding factors in attributing heat wave deaths. Certainly, the Chicago heat wave affected low-income areas and isolated individuals disproportionately. Some deaths occurred because windows had been nailed shut for fear of crime. The poor can be considered a sensitive subpopulation.

The developing world is interested in co-benefits – reducing local air pollution with energy efficiency measures provides immediate health effects. But can we persuade the developing world to follow a different path to a high standard of living than the United States followed? Especially given that we send them our old dirty cars so they can imitate our lifestyles? China is now making the auto industry a pillar of their economy, with a fourfold increase in vehicles predicted by 2020. But the good news is that they are moving faster than we did in terms of local pollution control, at least.

Where do we go from here?

Henry Jacoby, MIT, Chair

Eric Washburn, Office of Senator Daschle

There are many people in Washington who recognize and understand the problem, but the enormity of the challenge makes moving forward difficult. Industry remains nervous about the economic consequences of new policies. In the meantime, environmental groups are waiting for Congress to wake up, or for the tipping point at which things get so bad that there is a rush for legislation. The energy bill is one of the first moves forward at the federal level. The Byrd-Stevens Bill calls on the Bush Administration to pull together a stabilization plan. The Registry is another small step forward. But, even if we succeed in what we have on the table now, these are only small, incremental policies. Climate change is like the health care debate that has been going on for four decades. Are we heading down the same path with climate change? How can we shift the politics? According to Washburn, it will take a massive public investment in industry to get them to make the investments that need to be made now. The government needs to figure out the financial resources that are required for industry and automakers to make the investments we want to see them making. If we wait for the political system to enact policies to force industry to make these investments, we will not see the type of change that needs to start happening now.

Andrew Wheeler, Staff Member, Senate Committee on Environment and Public Works

According to Wheeler, we need to start over on the policy side, both internationally and nationally. The Kyoto process has failed and we now need to take a different approach. There are four areas in which we can and should move forward: (1) continued science and research on climate change and mitigation strategies, (2) establishment of a climate registry, (3) the President's Energy Plan, and the (4) re-authorization of the "Highway Bill" (TEA -3).

Looking at the bell-curves for the rise and fall of energy sources, we see that solar, nuclear and wind power are only barely moving upward, while oil and coal have peaked. Speeding up the move away from fossil fuels will not happen in the next 5-10 years, but will require decades. We need research and development to support this change. Regarding the registry, it is important to provide a mechanism to set benchmarks and allow for companies to claim credit for early reductions when a mandatory CO₂ program is established. We also need to implement the president's energy program. The US has started reaching out one-on-one to developing nations to help them to reduce their dependence on carbon. The re-authorization of the Transportation Efficiency Act (TEA) is another area in which we can move forward. Congestion has become a major issue as far as air quality is concerned. One example is the Big Dig in Boston, and improvements in emissions from congestion relief. This is a case of achieving emissions improvements without relying on CAFE standards. Following the analogy of low-hanging fruit, Wheeler suggested that perhaps we are picking our fruit off of the wrong tree by putting resources into CO₂,

which is 50-100 years out, while ignoring NO_x, mercury and other problems that are causing public health risks today.

Tim Profeta, Office of Senator Joseph I. Lieberman

While there has been increasing attention and activity in Congress regarding GHG emissions, movement toward concrete action has been slow. There are, however, several possibilities on the table. One example is the Byrd-Stevens Bill. This bill proposes dedicated resources in the White House for strategic planning on the issue of climate change, with the creation of a new office and budget. The office would be tasked with the creation of a national climate change strategy to reach Rio obligations for stabilization at a safe level.

While the current debate focuses on the "4P" legislation and the need for a comprehensive program for industry, utilities are only one-third of the domestic GHG problem. McCain and Lieberman are suggesting a new path, which addresses the economy-wide system. If we cannot take action internationally, the US needs to reduce emissions domestically in a more comprehensive manner. While the system established in Kyoto may not be the best structure for the US, by rejecting that system, we need to create our own precedent that is better and more efficient. In the meantime, without action, we continue to lose credibility abroad. The bill proposed by McCain and Lieberman, which will pursue a cap and trade approach, will be introduced this fall. Regarding the design variables of the legislation, they have met with many stakeholders. The goal is to introduce the bill before the end of the 107th Congress. The bill will be compatible with other efforts on multi-pollutant legislation, and will respect and protect the early action of progressive companies. Finally, the bill will provide as much flexibility as possible, including international trading, sequestration and other mechanisms for reduction and mitigation of GHG emissions.

Larisa Dobrianksy, DOE

The President's climate change initiative sets out an environmentally and economically sensible long-term vision. This is a measured approach that addresses the key shortcomings of Kyoto. It proposes to reduce greenhouse gas intensity by 18% by 2012, 4.5% below forecasted levels, which validates the US commitment to the UNFCCC. It is important to recognize that research is vital to decreasing future emissions, and that harming the economy and throwing away capital today is counterproductive. Economic growth is a solution, not a problem. \$4.5 billion has been allocated for climate change research and measures. That includes \$2.4 billion of programs and tax incentives for technology broken down into \$1.6 billion for R&D energy efficiency, nuclear, sequestration, forest and agricultural management, and clean coal, \$211 million for international efforts, and \$555 million for tax incentives for climate related investment. There are increases in funding for hydrogen, biofuel, low-speed wind, fuel cell, zero net energy building, CO₂ capture, and terrestrial sequestration. The 1605B registry program will be enhanced in order to create accurate, reliable, and verifiable records with reforms to protect early actors and provide for transferable credits. Bush has called on the business community for agreements and individual firm commitment. He also wants to broaden international cooperation in several ways. Assisting developing countries through expanding technology transfer is an effective, science based response to the fact that DC emissions are a large and increasing share of global emissions, and the opportunities for cheap mitigation there. \$155 million has been dedicated to climate change in the US AID 2003 budget, \$178 million for the UN GEF (a 77% increase), and \$40 million for a debt for nature program. Specific bilateral agreements and cooperatives projects will be revitalized. The plan is well calibrated, comprehensive, and an effective balance between near-term and long-term requirements.

Vicki Arroyo Cochran, Pew Center for Global Climate Change

The initiatives at the state and local level presented earlier in the symposium were a reminder of the type of change that can come about from a few dedicated individuals. While additional research on climate change and its impacts is good, action must be taken now. A Pew Center workshop led by Nobel Laureate Kenneth Arrow and titled "The Timing of Climate Change Policies" highlighted several key points. First, with climate change, we are entering into unknown territory, and there is the potential that climate change will not necessarily be smooth or incremental, but may include dramatic changes in the global climate. These changes may be irreversible, leaving impossible tasks for future generations. Therefore, we need to begin learning by doing, and seek out no-regrets options. Looking at a menu of options for the design of a domestic program, it was suggested that a mandatory reporting system, and an economy-wide cap and trade programs with a modest carbon price would stimulate change and spur technological development.

The Pew Center recently analyzed the Bush Plan, and has expressed concerns about the targets themselves and the targets' modest proposed deviation from business as usual. The US needs legislation for reporting GHG emissions and securing baseline protection for early actions. A lack of an articulated program creates considerable uncertainty for business, as they face a patchwork of state action and no strong federal stand on the climate issue. Furthermore, developing countries will be less likely to act if they do not see the number one emitter moving forward with real action. In summary, the response to the question of whether to “think globally and act locally” is that we should think and act at all scales – local, regional, national, and global.

Ken Colburn, NESCAUM

The bad news is that climate change is already upon us; the evidence is there. Some sections of the Northeast, for example, already saw warming of 3.5 degrees Fahrenheit in winter between 1895 and 1995, along with corresponding effects on natural resources industries. The good news is that states are beginning to take action. Better yet, states are beginning to recognize that doing the “right thing” environmentally is often the “right thing” economically as well. The fact that per capita income and average electricity rates are positively correlated – as are states’ rankings on both “Green” and “Gold” scales – shows that long-held notions that economic growth and environmental protection operate counter to each other and must be “balanced” are now obsolete. In the electricity sector, for instance, steps (like energy efficiency) that dramatically reduce air pollution also provide cost savings, enhance system reliability, reduce peak demands on the grid, and decrease vulnerability to price and supply shocks. Further, renewable energy sources are typically job-intensive, whereas central power stations are capital-intensive, requiring few workers to run them. Coal mining jobs are already declining due to mechanization despite increasing coal production, so wedding ourselves to the highly polluting coal-fired technology of the past instead of the job-creating energy efficiency and renewable technologies of the future will increasingly allow US citizens to be unemployed and ill. This dynamic is already evident, as we have already lost our edge in some renewable energy technologies. Modern wind power was developed in the US, for example, but the Danes now command 50% of the market compared to our 10%. Renewables are technology and labor intensive and thus provide more jobs, whereas “business as usual” energy favors capital and raw material consumption. Besides being cleaner, more secure, and more reliable, energy efficiency technologies are also more exportable. Adopting them aggressively will help to preserve and enhance our global competitive advantage; delay in doing so will not only harm the environment, it will endanger our future economic competitiveness.

Discussion

Returning to the issue of whether climate change should be considered a long-term versus a short-term issue, a participant suggested that it is misleading to characterize climate change as simply a long-term problem. The sooner we slow or reverse current trends, the easier it may be to achieve long term stabilization. There is further concern because of an analysis by Michael Oppenheimer suggesting that there is a limited time window to make the changes needed to reach stabilization; after this point it may be impossible to stabilize the climate. Notwithstanding, the US is stuck in the debate over whether to set limits, not even getting into the issue of how deep these reductions need to be.

Regarding CAFE, labor and industry have lined up against tightening the fuel efficiency standards, since they are still wary that this CAFE will impact their competitiveness. However, the argument has also been made that industry and labor could in fact be winners with some well-designed steps forward. A participant suggested that if anything will save the domestic industry, it is pushing the industry toward greater efficiency. One the one hand we are trying to protect jobs and profits, but that protection from environmental realities is leading to a decline of the domestic industry.

According to Amar, from what we have heard during this symposium, there is major disconnect between what is happening at the state and the local level. He asked why carbon would be different from historical experiences, where California has led the federal government in making changes. In response, it was suggested that federal inability to lead or to have a progressive role on these issues is because Congress works on a crisis or consensus basis. With climate change, the ability to get to consensus is hampered by the complexity of the issue. One way in which California may lead on the carbon issue is by winning in the “court of public opinion” through AB 1493. In this way, perhaps public support for these kinds of state actions can bring consensus to the federal policymakers.

On the federal level, we talk about climate change but not the impacts of climate change. Congress does not seem to be getting the message about the health issues related to climate change, since the causal connection is so complex. Furthermore, the health impacts are less acute for the US and other developed countries. By defining “health” more broadly, however, we would consider more carefully the recent increase in extreme meteorological events. These are not health impacts per se, but these changes mean people are drowning and losing their homes. Clearly, we can adjust, but this is going to be very disruptive and expensive. We need to understand what a few degrees temperature rise means in Alaska, for example, where homes are sinking into the permafrost that is not longer permanent, requiring adaptation today. We focus on transportation’s contribution to the problem, but at what point do transportation planners take into consideration the impact of climate changes, such as greater rainfall, on how streets are built and maintained? Another example of a group that may be increasingly sensitive to climate impacts is the farming coalition. They should not only worry about a larger tax on their trucks, but that water delivery in August might be interrupted, or that flooding will wash out more roads. The insurance industry is already getting behind climate change, since they realize the costly damage and risks associated with these climate impacts.