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Fifteenth Annual Symposium: Energy and Climate Change: North and South Perspectives: Keynote Address

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KEYNOTE ADDRESS

*Christopher Flavin**

Thank you very much. It is really an honor and a pleasure for me to be here with you today. I have had a chance to sit through the morning session and that wonderful group of panelists, which I think really gave you a very good tour of the major issues that the world faces on climate change over the years immediately ahead.

This is an amazing moment we are at today. I am someone who has been following the climate issue closely since it first emerged on the world scene at the very end of the 1980s, leading up, of course, to the Earth Summit in Rio de Janeiro in 1992. Clearly, we are now at a moment that is at least comparable to the historical turning point that occurred at the end of the 1980s and the beginning of the 1990s.

The challenge we face, though, is that in looking back at what has been accomplished since that period in the early 1990s, it is clear that most of the hopes and aspirations expressed by world leaders, by environmental organizations, and by scientists, have not even come close to being realized.

In fact, I was recently going back and reading an article I wrote in 1988. I must say that in some ways, it was shocking to see that things that I and many others were urging at that time, which seemed

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obvious then, are being discussed today with the same sense of urgency. But the challenge is that this time, we do not have the luxury of getting it wrong. We cannot miss the current opportunity presented by the kind of public awareness, the kind of readiness to act, that world leaders expressed at the United Nations last week.

I am firmly convinced, based on the science that I have read, and particularly the new reports of the Intergovernmental Panel on Climate Change, that we are within, by the estimation of most scientists, ten to twenty years of hitting a tipping point with the world's climate, where a substantial amount of really damaging climate change is going to become inevitable.[1]

Particularly, as I look around at the students in this room, I think it is very important to reiterate what many people know and what many people have stated earlier today, that unless we get a handle on this problem, unless we turn around the trend of greenhouse gas emissions, we are going to be looking at a substantially degraded world, one that is much less able to support human economic and social development than the one that we have today.

The poor are going to suffer the most, but I must say, even sitting here in the wonderful riches of Manhattan, this is not the kind of crisis that even the wealthiest people are going to be able to avoid.

One of the things I think is most striking is that over the million years that it took for humans to evolve from very primitive primates, the carbon dioxide concentration on the earth has never exceeded 300 parts per million up until recently. Sure, there is climate variability. There were even several ice ages and several warm periods during that period. But during that entire period carbon dioxide, which plays a key regulatory role, both causing and responding to temperature changes, never went above 300 parts per million.

Ladies and gentlemen, today we are over 380 parts per million. If this were a warning gauge in an aircraft that was running short of fuel, all of the red lights would be going off right now.

The challenge is this. The climate system, it turns out, is not this sort of steady, immutable thing — the atmosphere, the oceans. If you examine what has happened in the remote past, you can see that the climate flips dramatically into very different conditions.

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1. *See* Intergovernmental Panel on Climate Change, Climate Change 2007: Synthesis Report, *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

There was actually a time, tens of millions of years ago, long before there was anything like humans on the earth, when the concentration of carbon dioxide was significantly above even where it is today. That was a period when palm trees grew at the North Pole and the sea level was 200 feet higher than it is today. That is not a world with which we are familiar, and it is not a world with which we, approaching 7 billion people and eventually 9 billion people on the planet,[2] are prepared to cope.

So there is an extraordinary urgency. At some point we melt the ice cap over the Arctic. Suddenly the Arctic Ocean starts to absorb all that heat. Greenland is sitting right next to the Arctic Ocean. You lose enough ice off of Greenland, if it all goes, that alone would raise the sea level by twenty feet.

The other thing that happens as you start to raise the temperature dramatically in the far northern reaches of Canada and Siberia, is that there is an enormous amount of carbon that would be released both in the form of carbon dioxide and also as methane, which is a far more powerful greenhouse gas. If we don't get this trend turned around in the next couple of decades, the earth itself is going to start adding potentially as much or more carbon dioxide as we already are. That is the true nightmare scenario.

Let me now shift to what we are going to do about all of this.

You have already heard, I think, a lot of very good ideas about policies and about technologies this morning, and I am not going to try to repeat all of that, much of which I agree with.

But I want to make one fairly simple point. That is that we need a fundamental transformation of the energy economy as the real centerpiece of dealing with this problem. You are not going to solve this problem by planting a few trees, by shifting even all of our light bulbs to a different kind. We are not going to get to it all by any one simple means.

What we are going to need is a technology transformation, which needs to be accompanied by some lifestyle transformations. The two I think are really part of the same thing. I urge you not to think about them as extraordinarily separate, because I think that is a mistake that a lot of people make.

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2. Department of Econ. & Soc. Affairs, Population Division, *The World at Six Billion*, 6, U.N. Doc. ESA/P/WP.154 (Oct. 12, 1999), *available at* http://www.un.org/esa/population/publications/sixbillion/sixbillion.htm.

Now, why do I say a transformation is needed? The reason a transformation is needed is that we basically have an energy system that is 85 percent dependent on fossil fuels[3], most of which are used in an extraordinarily inefficient way. We need to rebuild that energy system in the 21st century to move into a post-petroleum age.

We have to do something that is as dramatic as our ancestors did 100 years ago. Remember this age of oil isn't all that old. Human societies existed for thousands of years without burning any fossil fuels, but the modern industrial system that we have today, which emerged in the 20th century, was highly dependent on burning a lot of fossil fuels.

What we need to do now is to create a different energy system, which I think has to have two fundamental characteristics. First, it has to be far more efficient, and waste a lot less energy, which means doing things in a much smarter way — for example, not moving around quite as much as we do today. Secondly, it has to be based on non-fossil, non-carbon-based energy sources, principally renewable energy sources.

That transformation I think is not as far off and is not going to prove nearly as difficult or as expensive as most people, and particularly most energy executives, think it is going to be. The reason is that I think we can make many of the same kinds of changes based on technology that allowed us to, for example, achieve an information revolution over the last few decades, and to do it a lot more quickly and a lot less expensively than anyone could have envisioned if you were trying to estimate what was possible back in the 1960s.

The process of economic change, once it gets going — and of course it needs guidance from government policy — begins to feed on itself. Lower-cost technologies fuel more investment, the investment, in turn, creates even lower-cost technologies, and the process continues forward.

Of course, while today the halls of Congress are full of fossil fuel lobbyists that are trying to block change, once things start to move forward, these new industries and these new technologies will have their own advocates. In fact, they are already starting to play a significant role in the process of change in this particular arena.

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3. U.S. DEPARTMENT OF ENERGY, ENERGY SOURCES: FOSSIL FUELS (2008), http://www.energy.gov/energysources/fossilfuels.htm.

The analysis by Rob Sokolow and Stephen Pecala at Princeton,[4] laid out this set of wedges, with which you can basically divide the pie of emissions reductions into these billion-ton pieces. I think that was really quite a brilliant presentation that those two gentlemen developed, because it allows you to sort of think about this problem in discrete and challenging but manageable pieces.

I think that what they say is that about half of the wedges that they have identified would be needed to get to stabilizing carbon emissions at the current level by 2050. Unfortunately, I think we are actually probably going to have to do better than that. Many scientists and many governments have now recognized — particularly the European governments and Japan, and I think Australia has now recognized this, and the U.S. may actually be getting close as well — that we probably need as much as a 50 percent reduction by 2050 and then further decline after that to avoid that dangerous level of warming over 2 degrees Centigrade.

To get to that, it is key that the wedges we choose — and I would describe it as something that must be an integrated technological and economic transformation — have to be those that are the most cost-effective and have to be ones that are really practical going forward.

I don't think that government planners can really choose those wedges today. I think you are going to have to let both policy forces and market forces to some degree play themselves out.

I think that, rather than taking things off the table today — you know, I am not particularly a fan of nuclear power, mainly because I think it has been an economic disaster rather than because I am particularly concerned about radioactive waste — still, I do not think we are in a position today where we can just ad hoc take things off the table. I think we need to look at all of the alternatives and create a level playing field which includes of course pricing carbon at an appropriate level, and then the marketplace ultimately will take hold.

Probably the technological solution that is getting the most attention in a lot of circles, particularly here in the United States, is carbon capture and sequestration. Again, I think that that is a very important technology. It would certainly potentially allow us to continue using fossil fuels, while putting the carbon dioxide back into the ground.

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4. *See* ROBERT SOCOLOW, ROBERTA HOTINSKI, JEFFERY B. GREENBLATT & STEPHEN PACALA, SOLVING THE CLIMATE PROBLEM: TECHNOLOGIES AVAILABLE TO CURB CO2 EMISSIONS (2004), *available at* http://www.princeton.edu/~cmi/resources/CMI_Resources_new_files/Environ_08-21a.pdf.

I do think, though, that for those who have not studied this technology, it is important to be aware of the range of technological hurdles that actually face that technology.

One place you could potentially put this carbon dioxide is in depleted oil and gas fields. Somebody recently did an estimate of all of the depleted oil and gas fields — and there are, by the way, a lot of depleted oil and gas fields in Texas. In fact most of them are depleted at this point. Somebody did an estimate of all of those fields, some of the richest original reservoirs that existed ever, and looked at what kind of storage capacity exists there. It turns out that if you took only the coal-fired power plants that are planned in Texas, you could fill up all of those reservoirs with carbon dioxide within a decade or two. The scale of what is needed means we are going to have to get well beyond depleted oil and gas reserves. We are going to have to figure out entirely new geological strata, perhaps deep oceans being another burial source.

In addition, there is going to be a huge pipeline network that will be required to connect the power plants to the geological structures that are appropriate for putting that material in place. Someone estimated that to deal with all of the coal-fired power plants we have today in the United States, you would literally have to replicate the scale of the current natural gas pipeline system in the United States, which is an immense structure built up over many, many decades, and which cost hundreds of millions of dollars, just in terms of the transportation part of it.

And then of course, at the upstream end, the basic technologies of being able to separate out and to control at an economical price the carbon dioxide are very much remaining to be developed.

The bottom line is that carbon capture and sequestration may or may not turn out to be a viable technology for disposing of some of the carbon dioxide, but two things it is not. One, no one would argue it is a complete solution, because it doesn't work for things like automobiles (the mobile sources of emissions) let alone households.

Secondly, it is not going to be fast. The first commercial plant to do carbon capture and sequestration, the earliest that that possibly could come online, according to the optimists and advocates, is 2020. That's one plant. And of course we are talking about having to build literally hundreds of these to make the kind of difference that ultimately is needed.

So carbon capture and sequestration may be part of the long-run solution. It is going to be approximately zero of what we need to do over the next critical ten to twenty years that I was describing earlier.

So that gets me to where I think the real optimism lies. It is on the energy efficiency front and it is on the renewable energy front.

Why am I optimistic here? I am optimistic because of what we are already seeing coming out of the laboratories, but, more importantly, what is actually happening in the marketplace.

Energy efficiency, as was mentioned earlier, has improved dramatically in most countries over the last thirty years. We have recently begun to pick up in the numbers. In the last three years, since oil prices began their march to the sky, there has been a clear shift upward in the level of effort going into energy efficiency. In fact, the U.S. economy has grown substantially over the last three to four years with only minimal increase in energy use. And you see that throughout most of the industrialized world.

McKinsey & Company, no group of raving environmentalists, recently argued in a major report that if we were — and McKinsey believes that we can — to take the annual rate of improvement of global energy efficiency from 1 percent per year, which has been the historical norm for the last couple of decades, and move that up to 2 percent per year, we could avoid an amount of carbon emissions that would be equivalent to several of those large wedges that the Princeton scientists have presented[5].[6] You would see improvements in automobiles, in buildings, in power plants, in industries, etc.

Most of the energy system is waste. I don't know how many of you have seen those flow charts that show the energy input at one end and the end use at the other, but the biggest flow coming out the back end is something called waste heat. Waste heat is the predominant thing that we produce in our energy system today. So we are going to be able to continue improving that efficiency for a very long time.

Let me mention just two key elements that I think are not getting the attention they need.

One is buildings. Buildings are really the big energy hogs today. Most of them are not built very efficiently. It's a classic example of market failures. There is an enormous potential, highly economical, where the extra investment up front is more than paid for in lower energy bills.

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5. *See id.*

6. McKinsey Global Institute, The Case for Investing in Energy Productivity 9 (February 2008), *available at* http://www.mckinsey.com/mgi/reports/pdfs/Investing_Energy_Productivity/Investing_Energy_Productivity.pdf.

One of the great things that has begun to happen again in these last few magic years, with the combination of high oil prices and concern about climate change, is that around the world at the national level and at the local level, there are policies being developed, and there are initiatives on the part of individual companies and industries, to create a whole new generation of buildings that are going to be much more comfortable as well as much, much more energy-efficient than those that are in place today.

Secondly, I think we are really on the edge of a sea change in the nature of automobiles. The internal combustion engine is transitioning to hybrid, which is then going to transition to plug-in hybrids. That is, you'll still have an internal combustion engine, but you can plug it in at night. You can do your city driving, forty-fifty miles, without using your engine at all. That then transitions, using this wonderful array of new, more economical batteries that are coming out, to an all-electric vehicle in the future. Electric motors are vastly more efficient than internal combustion engines. The power plants that produce that power, even today, are more efficient than internal combustion engines.

But of course, the other thing that is really exciting — and this is my segue — is that once you are running your automobiles on electricity, you don't necessarily have to get that electricity from fossil fuels.

The other thing that I think is just really stunning, if you look at the numbers and what has begun to develop over the last few years, is the skyrocketing development of renewable sources of energy. There has been work going on, both technologically and commercially, on things like wind, solar, geothermal, and bioenergy over the last thirty years. But what is happening now is the combination of political commitment, starting mainly in Europe but now spreading outward to the rest of the world, and the fact that the technologies have matured.

You've got a whole lot of new players jumping into those fields, including virtually all of the really big companies that are in the energy business — General Electric, Siemens, Mitsubishi, Shell, and BP. Combined with this, and this gets back to my earlier analogy with the information technology revolution, the thing that I think is most stunning and will have the biggest impact is that renewable energy is now literally the hottest thing in Silicon Valley. I would argue that at some level it is hotter than the Internet. I mean you tell somebody in Silicon Valley, particularly in the venture capital sector, that you are working in renewable energy, and you've suddenly

got a string of emails and voice mails saying, "I really want to talk to you because this is where my firm is now putting its interest."

There are dozens of startup firms now being created to develop new solar technologies, new wind technologies, new bioenergy technologies, and new geothermal technologies.

And these industries are growing fast. The biofuels industry is growing at 25 percent per year. The wind industry is growing at 30 percent per year. The solar photovoltaics industry in the last three years has grown at over 40 percent per year, with every sign that it is going to be faster than that over the next three years.

This is a whole new generation of modular, mass-produced energy technologies, operating by an entirely different paradigm from the large, centralized, fossil-fuel-based energy systems that are in place today. As these markets grow, the costs are going to come down and they are going to come down very, very rapidly as a result of the profits that are now available to put into research and development, but also as a result of the fact that you just have a greater scale of production, with mass production of various technologies.

So I think we are now really getting to the point where I can literally envision a day within five to ten years, based on the trends I see in the marketplace, where most of the new generating capacity is going to be renewable. Already in both Europe and North America, if you look at, not the total stock of power plants, but the new ones being brought online, number one are natural gas-fired power plants over the last couple years, but number two is wind power. Coal comes after wind. Nuclear is barely even on the list.

These markets are shifting. Very few people are aware of this because there is a tendency to look at the total stock of plants rather than what is happening in the marketplace today. But I think we could be in a place, five to ten years from now, where we find that virtually all of the new capacity is coming from the new sources. It is that kind of a transformation that we are on the verge of.

Now, let me shift to the policy questions. I think particularly, the presentation that we heard earlier on the European Union's policies was very enlightening in terms of understanding what has been going on in the part of the world that has really driven our markets most dramatically, particularly during the 1990s, but even in the last five or six years. I think there are two points I want to leave you with on policy.

One is that pricing of carbon is terribly important. Pricing carbon either through a carbon tax, or I think in the near term, more likely through carbon regulation, which some people like to call "cap and

trade" (fundamentally regulating carbon emissions and then allowing tradability among the polluters) I think is terribly important. Putting that price out there does make efficiency and renewable energy sources, potentially nuclear power, more economical than they otherwise would be.

It also just gives a signal. Everybody who is in a business that emits, which is essentially every business, is now thinking about carbon. They are thinking about what they are doing. They are at least measuring their emissions. They are beginning to control their emissions. So I think it is terribly important.

The second message I want to leave you with is that pricing carbon is not in itself the full solution, not even close. There is not a single policy bullet that solves this problem.

I think there are a lot of people, particularly a lot of neoclassical economists, who think it is. The reason it is not is that anyone who has studied energy markets closely and followed them over the last couple of decades knows that the lack of a full and reflective price is not the full problem. These are not markets that operate along neoclassical lines.

These are complex markets. There are institutional structures that cause things to be a certain way. There are impediments to investment in various areas. There are all kinds of manipulations that have been put in place by legislatures around the world at the behest of one or more interest groups. So you are not going to see a technology transformation just by pricing.

The best example of that is in the real world. The Europeans currently have a tax on gasoline that is the equivalent of over $100 a ton of carbon, well beyond what any policymaker could consider implementing because of the cries of consumers. Now, Europe is far more efficient. The cars are more efficient. There is not the level of inefficiency that there is in the United States. But Europe has paid that price and has not reinvented the car. It has also not abandoned the car. It is still putting out plenty of automobile-related carbon dioxide emissions. The reason is that there are a lot of other things that need to be done, probably even more so in the electricity sector than is true in the automotive sector.

That brings me to a couple of specific policies. Again, these are just going to be illustrative of the kind of thing that I think is going to be needed.

The European Directive on Renewable Energy,[7] is, I think, a huge step forward — making these requirements legally binding is a huge step. But essentially, the problem that the European Union has is that only a handful of European countries have made the enormous strides in renewable energy over the last few decades, led by Germany and Spain. It used to be led by Denmark, but the Danes have unfortunately lost their political commitment to this more recently. But Germany and Spain have really led and dominated the development of solar energy, wind power, and, increasingly, bioenergy in Europe.

Why have they done that? It's not that they are the only countries that have wanted to move forward, that have had national goals that they have put in place. What they have had is a very specific law. I am now turning with these policy recommendations to the many lawyers and soon-to-be lawyers in this room, because I think there is a lot of work for all of you.

The Germans created a law, passed originally by the German Parliament in 1991, called an Electricity Feed Law, which basically said that there will be a minimum price required to be paid by the electric utilities, passed on to electricity consumers, for generators of renewable electricity.[8]

What that did was it got at one of the key institutional impediments. The big utilities don't like renewable energy. It's basically competition for them. They are selling less of the coal and nuclear power that is the main asset that they own. They have tended to resist change in virtually every country around the world, whether it is the United States or China.

This pushed them out of the ability to block progress. It created a wonderful new set of industries. Now, it came at a cost. It did cause very minor increases in the price of electricity, though since even the coal and the nuclear are heavily subsidized in Europe, it turned out to be not that much of a penalty.

Germany and Spain, between them, have totally dominated these industries in Europe, totally dominate European exports — and the Danes to some extent too because of the earlier laws that they used to have in place.

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7. Council Directive 2003/30, art. 17, 2001 O.J. (L 123) (EC).

8. Wind-Works.org, The Original Electricity Feed Law in Germany (Paul Gipe, trans., 2001), http://www.wind-works.org/FeedLaws/Germany/ARTsDE.html.

Europe's challenge now, if I may put it so simply, is basically to figure out — and other countries may come up with different solutions — but I think increasingly it is accepted that that Danish-German-Spanish model is the one that is pretty darn economically efficient and works pretty darn well, by allowing power to be automatically sold into the grid by setting a legal price that incorporates the environmental externalities and by relieving the small renewable generators of the need to negotiate contracts with giant electric utilities that have a natural economic interest in not wanting to add competition.

So that is one policy. Electricity feed laws, which were hardly even known in the United States, are now actually being looked at very seriously at the state level in a number of areas.

We are still looking mainly at legal mandates in about half the states for the utilities to introduce renewable electricity. That has actually worked quite well in a number of states. In fact, the United States is now actually ahead of Germany, though not ahead of Europe, in wind power installations over the last two years. These European systems I think have really worked particularly well.

And then similarly on the energy efficiency side, standards and regulations are things that are very much going to be needed — energy standards for buildings, fuel economy standards for automobiles.

I think this is terribly important. We are going to have to have a complex matrix of policies, which need to be designed in a way that they are market-sensitive, that they work with the market, not against it. Carbon pricing has to be part of it, but I think only one piece of a broader array of policy elements that need to be put in place.

Again, I think if you are going to look at any model in the world today, it would be the European Union, because not only at the EU level but at the national level in Europe you have the world's only really fully functioning carbon market now — carbon is bought and sold among the major polluters in Europe today — but, in addition, you have this rich array of other policies that are moving forward, again both at the national and at the European Union level.

I want to conclude by focusing on what I would describe as the global bargain that needs to be struck on these issues. Of course we are focusing in this conference particularly on north-south issues. Those indeed have been the critical sticking points in the climate issue over the last almost eighteen years that the world has been working to move forward, first through the framework convention, then the Kyoto Protocol, and now on a post-Kyoto agreement.

Of course the problem in simple terms is clear. That is, per-capita emissions even in China are less than one-quarter the U.S. level, and in many African countries and in a country like India they are one-tenth the U.S. level.[9] Those countries are developing rapidly. Their emissions are going to naturally tend to grow much more rapidly than in the United States.

And yet, I think everybody recognizes, including most people in developing countries today, that they need to limit their emissions growth as well. We are now past a point where industrial countries totally dominate emissions. Going forward, developing countries are going to be more and more important. Bringing them more forcefully into the international agreements and accelerating the adoption of this array of new technologies in the developing countries I think is absolutely critical.

Now, the developing countries themselves are at very different stages of economic development and contribute at very different levels to this problem. I think this needs to really be recognized and grappled with in the next round of negotiations.

The ones that are most critical are China and India, with China, at least in the short run, being a good deal more important than India. You have probably all seen the studies.

China, by various calculations, either will very soon pass the United States in global greenhouse gas emissions or may indeed have already passed the United States last year. China, suddenly and dramatically, in the last few years has entered a much more energy-intensive stage of its economic development. Ten percent economic growth continues, but the energy growth has greatly accelerated. And China, being a largely coal-based economy, is getting most of that energy from the dirtiest of all energy sources, coal.

So China really needs to be brought into this agreement, as do a number of other rapidly industrializing developing countries. I think that unless they are, we are not going to get the kind of agreement that is necessary.

And frankly, I think there is basically sort of a two-way process now, where the United States and a number of other industrial countries are going to be very reluctant politically to move forward without China being in the boat. But from China's point of view, one of

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9. Energy Info. Admin., Dept. of Energy, World Per Capita Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980-2005, *available at* http://www.eia.doe.gov/pub/international/iealf/tableh1cco2.xls.

the main reasons that China is holding out so far on adopting any carbon limits and has been resistant — again, I think we did see some movement over the last couple of weeks — is that they see the United States as not playing its role, not being a responsible industrial country. I think if the United States were doing what the European countries and Japan are already doing, China would be much more likely to move forward.

But on the China question I am optimistic, and I have a reason to be optimistic. I was actually in Beijing last week meeting with Chinese officials at the same time that world leaders were here meeting at the United Nations. I find remarkable change under way in thinking in China on this issue. This is both in the urgency of the problem — you know, half of Shanghai would be under water if you get ten feet of sea level rise. China is incredibly vulnerable in terms of shortages of fresh water and a country that is relatively short on agricultural resources generally. But more importantly, I think China sees an enormous opportunity to be gained by getting off of this really unhealthy dependence on coal as quickly as it possibly can.

China has done an amazing thing over the last few years. Again, many people are not aware of this. I have just been referring with some praise to what Europe has done in renewable energy. But the most recent story that has gotten my attention is what has happened in China. China passed a renewable energy law, a serious one, for the first time in 2005.[10]

Most countries, including most European countries, often stumble coming out of the starting blocks with a major new law, particularly with the kind of complexity and the kind of political resistance that tends to exist with renewable energy development. I can go down a long list of European countries that have sadly disappointed, from the United Kingdom to Italy, where the rhetoric over a period of fifteen years has far outrun the ability to actually deliver market development.

The Chinese now are less than two years into the entry of this new law into force. The renewable energy markets are absolutely booming. China is already the number one country in solar hot water. It is number one in small hydro development. Both of those developments actually predate the law. But since the law has developed,

10. Renewable Energy Law (promulgated by the Standing Comm. Nat'l People's Cong., Feb. 28, 2005, effective Jan. 1, 2006), *available at* http://www.renewableenergyaccess.com/assets/download/China_RE_Law_05.doc.

they have come out of nowhere to become, last year, the fifth-largest country in wind power installations. They will probably be three this year. They will probably be number one within the next two to three years.

And in solar photovoltaics, which is a technology that is basically too expensive for the Chinese market, an amazing thing has happened. A bunch of Chinese companies have started up, new entrepreneurial companies, with some help from the Chinese government, some help from local provincial governments, some help from Western financial firms, such as Goldman Sachs, and some of them have even gone public on the New York Stock Exchange. China now is on pace. They have already passed the United States, which basically invented this technology back in the 1950s. They are actually on pace now to overtake Japan, which has been the number one country in this technology over the last half-dozen years.

So I think that there is a global bargain to be had, but it has to be based on a combination of moral understanding of the fact that the developing countries are going to be hurt the most, that they have so far contributed relatively little to this problem, and that the industrial countries have a responsibility to take the lead. But secondly, it needs to be based, and can be based, on a realistic understanding that countries — not just China, but potentially India, potentially Southeast Asia, potentially Latin America, potentially Africa — can create enormous economic success by developing 21st century energy technologies, by leapfrogging many parts of the industrial age, and by moving straight on to a set of technologies that are just becoming available now.

Now, too many people that sounds like a pipedream, because the conventional view is, again, that these technologies are too expensive, there is too much high technology required. But I have a simple analogy for you. Go into a remote village in Africa today and you are quite likely to see mobile phones and perhaps an Internet café, probably the availability of television, perhaps being powered with a solar system, which is increasingly true in many remote areas, in areas that never had landline telephones, that have never seen a mainframe computer, that have literally leapfrogged into a different kind of information technology.

I think it can be done. Indeed, I think it will be done.

The thing that I think is so important about what is happening in China in renewable energy today is something called the "China price." Anybody involved in manufacturing anywhere in the world knows what the China price is.

The China price is when your buyer comes to you and says, "I want you to lower your prices by 20 percent. That's what I'm demanding."

The manufacturer says, "Well, I'm sorry. I'd like to do that, but I can only lower my price by 10 percent because I can't afford to go to 20 percent."

The buyer turns to the manufacturer and says, "I need that price. That is the China price." That means that's the price he will be able to get that technology for if he buys in China.

Go down the list — computers, television, toys — I think we are going to see automobiles. Increasingly, the Chinese have been able to get to levels of price that have not been possible to envision in the West in manufacturing sector after manufacturing sector.

As we make this transition, and as a low-carbon energy economy comes about, low-cost, highly efficient energy-using technologies and energy-generating technologies, like wind power and photovoltaics, this dramatic emergence of China into this sector is going to make a huge difference.

So I think China not only has the potential to turn the corner on these skyrocketing emissions that it is polluting its own country with today and polluting the global atmosphere, but I think that those very low prices that are going to be delivered are going to push this entire sector of new technologies over a threshold, a threshold that will not only make them affordable in Beijing — anything affordable in Beijing is by definition affordable in New York — but I think we may even see it get to the point where it is economical in very poor countries like those in Africa, in areas where the fossil fuel economy never was affordable.

So I think we stand on the cusp of a potentially grand transformation. I think that it needs to involve a partnership between north and south. I think it needs to involve a recognition that technology and policy are not different things but really two sides of the same coin, and where technology change and lifestyle change — that is, lower consumption — also are not two distinct things but, again, part of the same integrated solution.

We need more public transportation. We need more personal responsibility. But we need that embedded in a different kind of energy system, one that does not depend on fossil fuels for its lifeblood.

Thank you very much.

Question & Answer

QUESTION: As you move toward electric vehicles, especially trucks, to what extent do you see that that may necessitate an expanded use of the traditional lead acid battery?

MR. FLAVIN: I think you are going to see virtually no expansion of the lead acid battery. There are much better batteries. I think you are going to be hearing about one of them, a nickel metal hydride, this afternoon from Nancy Bacon. There also are lithium batteries and a range of other alternatives.

Chemists have been struggling for a hundred years to develop better batteries, with relatively little success. I think we are really on the verge of a breakthrough now, partly because we have so many mobile devices, things like mobile phones and laptop computers, and the automobile will basically be able to draw off a lot of the technology that has gone into those sectors.

QUESTION: A very short question about the global bargain. What is your opinion about the cost and convergence theory that has been proposed by the Common Future Institute since the early 1990s?

MR. FLAVIN: Can you elaborate in one sentence what that principle is?

QUESTIONER: The principle is the allocation of the carbon emissions on an equal basis to every inhabitant of the planet. This would be a highly equitable way of going about it. You were talking about this leapfrogging and a moral understanding among nations. Then it is important to understand the history of the origin of the problem.

MR. FLAVIN: I think that, from an idealistic point of view, that is a wonderful strategy. I think a moral philosopher would have a very hard time disagreeing with it.

I think it is, frankly, a nonstarter politically. The world is not going to agree to the kind of large-scale redistribution of income that that would require.

I think that what we need is certainly some redistribution of income as part of this process — I would not argue against that — but I think, inevitably, it is going to take a hundred years, at minimum,

to actually get to the sort of level playing field in terms of carbon emissions.

Countries start at very, very different levels today. There are a lot of accidents of history. Countries have a lot of emissions — for example, China — because they happen to have a lot of coal. There are a lot of poor African countries that just don't happen to have a lot of fossil fuels, so they have not developed it in part for that reason.

I think that addressing it as a purely equity issue is not going to get to that win/win economic opportunity framework, which I think, frankly, is the only way we are going to politically move forward.

QUESTION: I think your talk was a marvelous one, but somewhat more optimistic than I would have expected. I am reminded of the famous saying of Pogo, that lovable cartoon character, with regard to pollution: "We have met the enemy, and they is us."

How can you get the American consumer and the American voter to accept the high level of taxation that the Europeans take for granted, which obviously is one of the most effective ways of reducing the number of cars or the use of cars? How do you get the American consumer or the American voter to accept the enormous subsidies for trains that enabled the high-velocity trains in Europe and simultaneously promote less use of cars and planes? How indeed do you get the American consumer to accept electric cars?

What is the campaign, the marketing campaign, that is necessary to make Americans accept a change in the American way of life and change to a greener outlook on life?

MR. FLAVIN: I think the key to that very good question is that you have to be making the efficiency improvements as you go along. You are absolutely right, the taxpayer is not going to accept a massive increase in taxes if it is not compensated for (1) by offsets, reductions in taxes elsewhere, which I think needs to be part of the bargain — you know, if you are reducing labor taxes, for example, income taxes, at the same time that you are raising energy taxes.

(2) You need to improve efficiency levels. If you are paying twice as much for electricity but your house is twice as efficient, your bill is just the same. This is something that Amory Lovins has been pointing out for a very long time. In fact, a lot of people are realizing that.

Those who chose to buy a Prius four years ago are paying a third as much for fuel as those that chose to buy a very inefficient automobile. That was not a tax increase. That was basically the world

oil market has added the equivalent of well north of $30 a ton. We have had a substantial carbon tax imposed on the oil market just as a result of market forces. People have basically accepted that.

So it needs to be integrated in a way that people are seeing that there is some reward from this, that it is not just an effort to raise taxes, but that there really is something to be achieved as a result.

I don't disagree that the political hurdles to making these changes are tremendous. But I also think that there are going to be tipping points in the policy and marketplace as well as in the climate. Things at some point get easier once the basic policy structure is in place, once these new technologies start to become economically competitive.

Unless we can maintain a certain level of optimism that in fact we can solve this very difficult problem — I think the more serious concern today is not that the world is totally in denial, as it was two or three years ago, that we go straight from denial to despair. That doesn't get us anywhere either.

QUESTION: There have been a couple questions about population, and you've alluded to the growth from 6 billion to possibly 9 billion. I'm not sensing on the list of issues that are discussed here today where the population factor fits in the level of urgency. Can you please address that?

MR. FLAVIN: Absolutely. It's interesting that the only national climate plan that I've read recently that directly addressed the issue of population was the Chinese plan. China noted the role of population growth and indicated, and took credit for the fact, that the dramatic slowing in population growth in China over the last several decades will mean that there are less emissions than there would otherwise be.

Now on the other hand, of course, if Chairman Mao had not promoted large families back in the 1950s and 1960s, there would not be 1.3 billion Chinese, which is part of the problem both that they have and the world has today.

Population is absolutely a key factor and, I think, should be part of national strategies; that is, slowing population growth.

One little secret that the Europeans don't like to mention is that — this is certainly not the only reason, and I am not taking anything away from the strong policies they have in place — but one big ad-

vantage they have had over the United States in the Kyoto Protocol[11] numbers is that the European population is essentially flat, it is barely growing at all; whereas the U.S. population is actually growing almost at the rate of the world as a whole. We've got a rate of about 0.6–0.7 percent a year. That actually adds up over the seventeen years since the Kyoto baseline went into force.

Now, obviously there are a variety of reasons, most of which do not relate to conscious policy, that population growth rates are much slower in Europe than they are in the United States. The United States, by the way, has about the same population growth rate as China does today. Again, the country would have a lot easier time if it had a slower rate of population growth.

Since it is the combination of population and per capita emissions that essentially determines how much carbon dioxide you are putting out, one can easily make a case that population growth in the United States is one of the biggest single variables in the global carbon dioxide equation, because one new American actually produces vastly more emissions than one new African. Of course, Africa has one of the highest population growth rates in the world, but because its per capita emissions are so much lower, population growth in the United States is actually a bigger problem for the climate than population growth in Africa.

QUESTION: I was particularly intrigued by the portion of your talk about leapfrogging technologies and the parallels you drew with the information communications technology industry. But I'm wondering. The two kinds of technologies are so very different, and currently there really isn't an economic basis necessarily that I can see where you could say that renewables will be at that point. I was wondering if you could talk a little bit more about that, or perhaps some policies that might bring it to that level, where we might be able to leapfrog in renewables as well.

MR. FLAVIN: Sure. You're absolutely right that you will never see energy efficiency doubling every eighteen months. Chip speed has been doubling every eighteen months since the 1950s. That's an extraordinary rate of progress that only occurs when you are actually

11. Kyoto Protocol to the United Nations Framework convention on Climate Change, Dec. 11, 1997, U.N. Doc: FCCP/CP/1997/L.7/Add.1, available at http://unfccc.int/resource/docs/convkp/kpeng.pdf.

detached from the physical world, as you are with computer technology, at least to some degree.

You are not going to see that rate of improvement, but you are going to see very rapid improvement. Here's an example. It is basically said, on average in the manufacturing sector, that for every doubling of the rate of annual production you get a 10–15 percent cost reduction. That has been observed across a wide variety of very familiar technologies, like televisions and computers, 10 percent to 15 percent for every doubling.

The production of photovoltaics worldwide is now doubling every twenty-four months. That's a 10–15 percent decline in cost every twenty-four months. Now, we are not actually seeing that yet in the marketplace, and the reason is because the demand has grown so rapidly that there is basically a shortage of supply. So the prices actually have gone up in the last two or three years. Everybody recognizes that that is a temporary anomaly.

There is so much capacity coming online — I saw one estimate that we may see an eight-to-nine-fold increase in photovoltaics manufacturing capacity, unprecedented levels, within just the next three to four years. There is going to be a glut created at some point, because I don't think — you know, basically you have two or three markets that are basically holding this up — Germany, Japan, California, Spain — and the policy process I think is not going to keep up. So you are going to end up with a glut of photovoltaics.

That is going to cause the prices to crash. It will almost certainly cause a bit of a shakeout in the market. But what is it going to do? It is going to be exactly like what happened at the end of the dot-com bubble.

One of the things that happened with the dot-com bubble is there was all of this fiber optic capacity that had been built. It was vastly overbuilt. Suddenly, the companies that owned a lot of that literally went out of business and you could buy fiber optic capacity for virtually zero. That, as Tom Friedman has reported in his recent book, rather than being the demise of the industry, was the absolute fuel that caused it to take off. [12] Suddenly, there was all of this incredibly cheap fiber out there, which caused the Internet now to diffuse and to spread into all kinds of new applications and took the growth into a totally different realm.

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12. THOMAS FRIEDMAN, THE WORLD IS FLAT 3.0: A BRIEF HISTORY OF THE 21ST CENTURY (2007).

I am about as sure as I can be sure of anything that we are going to see something very much like that with photovoltaics.

This is an amazing technology, because you can do it at any scale, from a handheld calculator or a camera to a large 1000-megawatt power plant in the middle of a desert. Costs get low enough and you can start putting them up anywhere and everywhere.

So I think that we are getting very close to that kind of a point. We don't need to get to quite the pace of change that we see in semiconductors to create an energy revolution.

It is partly that we are up against dinosaurs. I mean everybody finds Exxon and the National Coal Association sort of intimidating. They are big and they are lumbering and they have a lot of market share. The bigger the dinosaur, the harder they fall. We have seen that in industry after industry. Frankly, I wouldn't want to be one of the major investors in one of those businesses.

Thank you all very much.