Fordham Environmental Law Review

Volume 17, *Number* 2 2006 *Article* 3

Keynote Address

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KEYNOTE ADDRESS

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MS. RICHMAN: It is my great privilege to introduce our keynote speaker, Jeffrey D. Sachs. Professor Sachs is the Director of The Earth Institute, Quetelet Professor of Sustainable Development, and Professor of Health Policy and Management at Columbia University.[1] Professor Sachs also directs the UN Millennium Project and is Special Advisor to United Nations Secretary-General Kofi Annan[2] on the Millennium Development Goals, the internationally agreed goals to reduce extreme poverty, hunger, and disease by the year 2015.[3]

Professor Sachs is internationally renowned for advising governments throughout the world on economic reforms as well as for his work with international agencies to promote poverty reduction, disease control, and the debt reduction of poor countries. Thus, he was

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1. Mr. Sachs has been at Columbia since 2002, when he joined the faculty after 20 years at Harvard University. Since that time, he has served as the director of the Earth Institute, as well as a professor in the department of Economics, School of International and Public Affairs, and Department of Health Policy and Management. In 2003, he was appointed the Quetelet Professor of Sustainable Development.

2. Mr. Annan is the seventh Secretary-General of the United Nations. He is currently in the second of two terms of office. His first term began on January 1, 1997. His second term will come to an end on December 31, 2006.

3. The eight Millenium Development Goals are part of an effort by all the world's countries and the world's leading development institutions to achieve certain objectives by the year 2015. These goals include the eradication of extreme poverty and hunger, universal primary education, the promotion of gender equality and the empowerment of women, the reduction of child mortality, the improvement of maternal health, the combating of HIV/AIDS, malaria and other diseases, the ensuring of environmental sustainability, and the development of a global partnership for development.

last year's recipient of the Sargent Shriver Award for Equal Justice and was recently elected into the Institute of Medicine.[4]

Professor Sachs has written over a hundred scholarly articles and numerous books. His recent book, *The End of Poverty: Economic Possibilities for Our Time,* sets forth solutions to end the extreme poverty that exists throughout the world and provides moral and strategic reasons for wealthy countries to enact these solutions.

Before joining Columbia, Professor Sachs spent over twenty years at Harvard University, most recently as Director of the Center for International Development.[5] Harvard is also Professor Sach's Alma Mater, where he received his B.A., M.A., and Ph.D. degrees.

Please join me in welcoming the person named for the past two years by Time Magazine as among the 100 most influential leaders in the in the world. Please welcome Professor Jeffrey Sachs.

PROFESSOR SACHS: Carol, thank you very much. Thanks to you and your colleagues and all the participants for this important Symposium today on a very important and tricky issue: how to address global climate change and especially, how do we press it when Washington is doing nothing and we better do something. That is a pretty accurate description of the situation, alas.

I thought that what I might be able to add in my remarks today is something of the global perspective and something of the long-term perspective. This is truly a global and a long-term issue. It is not an issue that is going to be solved in the short term. It is not an issue that is going to be solved by the United States alone.

The essential physics of this is that greenhouse gases are a global process. It doesn't matter where you put up the carbon dioxide. It is what atmospheric scientists call "uniformly mixed in a short period of time," meaning that our carbon dioxide becomes the world's, and the same with China's and India's. It becomes a global problem.

Of course, the effects of the greenhouse gases on different parts of the world will vary in complex ways that are not understood by any

4. The Sargent Shriver Award for Equal Justice honors those who have contributed to the cause of justice for people in poverty. The award was named after the founder of the Shriver Center, Mr. Sargent Shriver. The Institute of Medicine was established in 1970 under the charter of the National Academy of Sciences. The mission is to provide independent advice to policymakers, health professionals, the private sector, and the public.

5. The Center for International Development was established on July 1, 1998 to serve as Harvard University's primary center for research on sustainable development. It was established to bring a cross-disciplinary approach to the challenges of sustainable development.

means with high certainty and great detail, but there is very good reason to believe that the effects, though unpredictable, will be large and potentially devastating. We will require global solutions to the challenge.

Moreover, this is a long-term problem. It is a long-term problem because not only do greenhouse gases uniformly mix, but they stay up there a very long time. So we are talking about a problem that has a very long time horizon to it as we accumulate the anthropogenic, or human-made, effects on the atmosphere.

It is also a long-time-horizon problem because the energy system is not something that is turned on and off in a short period of time. It is based on the core infrastructure of our economies. Power plants last about fifty years, automobiles, depending on what you drive, last fifteen to twenty years, industrial plants may last forty years, and residential structures often last a hundred years. So the energy demands of an economy are a reflection of a very long process of capital accumulation. Even if we were to take decisive actions now with regard to future emissions, the fact that the capital stock of our economy has a very long life expectancy ahead means that the change of our energy patterns would be quite a long process.

Take into account the world's change, and what we are talking about is really a global process that has a hundred-year time horizon to it. We are talking about a process where we have to think globally, and we have to think in the context of decades in order to get appropriate answers to this issue.

We are also thinking of a very complicated problem, because there is huge uncertainty about every single dimension of the problem. The physics of greenhouse gases, the links of economic change or economic activity to greenhouse gas emissions, the fluxes of those greenhouse gases, even how long carbon actually stays in the atmosphere, and where it goes when it goes from the atmosphere to the terrestrial ecosystems again (for instance: in the form of carbon taken up in trees, or in the soils, or the oceans). That whole physical process is still very much uncertain and debated.

The implications of the changes of greenhouse gases in different parts of the world, as I mentioned earlier, is, unfortunately, a crucial thing to know. Yet it is almost unknown right now because, as uncertain as the global models are, when you try to resolve them to a more local scale, there is tremendous uncertainty. What does this really mean for India? What does this mean for the Northeast of the United States? What does it mean for the Southwest of the United States? What does it mean for Africa?

Even if we knew the change on climate, we would have a hard time knowing what that meant for society. But we don't even know the change on climate.

But then, if we were told, "Well it means this in a complicated way," in terms of patterns of temperature and rainfall and other physical processes, linking that to the implications for society. Disease, crop productivity, sea levels, access to safe drinking water, effects on biodiversity — are all additionally huge unknowns.

And then, there are huge unknowns about how technology will change in the future to address this problem: what kind of energy systems will be economical in the future and what will it cost to substitute carbon-emitting energy systems or carbon-emitting transport or manufacturing processes for carbon-non-emitting or carbon-less-emitting processes. These are big uncertainties in the future.

And then there is the question of how to handle this for 6.5 billion people on the planet, with the population increase on its way to 9 billion people. I generally count, since I work at the UN, 191 countries, but there actually are quite a few not in the UN, so there are probably about 210 countries that are part of this story, albeit it is true that a few of them account for the vast amount of the problem, as India, China, the European Union (as an agglomeration of economies), the United States, and a few other [states] do have a disproportionate role in the greenhouse gas problem.

So, to put it technically, this problem ain't easy. We are not going to come up with a simple solution or prescription in a short period of time.

It is one of the most fun things to work on as an academic, because it is so complicated, there are so many parts to it, and it is so important. Therefore, it has all the great makings of a great research program for people who are involved. But that's not what you want to hear. You'd like to hear some actual solutions, not just what a great research problem it is and how exciting it is going to be to find out how we wrecked the planet and in which ways that we can't imagine right now. We actually want to do something a little bit more pragmatic than that.

So I recently wrote a paper with a colleague of mine, a wonderful, brilliant physicist named Klaus Lackner.[6] It was published in *The*

6. Klaus. S. Lackner is the Maurice Ewing and J. Lamar Worzel Professor of Geophysics in the Department of Earth and Environmental Engineering, Columbia University.

Brookings Papers on Economic Activity a couple of weeks ago. It is called "A Robust Strategy for Sustainable Energy."[7] The idea of the paper is that, with all of this uncertainty — the global, the intertemporal, the physical processes — is there anything that can be said reliably about this? Are we cooked, or are there solutions? Is this going to be hairshirt economics where we are just going to have to cut our living standards decisively in order to get this under control, or is this something that is manageable? Will technology solve the problem, or will we require fundamental changes of lifestyle and living conditions?

I don't know. But we actually came up with a few ideas, and I want to share some of the high points with you of what we do robustly know about this complicated situation. You will see that at the end I am actually a conditional optimist. We are going to find our way out of this at reasonably low cost, with one big question mark. But if that question mark is settled in the way that it looks most likely to be settled, then I am even optimistic, with our messed-up politics in this country, that we are going to find a way to do this. But without giving you the punch-line first, let me go through some of the things that I think are robust conclusions about energy systems and about the bad news and the potentially good news.

The first robust statement to make is that energy use roughly scales with income level. Now, what does that mean? It means that economic growth and development has right at the core rising use of energy.

And why do I stress energy? I should have just put a footnote, if that isn't clear to anybody. The biggest source of the problem is carbon dioxide, which comes from the combustion of fossil fuels. So the reason that we are talking about markets for greenhouse gases, and so forth, and market incentives is that the biggest problem of anthropogenic climate change is that we are a global fossil fuel economy. We use coal, natural gas, oil, and other forms of fossil fuels. We burn them all. Those systems of using fossil fuels are right at the core of our economies. That is what poses the problem.

We have other kinds of energy too, such as solar. It just happens to be so expensive and still so impracticable that it doesn't substitute

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7. Klaus S. Lackner & Jeffrey D. Sachs, *A Robust Strategy for Sustainable Energy*, BROOKINGS PAPERS ON ECONOMIC ACTIVITY, 2005, No. 2 at 215, 215-269.

for fossil fuel. And so the vast proportion of the energy use of high-income countries, like our own, is fossil fuel.

There are some countries and some parts of the world that rely almost entirely on renewable resources. That sounds good, except that I work in many of them, and those places are the most impoverished on the planet. The communities and villages that I work in in Africa, do not use fossil fuel at all. It is great news. However, they have a life expectancy of just forty years, there is no household illumination, there is no motor transport, there is no refrigeration, there is no electricity, there is no Internet connectivity, and there is no cell phone coverage. So you can do it, that's one option, and you survive about half the life expectancy of the rich world.

So if we had a cataclysm, we could live without fossil fuel and we would live in misery. 200 of 1,000 of our children would die before their fifth birthday. All that we have come to expect of a safer and more secure food supply would disappear because at the core of a modern food supply is fertilizer, and at the core of fertilizer is principally a process of using not only natural gas, but also other fossil fuels, to take atmospheric nitrogen, break those triple bonds which are in the N_2 molecule, make the nitrogen accessible to plants, and thereby have enough food to eat. I can tell you: if you don't have fertilizer, you go very hungry, which is true of the villages that I am working in.

So, renewable energy sources aren't all that they are cracked up to be. If you take the current use of renewable energy, fossil fuels have a hell of a lot going for them. They are what give us our quality of life right now. The question is: is there some other way? But energy is at the core of it, because that is the core way that this carbon dioxide is getting into the atmosphere; it is from the combustion of fossil carboniferous fuels.

So my first robust statement is that energy use scales with income or GNP, and that basically means that no one has figured out how to have economic growth without raising the amount of energy that is used — not China, not India, not other developing countries. While we want to talk about energy efficiency and all the rest, energy efficiency is a modest perturbation around a pretty tight line connecting income levels with energy use.

That means that as the world economy continues to develop, and poorer countries hopefully gain higher living standards, we will see a demand for more commercial energy input. That is a robust conclusion. There is no easy way through turning off the lights to break the link between economic development and increased energy use.

Yeah, turn off the lights, I'm all for it, but understand the scale. The scale is we have a lot of increased energy use in the cards. That's point number one. I just want to take away wishful thinking on that score.

Second, we are already with an unsustainable energy system. Just holding in place what we are doing right now — it is unsustainable. That is because right now the world is putting out into the atmosphere about 6.5 gigatons or 6.5 billion tons of carbon. Or, if you remember high school chemistry, multiply by 44/12ths — that's the ratio of the atomic weight of carbon dioxide to carbon — 6.5 X 44/12ths is something like 22 gigatons or billion tons of carbon dioxide going into the atmosphere.

That is raising the carbon concentration or the carbon dioxide concentration in the atmosphere. Prior to the industrial revolution, around the year 1800, carbon dioxide, which is just a tiny bit of the atmosphere, was at about 280 parts per million (280 carbon dioxide molecules per million molecules). Now we are up to 370 per million molecules. It doesn't sound like much. However, it's just enough to wreck the planet because this is pretty potent stuff.

Carbon Dioxide traps the infrared radiation that would otherwise be reflecting the solar radiation that hits the planet, sending it back into space as infrared radiation. But, instead, these molecules of carbon dioxide trap it, start vibrating, heat up, and transmit infrared back to the earth. That is the global greenhouse gas effect.

So we are already in an untenable situation, because at 6.5 billion tons emitted each year, the carbon concentration is rising about 1.8 parts per million per year. If you do that over the course of a century, you would get maybe to 560 parts per million. That is an interesting number, because it is two times the pre-industrial level, 280 to 560. That is a standard that is used a lot in the scientific literature – a doubling of carbon level. Almost every ecologist considers a doubling of the carbon level pretty dangerous, because that has a lot of different effects, which I will come to in a moment.

Now, that is if we don't change. But the good news from my point of view as a development economist, and the bad news from my point of view as an environmental economist, is that we are going to change massively in the future. There is no way that we are going to stay at the current level of energy use unless we have a global-scale debacle. Energy use is rising sharply because poor countries would like to have a little bit of what we have, and they are, broadly speaking, successful in economic development right now in Asia (though not so successful in Africa). Asia's energy use is absolutely skyrocketing, and it is growing 5-to-10 percent a year.

China's growth right now is approximately 9 percent per year. That means that China's economy is doubling about every eight years. That is quite a spectacular gain. They are making up for 500 years of lost time, trying to catch up with a gap that came from a very, very difficult half-a-millennium for them. They are closing the income gap very fast right now. That is all too the good from my point of view, except for the greenhouse gas effects. But it is good for the human well-being effect, and not to be stopped I hope. What it does mean, though, is a lot more energy use.

India, right now, is growing at about 8 percent a year. A billion people – one out of every six on the planet – are Indian. India is also in the middle of an economic boom.

So the fact of the matter is that the United States, bless our irresponsible hearts, while not really paying much attention to the damage it is doing right now, is actually not going to be the dominant source of the problem in the future. Asia will be. So we actually cannot solve this problem on our own.

Now, we are doing everything we can to not solve it, period. But we actually will not be able to solve this on our own because of the economic development taking place.

And I hope — and I work around the clock to try — that we get the same economic growth started in Africa. Africa hardly uses fossil fuels right now; it relies on cutting timber and deforesting for cooking fuels and so forth. However, Africa needs fossil fuels as well, because it could actually do with some electricity and some automobile and truck traffic. That is likely to come as well.

So that is a robust conclusion. That means that we are just way off the charts in terms of what would happen if we were to keep the same technology but just continued at the same economic growth. We would hit a doubling of carbon levels by mid-century, we would hit a tripling or more by the end of the century, and the consequences would be absolutely phenomenal.

Now, here is another piece of good news and bad news, depending on your perspective. If you are concerned about fossil fuels, this may be bad news, but on the whole it is very good news. The bad news and the good news is we are not running out of fossil fuels. One idea might be: "Well, this is all temporary because there is not enough oil to go around, so we are going to be forced to go to renewables."

A lot of people are writing very bad books right now about the collapse of the world economy in the 21st century. There is a little boomlet going on. It is killing a lot of trees, and it is a whole shelf in the bookstore.

But it gets one very basic thing wrong: even if we are running out of oil, which is arguable itself, we've got centuries of coal. That is a very important thing to understand, because coal can be turned into gasoline, coal can be turned into gas, coal can be turned into hydrogen. Coal can be turned into anything you want that we use fossil fuels for, through pretty well-established technical processes.

The main process that you are going to hear a lot about in the future is called the Fischer-Tropsch process, which is a process for liquefying coal.[8] Several such projects are now underway again in the United States. There were a few of these in the 1970s, but then, when the price of oil fell again, those projects stopped. But there are billions of dollars of Fischer-Tropsch investments in China right now, because China is filled with coal and this is good news for them.

So even if we were running out of oil and gas, my colleagues argue that maybe within the next thirty or forty years we'll peak — but not in 2006, as these books are stating. In any event, even if the pessimists are right, there is still most likely enough fossil fuel at low cost to go around.

So the reason for solving the problem of fossil fuel carbon isn't that we are going to run out of fossil fuels. That is probably not the way this problem is going to be solved. That's the bad news.

But the good news is if we really were at the end of fossil fuels, we really would be in a very serious crisis because the next best thing around is very expensive. Currently, a kilowatt hour of photovoltaics (solar power), is ten times more expensive right now than a kilowatt hour of a coal-fired thermal plant. That would be quite consequential for our standards of living.

So it is probably on the whole quite good that we will not solve this problem by running out of fossil fuels. In three or four centuries we probably will run out of fossil fuels, and we will need to make a transition to true renewables, solar being the most promising, and safe nuclear or fusion in the long term. But who knows where technology will go?

8. *See, e.g.*, Timothy Egan, *Seeking Clean Fuel for a Nation, and a Rebirth for Small-Town Montana*, N.Y. Times, Nov. 21, 2005, at A16.

The good news is that the incoming solar radiation each day is about 10,000 times the energy use on the planet right now, and there is enough solar to go around for I think it's at least a few billion years more. No one has come up with a great solution past that, but frankly, I'm not worrying about it and I wouldn't recommend you either. There is a lot of solar energy to potentially be tapped, and there will probably be a number of great breakthroughs in the future. But they may be many decades off.

So that leads to the next robust conclusion: we want to get off the current trajectory. I think that is a robust conclusion.

There are two places in the world that disagree with that, as far as I can tell: one is the Oval Office, and the second is *The Wall Street Journal* editorial page.[9] They also happen to be the two most irresponsible institutions that I know of right now.

Almost everybody agrees that the current trajectory, with all its uncertainties, is really dangerous. It is true that we do not know whether it is a 1.5-degree Celsius rise or a 5-degree Celsius rise. We don't know when the Antarctic ice shields will break into sea. We don't know when the Greenland ice sheets will melt. We don't know whether an end of the thermal hailing circulation, as my colleague Wally Broecker[10] has talked about and hypothesized, would have devastating effects. We do not know the ecological implications.

What we do know is that the risks are huge. We are entering a zone of huge uncertainty. What my colleagues at Lamont-Doherty Earth Observatory at our Earth Institute[11] have shown in the Paleoclimate Record, the ancient climate record, is that even small shocks to the global climate can have enormous effects on actual climate experience. In other words, even modest shocks of carbon dioxide or intensity of solar insulation — because the sun fluctuates in how

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9. *See e.g.*, Editorial, *Hockey Stick Hokum*, WALL ST. J., Sept. 14, 2006, at A12; Editorial, *Kyoto By Degrees*, WALL ST. J., June 21, 2005, at A16.

10. Wallace S. Broecker, Ph.D., is the Newberry Professor of Earth and Environmental Sciences in the Earth and Environmental Sciences Department of Columbia University, located at the Lamont-Doherty Earth Observatory.

11. The Earth Institute at Columbia University focuses on complex issues such as sustainable development and the needs of the world's poor. The Institute works on projects n the biological, engineering, social, and health sciences to combat problems such as climate change, global health, and water access. For more information visit http://www.earthinstitute.columbia.edu/about/about.html (last visited Sept. 22, 2006).

much energy it puts out — are changes that get magnified tremendously. So you can have, and have had in history, what is called abrupt climate change, where modest forcings, as the scientists call them, lead to huge outcome changes.

As a social scientist, I would add another nonlinearity, which is that even modest changes in the physical environment can have huge changes in the economic environment. If the rainfall falls a bit, that can lead to war among people who are hungry, for example. You wouldn't know it, saying, "Well, it went from 500 millimeters to 400 millimeters rainfall," but that's enough to start a war, or it is enough to have a banking collapse, or it is enough to have famine and mass refugee movements, or many other factors.

So I believe that there are at least two linkages of strong nonlinearity: first, our pushing on the climate can have huge effects; and even modest effects of the climate can have huge social effects. Two aspects of nonlinear response.

So there is a consensus among the scientific community that a doubling of carbon, we don't want to go there, it is just too risky. And it's not a little experiment on a petri dish; it's our one and only planet. And so it is probably a bad idea to find, "Oh yeah, but that was only 5 percent of the probability distribution." It's the only one we've got.

So it is a big mistake — and our President has committed the worst of the blunders of poor leadership, in not only doing nothing, but in deliberately obfuscating the worries and the truth. And as I say, they really are matched only by the utter irresponsibility of *The Wall Street Journal* editorial page, which I always mention because it is so unaccountable and so scientifically ignorant, that we really need to be aware of how much damage it does. It is the leading, most read newspaper probably in the country, certainly in the business community, and it is just filled with nonsense, month after month, on this very, very important issue.

The kinds of effects are also unknown. It is not just the temperature, it is not just the sea level, it is not just the disease transmission, it is not just the crop yield stress. Even something which most people aren't even aware of, that other than the climate, simply the carbon dioxide itself is changing the chemistry of the oceans, so the oceans are becoming acidic, and the acidification of the oceans is killing, maybe decimating, the corals, which are a crucial part of the marine ecosystems, and maybe decimating a big part of the food chain of the oceans as well. There was a very recent review in *Nature* of the acidification and its implications.[12] This is big stuff.

And that is even aside from the climate model. No earth scientists disagree with the fact that if you put more carbon dioxide in the atmosphere, you get more carbonic acid in the oceans and you get a decrease of the pH, and there are strong reasons to believe that that hinders the formation of exoskeletons of marine life, like the corals.

So what do we do about it? I would say everything I have said I believe is pretty robust conclusions so far, without knowing the precise areas. So what can be done about it?

We would like to believe that a bit of — or even more than a bit — that good energy efficiency, that good conservation practice, that wind power, that solar, that better insulation, and so forth will carry us through. Probably not.

In other words, the nice things that we like are probably good things, but they probably are not at the same scale as the problem. So everything is quantitative; it is not just qualitative. Turning off the lights, and walking rather than the extra drive in the car, and better insulation and so forth could make a difference, maybe — I'm making it up — 20 percent energy use, maybe 10 percent — but the energy increase that we are likely to experience is maybe threefold, because of the growth of the world economy. Starting from a baseline, we are already unsustainable. In other words, the key here is quantitative reasoning, not only qualitative reasoning.

You have to ask, "Are we going to get on top of the problem or not?" — not "Are we going to do the right direction of change?" but "Are we actually going to solve the problem, are we going to be able to head off a doubling, say, of carbon concentrations?"

The usual ideas right now, of more energy efficiency and more renewables, particularly wind, solar, biofuels, and so forth — my view with my colleague Lackner in this paper is that those are good things but they are probably not decisive, probably not even close to being decisive actually, that in fact you already take them into account in the baseline — yeah, there will be further energy improvements, but we still have a massive, massive increase of human-led emissions.

The fact of the matter is that China and India are likely to use their coal, because it is cheap, and so even if alternative energy sources come along, that coal is going to be used. And we actually use more

12. *See* Quirin Schiermier, *Researchers Seek to Turn the Tide on Problem of Acid Seas*, 430 NATURE 820 (Aug. 19, 2004).

stones than we did in the Stone Age also. So when people talk about the post-fossil-fuel age, it doesn't mean we are going to stop using fossil fuels. We are probably going to use fossil fuels big time for the future.

In addition to crucial work on developing alternatives, we see solar as the brightest prospect at a horizon of fifty years; nuclear has potential but is very dangerous right now — and I'm not talking about the dangers of the power plant or the storage of spent fuels, but the dangers of proliferation, which seem to me to be *the* dangers of nuclear, much, much more than the danger of the plants and the fuel disposal. But the proliferation problem is utterly unsolved, as we notice every day, thereby making nuclear a very tricky and limited option.

It does seem to us that fossil fuels are with us for quite a ways in the future, especially coal, tar sands, oil shale, and so on. That is a lot of carbon dioxide that is going to be burned.

So our view has been, and in this paper it is described, that probably the most robust short-term solution would be technologies that would capture the carbon at source, in power plants and industrial plants, as the fossil fuels are burned and then sequester that carbon in geologic storage of one form or another. This is a promising but unproved technology in some ways, but some of it is done right now.

It is known by the engineers pretty reliably how to take the carbon dioxide out of the exhaust stream of a power plant, especially if the power plant is designed that way. It is also known how to pump carbon dioxide into the ground by taking it through pipelines to a place to put it underground. That is done also in some limited cases in oil and gas fields, because it is one of the key ways for what is called enhanced oil recovery, is you push carbon dioxide down into the ground, create pressure, and you force up more recovery of the oil and the gas. When you do it there, actually companies pay for carbon dioxide to put under the ground. It is also very likely the case, but a bit less proved, that the carbon dioxide that you put under the ground in those circumstances stays under the ground so that it is actually sequestered.

Our view is that this is the most promising single step that can be taken in the next quarter-century, or even next half-century, to make a consequential difference. The reason for the optimism is that the best evidence is that the cost of capturing the carbon in a new thermal-fired power plant, especially a coal plant that makes electricity, transmitting it in a pipeline and sticking it under the ground, is probably one-to-three cents per kilowatt hour only. That's still a lot of money — it is tens of billions of dollars a year for the world — but it is not an inordinate amount of money for a tens-of-trillions, and soon to be hundreds-of-trillions, dollar economy.

Now, from my point of view, there is one huge question mark, which I told you about earlier. I said I am optimistic subject to one question mark. Does the carbon really stay down, and are there enough places convenient to stick it?

There are not enough oil and gas fields. You know, we just do not need all the carbon dioxide that we produce. And even if we go on a binge of soda drinking, it is just not going to be enough. If we require Coca-Cola in the morning, afternoon, and evening, at twice the fizzies, we simply probably do not have enough use for the carbon dioxide. Right now it is 22 billion tons of carbon dioxide. That is a lot of stuff.

So we have to find big, big repositories for that. The geologists say, "Yeah, you know, probably there are enough sedimentary layers around the world to sequester that amount and a lot more." That's the most recent conclusion of a serious study of this by a panel of geologists for the Intergovernmental Panel of Climate Change.[13]

"Aw, don't worry about that." They say "highly likely," which they translate as above 95 percent certainty. So that is my question mark.

If this technology can really be proved, then what our conclusions show is the following: the previous step plus one major step, which is not so easy for this country (I think the rest of the world is going to get it; we'll probably eventually get it as well) and that step is more efficient automobiles with more miles per gallon: hybrid plus.

Those two steps, capturing the carbon at power plants and doubling the trajectory of miles per gallon, would be enough to keep the carbon levels well below doubling by mid-century.

The cost of that we calculate in this paper, on the optimistic conclusion that this carbon capture and sequestration works as advertised right now, would be between 0.1 and 0.3 percent of the world's GNP. In other words, for well under 1 percent of the world's GNP, maybe even a tenth of 1 percent of the world's GNP, we would be able to get on top of this.

13. The Intergovernmental Panel on Climate Change (IPCC) has been established by WMO and UNEP to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. It is open to all Members of the UN and of WMO. For more information, visit www.ipcc.ch/.

It is likely that the shift to hybrid is a pure gain, not a cost, because the savings would be enough to pay for the extra costs of making hybrids relative to conventional automobiles. The fuel savings is enough to offset the cost of the batteries, broadly speaking, at current energy prices.

The other cost is this one-to-three cents per kilowatt-hour, which looks to us to be something like 0.1-to-0.3 percent of world GNP. In the end, we calculate something like $240-to-$720 billion per year of cost of sequestering carbon — hundreds of billions of dollars by mid-century per year. We also calculate that by mid-century world GNP consistent with that level of energy use is something like $250 trillion of global income. So the point is — maybe we won't get that much income, but then we wouldn't use that much energy either — that we would at a relatively low cost in the end be able to handle this problem.

Our conclusion, therefore, is: first, don't run away from this problem. It is manageable. Of course, the President would have to read a paper, so maybe it is manageable in the next administration. I am a little annoyed with the White House I have to say. That's not a big secret.

Second, we need to get started now, because if you put in a new power plant, you want it to be able to capture the carbon now, because if it is not able to, you've got about a fifty-year life of that new power plant. So we are interested in quickly testing this proposition, that power plants designed for carbon capture and sequestration can operate at low cost.

The most promising of those is what is called an IGCC power plant, an integrated gasification combined cycle coal-fired power plant. General Electric makes some of the best. I am hoping that public policy and General Electric, a kind of public-private partnership, working with China, working with India, working with us at the Earth Institute, and working with others, can get some of these prototypes going in the next couple of years so that we can actually test this.

I have to tell you, unlike many things I work on, if that route doesn't work, I don't have a great backup speech right now. So that's why I put a big question mark there, because the next-best technology is a hell of a lot more expensive than this one is made out to be.

So if IGCC works and if the geologists are right, we are in reasonable shape if we actually decide to do something. If it doesn't work, I can't tell you I've got a great backup story. We only wrote one paper, not two. Wind and energy efficiency and all the rest isn't going to solve the problem, and certainly not for China and India, which are going to be using their coal. So we believe that we need to put this into operation with much, much greater urgency than now.

We also believe that for this to work there have to be market-based incentives of the sort that this conference is studying and talking about, that there will have to be a price of carbon in the market, or something which differentiates those who do stick their carbon back in the ground from those who do not, so that there is a financial incentive to do it.

Or a regulatory incentive. You could declare that all new power plants have to capture their carbon and dispose of it — that is a command-and-control approach — and it may make sense in certain contexts.

But then there is the politics. There are two levels of politics that I want to mention quite briefly.

One is our domestic politics. I believe we are primed for kind of a breakthrough on this issue. If it is right that the costs of addressing this are as small as they seem to be as a share of our income — not in absolute dollars, but as a share of our income — we are going to get to the right answer. Hurricane Katrina is getting us to the right answer a lot faster, because that is the kind of effect that we are likely to see from human-made climate change. Maybe that was an effect of human-made climate change. But if it wasn't, it will be in the future. Category 4 and Category 5 hurricanes, that's what we should expect from the warming of the Caribbean waters through manmade climate change. So the public is waking up to this in a very, very painful way.

The second thing is that I believe that the number one reason for the Administration's attitude was the view that "we will not talk about this issue because Bush wanted to carry West Virginia in 2004." That to me is really the essence of this story. If you look back at the 2000 election, which was decided by Florida, it was equally decided by West Virginia, by a tiny swing of votes. So I think that Karl Rove[14] took the decision early on: "We are doing nothing to upset a single coal state in this country."

The view has been that getting climate change under control is anti-coal. I think that is wrong, because I've just said why clean coal

14. Deputy Chief Of Staff to President George W. Bush.

could be part of the solution. So we are beginning to work with governors of coal states, to talk to them about how coal can be used effectively and safely if the power plants are prepared for carbon capture and sequestration.

We have begun work with the governor of Montana, Governor Schweitzer, and asked him to help pull together a number of other coal state governors to try to get clear, and then get clear to the country, that coal is going to play a big role for this country and that it can be used cleanly if the technology is set in the right way. That to me will change a lot of the politics, because if you look at who has voted for and against the McCain-Lieberman legislation,[15] the coal states have uniformly voted against up until now.

Senator Robert Bird,[16] in the first vote of the McCain-Lieberman legislation, gave a wonderful floor speech about the dangers of climate change. Senator Bird, as you know, is one of our most eloquent political leaders. He went on for two pages about the dangers of climate change. The last sentence said: "And, therefore, it is with a heavy heart that I vote against this bill." The point he was making is he comes from West Virginia, and that is going to be the determining factor, but he knows what he is doing. I believe that with the right technological outlook he will be able to vote the other way.

Finally, we need a global approach to this view, and we need to help the poorer countries get on the right path. Now, when they see us with our butts in the air and our heads in the sand that is not exactly a great role model. That is how we are viewed in the rest of the world right now, if you will take the image, on this issue. We need to do better than that. More than that, we need to help pay for these prototype plants early on, and recognize that if we are going to get the poorer countries onto the right path — and we need to — then we are going to have to help pay for it, because we have done almost all of the increase up until now because we use energy at ten times the rate or poor countries and, therefore, we are going to have to make some financial contribution to all of this to get it done.

Given the costs as I have outlined them of action versus the costs of inaction, I will conclude where I started: I am a cautious optimist.

Thank you very much.

15. The Climate Stewardship and Innovation Act (S.1151), Oct. 2003
16. Senator, West Virginia.

MR. SELIG: Thank you, Professor Sachs, for your wonderful speech.

We have time for one or two questions, if anybody would like to ask them.

PROFESSOR SACHS: Burning questions, so to speak.

QUESTION: There has been a fair amount of recent discussion about the effect of ozone versus carbon dioxide. Do you have thoughts?

PROFESSOR SACHS: Well, the tropospheric ozone, the lower level, is smog and disease, but it is not the main contributor for long-term climate change. The stratospheric ozone depletion, which is the thing that was coming from the aerosol bottles, is also not a major contributor to climate change; it is a major contributor to hazards of skin cancer and other risks of unshielded ultraviolet radiation hitting the earth.

The main factor in climate change is the carbon dioxide. There are a lot of other greenhouse gases from industrial processes, also methane from agriculture, from rice paddies and so forth, and a number of other greenhouse gases that can play an important role in all of this. My colleague, Jim Hansen[17] — who is really the hero of this issue, because he is the NASA scientist that they were trying to squelch, and he said he will not be squelched in this, and is not only a great scientist and was the first person ever to testify in Congress about this issue, but he is a very brave person also — he is of the view that controlling these other greenhouse gases is also consequential, though in the long term it really is the energy system.

QUESTION: Last week James Hansen, in a presentation at the New School[18], had stated that the best mechanism at this time to reduce our carbon emissions is immediate implementation of emission reduction through efficiency technologies. That does not exactly concur with your views of bringing in technologies to sequester the carbon, which seems to be your priority.

PROFESSOR SACHS: Right. I think the difference is what you can do in the short-term and what you need to do in the longer term. It is the time horizon issue. It is not contradictory. It is just that if

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17. Dr. James E. Hansen, NASA Goddard Institute for Space.

18. *See* James E. Hansen, Director, NASA Goddard Institute for Space Studies, Can We Still Avoid Dangerous Human-Made Climate Change, Address Before the New School's Social Research Conference (Feb. 10, 2006), *available at* http://www.columbia.edu/~jeh1/newschool_text_and_slides.pdf.

you look out over a fifty-year period, given global economic development, efficiency gains will not be sufficient. That is the point.

QUESTIONER: I work at the Sierra Club[19] here and I also do NGO work with the Energy Caucus.[20] It seems from a world view position that the lack of effort from all the governments and institutions and industry in their reduction of emissions — whether it be green standards for all new construction, which is nowhere to be found on the panel — there are so many measures that we have not even begun to look at.

PROFESSOR SACHS: That is correct.

QUESTIONER: I don't see in the world, or even coming out of the UN, a kind of impetus or direction towards using those options prior to bringing in technologies such as carbon sequestration.

PROFESSOR SACHS: I wouldn't say that. I am not arguing for one solution, by the way. I am just saying that when you add up quantitatively all the different solutions, they are all going to play a role. So don't misunderstand. I am not against energy efficiency. Many companies have found that they just purely save costs and they are just neglectfully wasting energy. And certainly, we could have a much more efficient automobile fleet in the short term, and we could have a more efficient housing and commercial structures stock than we do. So I am not arguing against it, and I am certainly not arguing against wind power and other things.

I am just saying quantitatively we are a fossil fuel economy and the use of fossil fuel is going to grow. That is what I am saying. That is the claim that I am making.

But in terms of what the UN does, the UN has a normative role and a scientific role in this. The normative role is the Agreed Framework,[21] called the UN Framework Convention on Climate Change,[22]

19. The Sierra Club, with membership totaling more than 750,000, maintains to be the largest and most influential grassroots environmental organization in America. *See* Sierra Club, http://www.sierraclub.org/inside/ (last visited Sept. 20, 2006).

20. *See* Non Government Organizations Energy and Climate Caucus, http://www.energycaucus.org (last visited Sept. 20, 2006).

21. United Nations Framework Convention on Climate Change, Essential Background, http://unfccc.int/essential_background/items/2877.php (last visited Sept. 20, 2006).

22. United Nations Framework Convention on Climate Change, http://unfccc.int (last visited Sept. 20, 2006).

the UNFCCC. Bush Sr. signed that in 1992. The Kyoto Protocol,[23] of course, is the implementation part of the Framework Convention, and we did not sign that. Other countries did. It is a start. I am all in favor if it. It doesn't get us very far, but still it puts a framework in place.

So I wouldn't say the UN hasn't done anything. That is an invitation to save money for companies in Europe. If they can use less energy, they actually don't have to buy their carbon emissions rights right now, or they can sell the ones that they have. So they have a good economic incentive to do what you are saying right now, and I think that that is the right way to go, to put a carbon price in place. It is this country that hasn't done it. That is the Administration's neglectfulness.

So I don't disagree. It is just that quantitatively I am saying that if you look at the amount of electricity growth that is going to occur in the future, it is going to be huge, and it is going to be coal-fired to a very significant extent.

Maybe one more.

QUESTION: I'm sorry. I would like to ask if you can elaborate on the sequestration point that you made. Were you just considering sequestration in geologic formations?

PROFESSOR SACHS: Yes.

QUESTIONER: Did you and your colleague also include sequestration in the deep oceans? And I guess a follow-up to that, if you could address it at the same time; what about the risks about catastrophic release?

PROFESSOR SACHS: Yes. Sequestration, as I said, is the biggest unknown in my view of all of this issue. We know a lot about pipelines, we know a lot about removing carbon dioxide from flue gases and so forth, but we don't know about sequestration. So that to me is the biggest puzzle.

There are many kinds of sequestration, including biologic sequestration, which is afforestation and reforestation and avoid deforestation.

Those are all good as well, but they are quantitatively again limited in scale. So they don't solve the problem. I keep stressing that because there are lots of nice things to do, but the question is are they

23. *See* http://unfccc.int/resource/docs/convkp/kpeng.pdf (last visited Sept. 20, 2006) (providing full text of the protocol); *see also* The Kyoto Protocol, http://unfccc.int/essential_background/kyoto_protocol/items/2830.php (last visited Sept. 20, 2006) (providing background information on the protocol).

enough. So it becomes a quantitative question, not just a qualitative question.

There are many places you can stick Carbon Dioxide, although you have to stick 22 gigatons, and rising, of it. So it is a lot actually.

There are many proposals of where to put it. One is in old oil and gas fields. Another is in aquifers with the right geologic structure to prevent the CO_2 from coming back up. A third is in the ocean bottom or below the ocean floor, on the theory that it would actually gravitationally by density sink at that point even farther, though putting gigatons and gigatons of carbon into the deep ocean probably is not going to win a lot of enthusiasm.

So I do think that this is a big issue. There is no regulatory framework and there is just not enough known about the geologic consequences of all of these different alternatives right now. If I were running things, this is what I would be out doing big time, is lots of experiments on geologic sequestration, because I'd like to know the answers to this, because as I say, to me it is the first node of the decision tree. If it does work, you go this way. If it doesn't work, you really start worrying and you have to go a different direction.

But the answer is all that you said is hypothesized, but nobody really knows right now, including the question of catastrophic release. You know, you'd have to have safety standards, monitoring, and a whole regulatory framework, which doesn't exist right now.

Thank you very much.