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A Comparison of a Cap & Trade System v. Alternative Policies To Curb U.S. Greenhouse Gases

By Michael Canes

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Michael Canes

February 22, 2007

Jeff Kueter: Good afternoon. I am Jeff Kueter, the President of the George Marshall Institute, and it is my pleasure to welcome you to this installation of our Washington Roundtable on Science and Public Policy. This is a continuing series of the Marshall Institute designed to bring together the scientific and technical communities to discuss issues of importance.

Given the considerable interest in climate change topics in the early part of this year, we asked Dr. Canes to discuss a study of cap and trade we released in December 2006. Cap and trade programs, of course, have come to the forefront of the policy debate over how best to respond to climate change. By contrasting proposed cap and trade programs with the empirical outcomes of ongoing technology deployment efforts, Dr. Canes' report offers a basis for policymakers and the public to compare potentially competitive options and to make informed judgments about the utility of one approach versus the other or some combination thereof.

Dr. Canes is a Senior Research Fellow at the Logistics Management Institute. He previously was Vice President and Chief Economist of the American Petroleum Institute, where he sponsored the early development of the Charles River Associates Multi-Sector Multi-Region Trade model for climate change policy analysis. He has been a member of the faculty of the Graduate School of Management of the University of Rochester. He has a PhD in Economics from UCLA and an MSc in Economics from the London School of Economics. Please join me in welcoming Dr. Canes.

Michael Canes: Thanks very much, Jeff. It is a pleasure to be here today. I appreciate very much the opportunity to spend a few minutes with you discussing some of the issues surrounding climate change policy. I should say that I am a Senior Research Fellow at the Logistics Management Institute, but I am speaking here entirely on my own; the views I represent here are not necessarily those of LMI or of anybody connected with the organization.

[*] The views expressed by the author are solely those of the author and may not represent those of any institution with which he is affiliated.

I intend to make a series of points with you here today and I will give a series of arguments in each case why I think those points are important and valid. First, that any compulsory constraints on fossil energy use we might impose will have an impact on U.S. GDP. Second, that a cap and trade system, which is currently being discussed in a number of quarters including Capitol Hill, is a particularly costly means of constraining greenhouse gases (GHGs) relative to other options that I will talk about it. Third, I will talk about what has actually been happening, what the record looks like with respect to U.S. greenhouse gas emissions and curbing those emissions. If you are not familiar with that record, there may be one or two surprises for you in how those numbers look. Fourth, that curbs on greenhouse gases, while an important objective, are not our sole social objective, and that has implications for how we should view the problem and possible policy options. And finally, that well-funded research on means to deal with climate change, coupled with strong capital recovery incentives, provide powerful mechanisms to curb U.S. GHGs. I will talk about that as one of the options.

First let me spend just a few minutes on the point that energy and output are related, and that therefore curbs on energy consumption will have impacts on output. Output is produced by a combination of labor, capital and energy. Energy is both a substitute for and a complement to labor and capital. By that I mean that labor and capital can be substituted for energy to perform work and produce output; that is the sense in which they are substitutes. However, more energy makes labor and capital more productive and hence increases their per unit output; that is the sense in which they are complementary. I will assert also that more output requires more energy. Much cost-effective energy efficiency is possible, but on-going U.S. economic growth will require more energy use. I will spend just a few moments on each of those points.

Figure 1

Output is produced by a combination of labor, capital and energy. What you see in Figure 1 is a drilling rig. That is a way in which labor and capital combine with

energy, which is used to drive the drilling rig to produce output, which in this case is oil and gas. This is a pictorial representation of the point that all three resources go into the production of output.

Figure 2

But labor and capital can be substituted for energy to perform work and to produce output. So if you want to do with less energy, you can substitute people to do work (Figure 2). You must perform work to produce output and there are ways to substitute labor or capital for energy, sometimes productively, sometimes not so productively, but it can be done.

Figure 3

More energy makes labor and capital more productive and increases their per unit output. Figure 3 is a picture of a steel mill; it shows that workers with capital and a lot of energy can produce a lot of output. If you add energy to the mix, you can ac-

complish more work with the same labor and capital, which means that the capital-output ratio and the labor-output ratio are enhanced with the addition of more energy.

Much cost-effective energy efficiency is possible, but ongoing U.S. economic growth will require more energy use. This is a topic of some controversy among people who are conversant with energy technology and particularly energy efficiency technology. There is a belief that a great deal that can be done cost-effectively to reduce energy use and to provide the same level of services with less actual energy input. I think there is something to those arguments. I think there are high transaction costs associated with knowledge about energy efficiency so that sometimes it is difficult to employ energy saving methods that would be cost-effective if people had perfect information about what can be done. Nevertheless, when you think of more cost effective energy efficiency being employed in vehicles, structures and processes on the one hand, and of income growth generated by population and productivity growth on the other, you come to the inescapable conclusion that we are going to demand more energy in the future than we are using today. It is simply inevitable. It could be that for years we could conserve our way out, but eventually we will want to use more energy and we have to plan for that.

Figure 4

So what are the implications of curbing fossil energy use, which is what we have in mind when we talk about curbing greenhouse gases? Fossil fuels make up about 85 percent of total U.S. energy use. Oil makes up about 40 percent of our energy use, coal about 23 percent, natural gas about 23 percent – that is about 85 percent – nuclear accounts for about 8 percent and renewables (Figure 4) for about 6 percent. So when we think about curbing fossil energy use, we are thinking in terms of curbing the

vast majority of the energy that we use. Constraints on fossil fuel use will force substitution of higher cost, less productive inputs and hence reduce the growth of U.S. GDP. This is an implication of what I was saying before; if you curb the use of one input and instead use others that are higher cost or less productive, you will have an impact on the growth of GDP. The magnitude of these costs will depend in part on how the constraints are imposed.

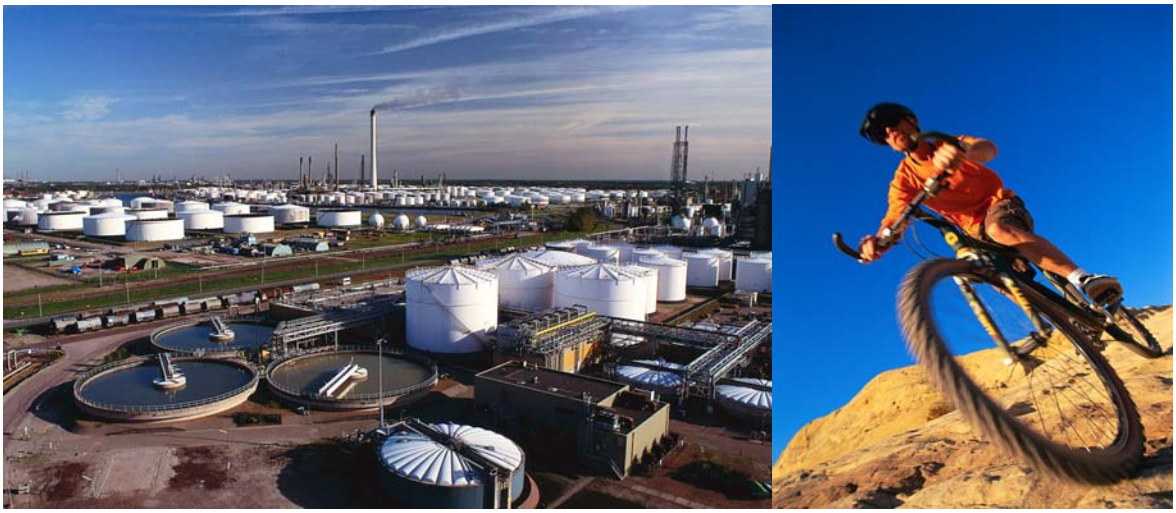

Figure 5

Figure 5 (left) shows an oil refinery. As I said, oil is the single largest fuel, representing about 40 percent of total energy use and almost half of fossil energy use. Constraints on fossil energy use will force substitution of higher-cost, less productive inputs and hence reduce the growth of U.S. GDP. Figure 5 (right) is meant to illustrate a move from oil-utilizing vehicles to a less productive form of transportation, not something we want to do.

The magnitude of costs will depend on how the constraints are imposed. I am going to look at a cap and trade system and compare it to a carbon tax, which many economists believe would be a superior device. Also, I will propose a third alternative consisting of research and development, enhanced capital recovery incentives and private-public partnerships. I will talk about all of those, but for now I am going to focus on the cap and trade system.

As those of you who are familiar with cap and trade know, it is meant to be a constraint on carbon and it would be a constraint on fossil energy use as well. Tradable emission rights would be created under such a system and they could be either given away or auctioned. There are all manner of proposals, but I stress that no tradable emission rights in the United States have ever been auctioned. Therefore, when you think about what is actually likely to happen, given the political calculus of installing such a system, the more you try to add auctioning as a feature, the more resistance you are likely to get. Tradable emission rights have not been auctioned in the past and one has to question whether they will be auctioned in the future.

Theoretically emission rights could be traded internationally; that is the idea. The Europeans have a scheme and if we had a scheme, rights could be traded between us and them and with others as well. There are already institutions in place for joint development projects, so it all could be done on an international scale. A tradable rights regime could have a "safety valve" feature, where the government would be prepared to sell extra allowances at a pre-set price, so that if there were too much volatility in the market prices of these allowances, there would be a way of reducing that. However, when you look at actual proposals, while some have a safety valve feature in them, a lot do not. There is a reason for that. Many in the environmental community are very uncomfortable with a safety valve because it means that you may not reach the particular quantitative goal that the cap and trade system was set in place to achieve. So whether there would really be a safety valve feature is open to serious question.

So what are the magnitudes of the costs of a cap and trade system, if that policy were adopted? You begin with the GDP losses. These arise from the point that I was making earlier, that when you constrain energy use and are forced to substitute labor and capital, you will have an impact on GDP. EIA has done a series of estimates of different cap and trade proposals and they all end up concluding that after a period of time the losses begin to accumulate. They reach small percentages of GDP, but GDP is very large, and therefore the numbers run in the tens of billions annually after some years. Even in the most benign of the proposals, meaning they have safety valves and are slow to develop, those are the numbers that EIA projects. The numbers can run in the hundreds of billions of dollars annually and when broken down by family, they are several hundred of dollars per family per year after the constraints have been in effect for some time.

Data Resources Institute (DRI) and Wharton Econometric Forecasting Associates (WEFA), which are now all one firm, and Charles River Associates also have made estimates. The magnitudes of their estimates depend upon the particular features of the program, whether there is trading, whether there is a safety valve, whether there is international trading and so on. But they all find that the costs are significant and run into the tens of billions at least, in some cases hundreds of billions if you constrain the program more tightly. So, economists who have done work in this area conclude that you are going to have costs in term of GDP and they will be fairly substantial.

However, while the costs of constraining fossil fuels are always estimated by these models, there are two forms of costs which, to my knowledge, are never estimated in the models. The first is the cost associated with competition for the allowances, because if you distribute allowances for free, then they are a form of windfall wealth. People understand they are forms of wealth and therefore they want to have more of these allowances. A regulatory process of some kind would be needed to distribute them, after which they would be traded. That would induce rent seeking, which means trying to get something from the regulators through lobbying. Resources would be put into that and there would be a lot of money at stake. The U.S. produces

roughly 7 billion tons per year of carbon. So if you thought the price was going to be $20-30 a ton or something in that range, you are talking $100-200 billion. The number might be smaller to start. But nevertheless you are talking about very significant amounts of money and therefore very significant inducement to put resources into obtaining allowances from the regulators.

What sorts of strategies might be followed? I am not sure, but those seeking allowances might argue that "our area of the country is particularly disadvantaged" or "we have a lot of poor people here" or some other rationale why historically they are in a more deserving position than others and should get more allowances. Of course, if the allowances were all auctioned, this problem would not exist, but as I mentioned earlier, that is highly unlikely. The likelihood is that many if not all of the allowances will be freely handed out, probably roughly based on historic use, and that would induce costly rent-seeking behavior. How high might those costs be? That is hard to say. People have to understand the rights distribution system and have to see what may be possible, but in theory if there is $100-200 billion at stake, all of it could be absorbed in the lobbying game. Perhaps the costs wouldn't reach that magnitude, but whatever resources are incurred in this activity are never included in modeling estimates; at least, I have never seen them estimated.

In addition, there are costs of monitoring a trading program. If it is a domestic program, there are costs of measuring what each emitter emits annually. If an emitter says they are reducing their carbon emissions and so have rights to sell, that has to be monitored, it has to be proven, and there has to be a process for that to happen. There are possibilities of black markets in allowances, since allowances would have value, and also in fuels not attached to allowances. Unscrupulous parties could offer fuels "for free," that is, without the allowances. All of that will have to be monitored in a cap and trade system. Even in a best-case scenario, covering only primary producers of fossil fuel energy, we are talking about thousands of emitters. If there is an international trading program, the problems become much worse. It is very difficult to monitor behavior all over the world. Governments are involved and they can be offering, under an international allowance trading system, allowances for projects in their countries. But are the allowances real? All that has to be monitored and the costs of doing so would be even higher. Again, to my knowledge, these kinds of costs, the monitoring and administrative costs, are not generally included in the econometric estimates.

When I look at a cap and trade system relative to a carbon tax, if just those two options are on the table, I believe a carbon tax would be the more efficient way to go. A number of economists have made this comparison, and I cite here four of them. William Nordhaus has been working on this problem for many years at Yale. He put out a paper in 2005 pointing out how volatile the price of carbon would be under a cap and trade system and how volatile the price of energy would be as a consequence, and the impacts this would have on the economy. He estimated substantial deadweight losses from such a system and recommended against it. Richard Cooper at Harvard covered

a lot of the same ground and basically argued that an international trading system is unworkable, that the monitoring problems are so great and the chances of corrupt entities being involved in it so great that it probably would not work. William Pizer of Resources for the Future wrote a paper in 1999 in which he compared the carbon tax approach to the cap and trade approach. He said that it all depends on the particulars of the cap and trade system, but that the carbon tax is up to five times more cost effective than cap and trade. Finally, Rob Shapiro, who used to be with the Progressive Policy Institute and was active in the Clinton administration but now is with a company called Sonecon, wrote a paper issued just this month. He argued against a cap and trade system on many of the same grounds as the other economists. He talked at some length about the dangers of manipulation of the international allowance market by entities with incentive to do that and concluded, as did the others, that if you are going in this direction, a carbon tax is the way to go.

I want to talk now about what the U.S. has actually been doing and what its record looks like. We start with the fact that while our GHGs have risen since 1990, the GDP of this country has increased more rapidly than most major western nations. We will take a look at those data in just a second so you can get a sense of what I am talking about. The U.S. has reduced the carbon intensity of its GDP faster than most large industrial countries. This is a very important point in my opinion because it measures how rapidly carbon is being reduced relative to GDP growth. Such growth is crucial because constraining carbon is not our only social objective. We have other objectives and the way to pay for those is to generate as much GDP as we are capable of. I won't get into all of these at the moment, but they include a lot of different things, including other environmental objectives. So carbon intensity becomes a crucial metric, because if we are trying to grow GDP as rapidly as we can, but still want to deal with the carbon problem, then carbon intensity is a good way to measure our progress because it tells us whether, given our GDP growth, we are cutting our carbon use at a sufficiently high rate. Immigration and population growth often are ignored in assessing U.S. GHG emissions and these account for about one-third of the growth in U.S. emissions between 1990 and 2004. I will come back to that and show you the data that support it.

CO_2 and GDP Growth, 1990-2004

Country	% incr. in CO_2 (1990-2004)	% incr. in GDP (1990-2004)
U.S.	**17.9**	**52.1**
France	10.0	27.1
Germany	(6.6)	18.2
Italy	17.3	21.5
Japan	24.4	21.1
Spain	61.2	41.8
U.K.	(3.1)	39.2

Table 1

Table 1 shows some numbers on carbon dioxide and GDP growth between 1990 and 2004. The raw data are taken from EIA tables and I have condensed it into a convenient form. I only show here a comparison with some of the other leading OECD nations; there are many others, Austria and Belgium and so on. Our record is impressive compared to just about all of them. Our increment in CO_2 between 1990 and 2004 was almost 18 percent, which, for example, would compare with what Italy did. It is less than some other countries, but more than others. If you look at the increment in real GDP between 1990 and 2004 in real terms, ours was about 52 percent, greater than that of any other of these Western nations. So if you compare us to Italy for our CO_2 emissions, they look about the same, but you can see our GDP grew about 150 percent more than theirs. There are countries like France who constrained their GHGs more than we did, but their growth in GDP was just about half of ours. The Germans and the U.K. have good records with regards to GHG reductions, but as many of you will know, both those countries had special circumstances over this time period. The Germans absorbed the East and were able to shut down a number of inefficient factories and coalmines. That made a lot of difference in their data. The U.K., back in the Thatcher era, moved away from subsidization of the coal industry and towards the use of gas from the North Sea and that made a difference in theirs. I don't say that these account for all of their performance, but they were important factors for those two countries. Also, of the countries that constrained their GDPs well, only the U.K. had economic growth anywhere near that of the United States.

Carbon Intensity of GDP by Country
(MMT/$1000 US in $2000)

Country	1990	2004	% Reduction (1990-2004)
U.S.	**.19**	**.15**	**21**
France	.09	.08	11
Germany	.16	.12	25
Italy	.12	.12	0
Japan	.07	.07	0
Spain	.14	.15	(7)
UK	.14	.10	29

Table 2

So what about carbon intensity? What does the record show over the period 1990-2004? Table 2 provides data measured in millions of metric tons per thousand dollars of U.S. GDP. The comparisons are made on a purchasing power parity basis, I believe, and this is all in constant 2000 dollars. The U.S. has cut its carbon intensity over the time period by about 21 percent, which compares pretty well with most of the other large countries. The two closest competitors again are Germany and the U.K., in part because of special circumstances and in part also because they were active in other ways. But the data show that we have been doing pretty well compared to most other Western countries.

What about 2005 and 2006? We have partial data; the tables aren't complete at EIA, so I couldn't update the tables shown here. But I do know that in 2005, according to EIA and EPA, U.S. carbon dioxide emissions increased .3 percent while GDP increased 3.2 percent. So the differential is about 3 percent. For 2006, we only have ten months data so far on fossil fuel use in the United States. The latest *Monthly Energy Review* has this data, showing coal consumption down about 1 percent, oil consumption down 1.3 percent, and natural gas down .8 percent. So roughly speaking, fossil fuel consumption was down about 1 percent over the ten months through October, whereas we know for the year 2006, U.S. GDP increased about 3.4 percent in real terms. The differential there will run around 4 percent for the year, that is, the intensity will drop by about 4 percent for the year, so I conclude from these data that U.S. carbon intensity dropped about 7 percent over the years 2005 and 2006. What that means in terms of the top line of Table 2 is that we were now at about .14. Seven percent would be roughly a drop of .01, so we are at about .14. We are moving in the right direction. Other countries might be moving too; I don't know, since I don't have updated data for them. But we continue to reduce carbon intensity at a pretty good rate in the United States.

Population Growth

Country	1990 Population	2003 Population	% Change
U.S.	**250.0**	**291.0**	**16.4**
France	56.7	59.8	5.5
Germany	80.0	82.5	3.1
Italy	56.7	57.4	1.2
Japan	123.6	127.6	3.2
Spain	38.8	41.9	7.8
UK	57.3	59.4	3.7

Table 3

Still, when you consider the record of the United States over the time period, our carbon dioxide emissions did rise. However, if we look at population we will see one reason why. Population in the United States went up about 16-17 percent over this time period whereas for every one of the other large OECD countries, population increase was in the single digit category, many around 2-3 percent, France around 5 percent (Table 3). So there is a big difference between what has happened in the United States and elsewhere, and that accounts in part for why our emissions rose by more than some others over that time period.

Where did the population growth come from? Some of it was generated just by people having kids here. But a good part of it, actually about 54 percent of the population growth over the period 1990-2003 (here my data is switched by a year) is due to immigration. Immigrants and their offspring accounted for 54 percent of U.S. population growth, 21.3 million of a 39.2 million total increase in population over that time period. Over that time period, our greenhouse gases grew 12.4 percent. How much

difference did immigration make over the time period? Suppose immigrants only produce two-thirds the greenhouse gases per capita of others in the U.S., on the theory that they are not as wealthy as the average American so they don't consume as much and don't travel as much and so on. I use that number as a rough estimate. If you take 50 percent of the population growth and two-thirds of the per capita greenhouse gases, then immigrants account for about one-third of the 12.4 percent. In other words, counterfactually, had there been no immigration over this period, no immigrants nor children of the immigrants, U.S. greenhouse gases would have grown about 8 percent as opposed to 12 percent, and other countries' greenhouse gases – wherever the immigrants were coming from – would have grown more. The people who immigrated instead would have been in those countries, they would have consumed something, and there would have been more greenhouse gases emitted there. So when international comparisons are made, I point out that the U.S. is a country that imports people as well as goods and services and that this has some impact on greenhouse gases here.

What is actually going on in curbing greenhouse gases and what impact have some of the programs had that we have in place? Are all of these intensity reductions accidental, or are we actually doing things that make a difference in the record in this country? We know that we are spending about $3 billion a year at the federal level in research and development on climate. Some of that is spent developing technologies that help us become more energy efficient. I will show examples of that shortly. Some is paying off in terms of more productive capital equipment that uses less energy per unit.

The Asia-Pacific Partnership doesn't get a lot of notice. This partnership includes the U.S., India, China, South Korea, Australia and Japan. The Chinese are rapidly catching up with the United States in terms of total greenhouse gases. India is growing rapidly too, and in not many years, India will be one of the large-scale emitters. The Asia-Pacific Partnership is intended to begin to address that problem. It does so through encouraging technology transfer among the countries involved and also technology transfers to others to help them use energy more efficiently. It is a start to bringing the Chinese and Indians and a few others into a world effort to curb GHGs. It is voluntary; whatever targets or goals are set are voluntary, but nevertheless it is the first mechanism I know of to begin to deal with the question of Chinese emissions or Indian emissions in a world in which we are going to try to deal with the GHG problem.

There are a lot of public-private partnerships. These don't get a lot of publicity either, but you may have heard of some of the names, like DOE's Climate Challenge, Climate Wise (managed jointly with EPA), Clean Cities, Carbon Sequestration, and the Biofuels program. There are a lot of these in which the government works with the private sector. Sometimes they subsidize private companies, but often it is just asking such companies to set goals and then to give favorable publicity to those that reach their goals. A lot of companies have signed up. There are multiple reasons for that, I

think. Sometimes they like what we might call the public relations benefits. In other cases, it may be that people in the companies, the CEOs, feel that "there is a problem here and I am willing to be part of the solution. I am willing to commit my company to try to help." So you have these partnerships. EPA has some too, Energy Star, Natural Gas Star, Coalbed Methane, Waste Wise and so on, a series of partnerships EPA works with private sector entities to curb emissions on a voluntary basis, but usually with goals and commitments on the parts of companies.

Environmental groups also have these kinds of partnership programs with businesses. These are not U.S. programs, but they are important in that entities like Environmental Defense, World Wildlife Fund, the Pew Center on Climate Change, and the World Resources Institute work hard to get companies to commit to voluntary GHG reduction goals, which they then publicize positively if they make them and not so positively if they don't. Finally, there are programs at the state and city levels. Some of those are getting more publicity now with what is going on in California, but I am talking here about voluntary programs. Minnesota Releaf has to do with tree planting in that state; Seattle City Light has to do with putting more efficient lighting in that city and encouraging businesses around the city to do so.

What are the results of these various programs? I will quickly describe some of the technologies coming out of DOE's program that are aimed at trying to develop more efficient uses of energy. Thin film solar, improved wind turbines, superconductivity advances, lithium battery advances, better industrial process catalysts, and more efficient biofuel production are just a few of the technologies which have been both developed and deployed. Several years ago the EPA and DOE, in the Climate Action Report to the United Nations Framework Convention, estimated that voluntary programs taken as a whole would yield about a 9% reduction in U.S. GHGs in 2010. About a year ago I went back and checked with someone from EPA who worked on that, asking whether this is still a valid estimate. He told me that it is; we are still on track to get to that point.

Climate change is an important social issue and steps should be taken to deal with it; I do not question that premise. But I do question whether we should focus on that to the exclusion of all else. That drives my thinking about what we should be doing. I have identified a few of our other social goals, and there are many others: infrastructure maintenance and expansion, education, population health and welfare, other environmental objectives, poverty reduction, the global war on terror (which maybe should be at the top of the list), and help for others abroad via foreign aid of various sorts. These are all worthy social objectives and we have to have the wherewithal to pay for them. So I become nervous about constraining the growth of GDP when I think in terms of all the different things we want to do. Let's be careful about how we go about dealing with a problem which is important, but not the only problem we have to face. GDP growth enables all U.S. social objectives by which I mean it provides the resources whereby we can deal with other social issues.

I have moved beyond cap and trade and carbon taxes for the moment to policy choices: strong research, development and deployment programs, as I was describing, energy efficient technologies and low carbon fuel alternatives including, most likely, nuclear, strong capital recovery incentives, recapitalization and replacement of the capital stock. In the end, when you ask how we are going to curb carbon emissions and cut the GDP intensity of carbon, it is going to be through replacement of less efficient capital stock with more efficient. That means structures and equipment, buildings, HVAC systems and vehicles. One way in which to induce people to do that is to promote strong capital recovery, that is to say, accelerated depreciation or expensing or a tax credit or whatever it might be that would give people an inducement to replace existing capital equipment with more energy-efficient versions. We should also maintain and strengthen our voluntary GHG reduction programs. By that I mean that some of them work better than others. By rewarding the programs that are getting us better results and not putting as much resources into programs that are not getting us as good results, we can strengthen the voluntary programs beyond where they are today.

Finally, I conclude that curbs on fossil fuel use will reduce GDP growth, and a cap and trade system is a particularly costly means to do so. If we are going to constrain GHGs through compulsory means, a carbon tax would be a superior way to go, in my opinion. Curbing GHGs is important, but it is not the country's sole objective. The U.S. has reduced the carbon intensity of its GDP at a rapid rate and we are continuing to do so. A strong R&D program to promote energy efficiency and low carbon fuels coupled with aggressive capital recovery incentives can and will provide effective tools to curb U.S. GHGs. Thank you very much. I would be happy to take questions.

Questions and Answers.

Question: In your report that you had us read before the presentation, you included a country that is not on your slides – it is Denmark. I am curious to know what the cause is for their numbers. Their numbers are literally off the chart; they are real low and they still have growth in population and growth in GDP. I am curious; is that because of windmills? It is so different from the other countries.

Canes: They do show a reduction, but I don't know exactly what the Danes have been doing, a gas substitution program possibly. I would have to look that up and get back to you.

Question: I have a question in terms of Congress and their "interest" in this whole issue. They propose tax credits year after year, such as for wind power. Isn't that manipulating the market and how do we get Congress out of choosing the winners and the losers? Shouldn't the market be choosing those winners and losers in energy?

Canes: That is an excellent question. The argument, I think, is that there are certain technologies that are in the development stage and we have to bring them along and

encourage them. But then soon they will stand on their own two feet and after that you don't have to subsidize them. That is the theory behind bringing wind power along or solar or some other new technology.

Question: But should we even be subsidizing them to begin with?

Canes: Well, I am just giving you the argument that is made for that. They are infant industries, so we get them on their feet and then they should be able to compete on their own. The problem is that once you create an incentive like that, then you have a group that wishes to defend it, for obvious reasons. And they lobby and they generally do get the extension. We have had subsidies for corn-based fuels and for other things for a long, long time and it is very hard to remove them, once they are in place.

Question: But when you look at what the benefit has been, when you look at wind and its contributions to electricity, it is dismal. For the future, we will have to depend on fossil fuels if we want reliable energy.

Canes: There are many arguments with regard to wind: it only blows some of the time and you need backup and that makes it much more expensive than it seems to be. But I see demand for energy in the United States continuing to grow for the indefinite future. I think that we are going to need all the forms of energy that we can find. We may wish to tilt away from carbon-intensive fuels; I believe that we can control nuclear energy well enough that we should be looking at that. But I am not ruling out something like wind. I put the windmills up on the screen earlier mainly to relieve you of having to see more oil and gas refineries. But I put it up also because wind may be one of those technologies that can contribute, maybe a relatively small portion, but perhaps one day a more significant contributor. Wind can make contributions in some areas of the country and I wouldn't rule it out.

Question: I agree largely with your analysis with regard to the preference for a carbon tax over a trading scheme. What do you know about the GDP effects of a tax? Let's say you were going to set the tax at $20 a ton, as they are talking about in Europe. What would be the impact of that? Would you offset that with reductions elsewhere, such as with taxes on labor?

Canes: That's a very good question. I have not personally estimated that, but I imagine it would depend on a couple of things. One would be whether you phase the tax in over time, so that people can anticipate what it would be and could behave accordingly, as opposed to just slap it in an unanticipated fashion, which I think would have adverse effects on the economy. The other is how the money is spent, what is done with the money as it comes in. Is it spent efficiently in some way? If it were up to me, I would use some of it for capital recovery incentives. The reason we are taxing carbon in the first place is because we want to induce people to use less of it. If we think that is very important, then let's use some of the revenues to give them a positive incentive to re-

place equipment and thus cut carbon. In other words, it would be a two-pronged program; tax would be half of it and you would use capital recovery incentives as the other part to induce people to make changes.

Question: Has LMI done much analysis as to the contribution of the highways, the fact that cities have expanded into suburbs, adding to the heat retention, absorption and reflectivity of the black surfaces, roofs and parking lots and so on? That has contributed and probably goes parallel to the expansion we have seen over the centuries.

Canes: First of all, I have to say again that I am speaking on my own here, not for our company. But LMI has not, to my knowledge, worked on urban or suburban sprawl. There is something to what you say, but you have to recognize that this reflects people's preferences. It isn't an accident that people are moving into suburbs and new highways and parking lots are being built. It is because this is how people want to live in the United States. You can argue that they should live differently; I would like them to live differently or other people would like them to live differently, but this is an expression of free choice, opening up new places and then building the infrastructure to support that. That isn't necessarily a bad thing. So we have to be a little bit cautious about how far we are willing to go in stopping people from doing what they want to do. We can give them other incentives and they may behave differently, but it is an expression of the American public in the marketplace that leads to this phenomenon.

Question: I may be able to provide some insight about Denmark. I was in Denmark two years ago and heard a Danish minister say that he was very proud of their wind power. I think it is upwards of one-third of their electricity right now. My question to you is about the government's role in trying to revitalize the electric distribution grid; how much the government is investing in that? There are a number of issues tied to that. One is the issue of base load electricity generation. There's a view out there that coal, nuclear and natural gas will provide, as you know, the major base load power, but that is partly a function of how we distribute electricity in this country. There have been a lot of press stories recently that the electrical distribution grid needs stronger support. People in the security field like me are trying to make the point that if we want to be more resilient against terrorist attacks and natural disasters like Hurricane Katrina, it might make sense to have more decentralized types of regional grids. That could allow people to actually sell the energy they generate through wind, solar, or whatever means, back into the grid and that would allow us to tap some of the other non-traditional sources of electricity generation.

Canes: That already exists to some extent in some states. And I appreciate your filling us in about the Danes; I had forgotten about their wind programs. On this question about the security of the grid, I agree with you. I think there are important questions associated with that. I am a member of a Defense Science Board study that is looking into this question from the perspective of military installations. That is rather specialized, but nevertheless this problem has come to our attention. I tend to agree that

there is potential problem here and that distributed energy may be one part of a solution to create greater resiliency. But this goes far beyond what I know about and what I am talking about today and into the incentives that you want created at the local levels by state utility commissions. It is probably too far beyond us to talk about that much today, but in general, I agree with the directions that you would encourage and think there is something to doing so.

Question: When you ran your cap and trade models, did you factor in at all the potential increase in GDP that would be created by the new market in trading carbon?

Canes: To me, that is a cost. Those are resources that you have to put into a cap and trade system. The whole idea is to do it more efficiently than just command and control. Cap and trade allows trading, and in that sense you could say there is gain in efficiency relative to merely saying, "This is what you are limited to." But you have to ask, what are the resources that we are going to have to devote to this system? Putting together an exchange is part of that; all the people who are involved, the traders and so forth, that is a cost. Those are resources that are diverted into making a cap and trade system operate. That would be my reaction.

Question: I have a similar point. The sulfur dioxide (acid rain) program is an allowance-trading program. There is no black-market because the government issues serial numbers for its allowances. Why hasn't that been tagged with some of the criticisms that you see leveled at the European system and carbon trading in general? It is widely viewed as an essential program, as far as I know. What do you see as the level of political support among our elected leaders for instituting a tax in the U.S. and elsewhere?

Canes: On the first question, the sulfur dioxide trading program is a lot simpler to monitor and control because there is a relatively limited number of sources and it is only one gas. In contrast, there are six greenhouse gases and many more sources, literally thousands. The one criticism that has been made about the SO_2 program is that the price has been somewhat volatile, at least recently. That is the notion behind some of Nordhaus's criticisms and Cooper's too, that you may get volatility in the allowance market and that is not good. That tends to be a cost. In the case of the sulfur dioxide market, maybe that is less of a problem. On the question of political support for a carbon tax, I might say tongue and cheek that once you get outside the economics profession, the numbers tend to fall off pretty quickly. If you wanted to create a political coalition behind a carbon tax, you would have to identify what you would do with the monies in a way where people saw that they would be getting something out of such a program. I am not sure that is a good thing to do; then you start to create some of the very same rent seeking costs that I associate with a cap and trade program. Nevertheless I think that is how you would have to build support for a carbon tax.

Question: Most people tell me that volatility is a way for the market to understand what the prices are and it is not necessarily a bad thing. It can be a bad thing, but

when other markets are rising, futures markets tend to deal with the volatility. If you had a futures market that arose in conjunction with this kind of trade market to handle volatility, would that not be an economic way of addressing that concern?

Canes: So you are saying, suppose you have volatility; prices of carbon, for example, are going all over the place, but you have this market in place, a futures market, so people can hedge. Volatility may impose costs on people, but there are ways to cut those costs. If they are willing to buy futures, if they are willing to hedge on prices, then they can cut the costs to themselves. They could economize their costs some if they were very skilled. It is surprising how few people actually take advantage of that; for example, the Federal government in buying fuels does not take advantage of futures markets. Its buyers have their reasons; they are not exposed to the same kind of financial risk as private sector players. But even besides that, they feel it is not something that they wish to take advantage of. This leads me to believe that there may be others as well. In any case, volatility does impose costs. The fact that they can be economized helps some, but it doesn't make those costs go away.

Question: I wanted to get your critique on cap and trade extended to carbon sequestration. Just from an economics perspective, putting the technical questions aside, how do you look at the property right that is going to be created by another wing of capital recovery incentives? They aren't going to be focused on avoidance; they are going to be focused on use of fossil fuels with capture. So we have similar issues related to monitoring costs, potential fraud and abuse, which agency is really going to sign off on the warrants and the liabilities that, yeah, it is sequestered and for how long. These are the issues going on behind a lot of the debate going on the Hill right now.

Canes: I agree; I think sequestration is in its very early stages and a lot is not understood about what might actually happen. As I understand it, the quantities of CO_2 that would be created would overwhelm existing markets, which are for soda pop and enhanced oil recovery. Therefore you would have to pump the CO_2 into the ground and there are questions whether it would stay underground and how far you would have to take it to find a proper reservoir and so on. I have seen rough estimates of what it would cost to sequester carbon for a coal liquefaction plant that used integrated gasification/combined cycle technology. The estimates are that it would add about 30 percent to the overall cost of such a project. And that is without answering some of the questions that you raise, whether in fact even if you did everything correctly, you could be certain that the carbon dioxide would stay under the ground and so on.

Question: Who would take the liability, from an economic standpoint, of it staying in the ground?

Canes: That is a question that I haven't given very much thought to. Presumably it starts with the person who produces the CO_2 and then the question is whether that person can sell off the risk to somebody else. Maybe someone would become a specialist

in burying CO_2; I don't know. As I say, we are in the very early stages. DOE has done some very small scale testing and they plan to do larger scale testing to find out if CO_2 storage is stable and can be done in a practical way on a large scale. We just don't know. We have years to go on that.

Question: To follow up on the carbon capture and storage, people are asking that question. You can look at the IPCC report on carbon capture and storage; clearly people are trying to figure out how to answer it, but there isn't really an answer yet. The earlier question on the electric grid versus distributed energy and one of your slides on capital costs reminded me that you get capital costs when you combine fossil fuel with a piece of equipment. All the policies that you talk about really focus on the fuel, not really on the equipment. If you start thinking in that direction, doesn't this impose a sort of a speed of adjustment, if you want to reduce carbon emissions? People aren't going to throw away their cars because they get 18 mpg when there is something else out there that gets 36 mpg. If they sell it, someone else buys it, so it is still on the road. So doesn't the life of capital stock impose a constraint on how fast you can reduce emissions without imposing big costs?

Canes: The direct answer to that is yes; legacy equipment does impose constraints. At least part of the R&D is intended to find ways to use capital equipment more efficiently. Some of the R&D done by DOE, and maybe by others as well, has resulted in better equipment. The capital recovery incentives that I talked about were meant to induce a more rapid turnover of capital stock than would otherwise take place. Economists would say that this equipment has a physical life, but it has an economic life, too. Economic life means that when it becomes profitable to replace it because it has gotten too costly to repair it or because the tax incentives are so great and the new equipment is so efficient relative to the old, then you go ahead and replace it. Sometimes the equipment is not totally exhausted in a physical sense, but it is exhausted in an economic sense. If so, even if you gave it away, no one would want to have it. So these inducements, the new technology, all these things can speed up the replacement process and can lead to a shortening of the economic life of the older equipment. That is the idea behind these incentives.

Question: You talked about the decline in carbon intensity relative to GDP in the United States. I wonder if maybe some of that is due to the decline of relative contribution of heavy industry versus things like stock markets and commodity markets, where that economic activity isn't nearly as resource intensive in the U.S. as in other places.

Canes: I think that is absolutely right; that is one of the reasons. The change in the industrial structure of the United States is one of the reasons why we see the kind of data that we do, probably not just in the United States, but in other Western countries as well. That's a good point.

Question: I have a question about the scalability of voluntary programs. You made some contrasts of those approaches vis-à-vis regulatory or tax approaches. But you didn't discuss how big a problem you can apply it to. You can think of these programs as tools applied to a problem in the same way that a tack hammer and pile driver are similar tools, just adapted to different-sized problems. How far could you take a voluntary program? If it were the judgment of Congress that we had to reduce emissions by 20 percent, would you advocate a voluntary approach for that or are there thresholds?

Canes: Good question. I gave you the joint EPA/DOE estimate for 2010: 9 percent for voluntary programs. If that is still on track, as I am told it is, and you wanted 20 percent by 2010, then probably not. We could encourage, we could give more prominence to voluntary programs, we could publicize them more and maybe get another percent or two by doing that, but we probably couldn't get 20 percent. So the answer would be that you would have to use other means. Capital recovery and R&D might help along those lines. That would be my answer.

Question: As a follow-up comment on that, Resources for the Future earlier this month published a book of case studies on the effectiveness of voluntary programs. I think it was their conclusion that for climate-related programs, as opposed to say toxic substances, the effectiveness tended to be in the low single digits, 2-5 percent of business-as-usual.

Canes: I wasn't aware of that and I haven't seen their estimates. You could say that the people at EPA/DOE have their own reasons for estimating a higher number. These are their own programs, admittedly. But they also know something about the impacts of their programs. I am not necessarily critical of the RFF estimate, but I would have to see the methodology used. I am just not familiar enough with it to be able to comment on it.

Question: What do you think of imposing constraints on upstream energy producers as opposed to anything downstream to help to mitigate the costs of a cap and trade?

Canes: I think it is assumed that is the way it will be done. Downstream is virtually impossible. If you are talking about the consumer level, it is obviously impossible, but even if you meant the distribution level, in the petroleum industry, there are a couple hundred thousand gas stations. A constraint program imposed at that level is not feasible. It would have to be done upstream and even then it would be an extraordinarily complicated program.

Kueter: Thank you, Mike, for a great presentation.

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