

**Using Technology to Reduce
Greenhouse Gas Intensity
In the Developing World**

with

David Montgomery

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W. David Montgomery, Vice President at the economics and business consulting firm of Charles River Associates, directs CRA's Environment practice. He is an internationally recognized authority in energy and environmental policy and regulation. Dr. Montgomery also has a special expertise in the area of energy price forecasts, having supervised the U.S. Department of Energy's energy forecasting and economic analysis activities for a number of years. He was previously Deputy Assistant Secretary of Energy and Assistant Director of the Congressional Budget Office, with responsibility for all natural resource and commerce program analysis, and has taught at the California Institute of Technology and at Stanford University. Dr. Montgomery has published widely on oil, natural gas, and electric utility regulation; on the use of economic incentives in regulatory programs; and on the taxes and environmental regulations affecting energy industries.

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March 31, 2004

William O’Keefe: On the topic of climate change, there are a lot of things people don’t agree on. But they do agree on the fact that the source of most greenhouse gas emissions in this century has come from developing countries, that any actions undertaken to reduce emissions ought to be cost effective, and that dramatic reductions in emissions can be achieved at less expense in developing countries.

David Montgomery has done some work which demonstrates potential for both reducing the growth of greenhouse gas emissions and doing so in a way which helps countries to achieve their economic aspirations. I have known David for well over ten years. He has a great reputation as being one of the leading energy economists in the country and has done groundbreaking work in the energy area and also in the climate area, so we are very fortunate to have him here today.

David Montgomery: Thank you very much and thank you all for coming out for this Roundtable. It is very gratifying to see everyone here. The challenge that I was facing in starting to work on this project a year or two ago was to look at alternatives to the Kyoto Protocol and the current international system, which essentially establishes long-term targets and timetables, which are not being adhered to and do not seem to be affecting current behavior. I wanted to investigate the opportunities for actions that could be undertaken now to produce immediate and irreversible reductions in carbon emissions and where we could look to find those policies. The most obvious place, as Bill mentioned, is in developing countries, because of what we know of the magnitude of their emissions and what we think we know about how cost effective it could be to reduce emissions in those countries.

The difficulty is that developing countries do not have the same perspective on their priorities that the negotiators at the framework convention of the Kyoto Protocol had. In developing countries, the major policy concern is economic growth and dealing with poverty and more pressing environmental issues, such as water you can’t drink, air you can’t breathe, and other critical health issues. We are seeing this more and more clearly in the variety of other international forums that deal with global economic growth and broader trade issues. The reason for focusing on developing countries’ climate policies clearly is the rapid growth in their CO₂ emissions that we anticipate and the untapped opportunities we think we see for reducing their carbon emissions. The difficulty is that tapping those opportunities requires policies that must be interesting to developing countries, which basically means policies that provide improved standards of living and increased economic growth at the same time that they provide reduced emissions. Now, is this possible? That is what I want to discuss.

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My two goals in this talk are to look at the potential for reducing developing country emissions in a way that allows continued or accelerated economic growth, and then to talk about the steps which are required to achieve that potential. After that, I would like to open this up as a roundtable discussion because you are the policy thinkers and policy makers and I would like to engage you to think about that question of whether there is an opportunity there and if so, how we can go about exploiting it.

Developing Countries Are the Largest Source of Near and Long Term Emissions Growth

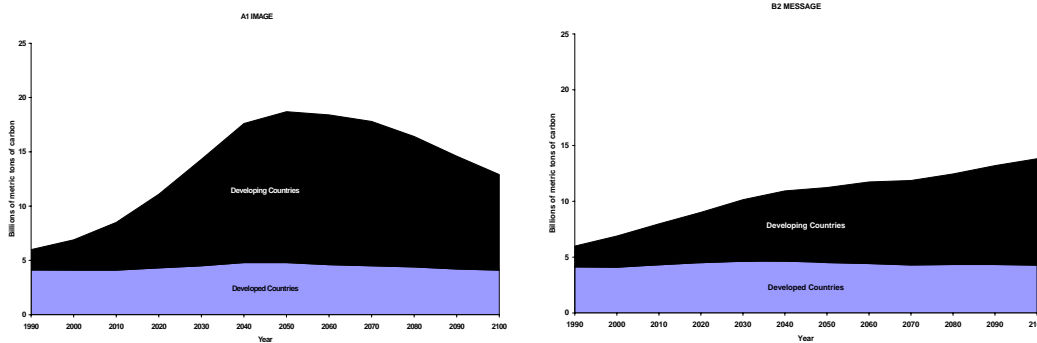


Figure 1

Now to establish the first point, the developing countries are expected to be the largest source of both near- and long-term emissions growth. In Figure 1, I have taken two of the accepted scenarios from the Intergovernmental Panel on Climate Change’s Special Report on Emissions Scenarios in order to look at the comparison between developing countries and industrial countries. The lower bar on the left-hand chart is the projected emissions from industrial countries over the next hundred years, to 2100. The first scenario describes relatively rapid economic and emissions growth in developing countries, followed by a period of accelerated technical progress which brings those emissions down. It shows that by about 2050, the developing countries will have emissions that are about three times as large as the industrial countries. The second scenario describes slower, more continuous growth and shows that by the end of the next century, developing countries will have twice the emissions of industrial countries. These scenarios suggest that not only is there opportunity there, but that there is an absolute necessity of dealing with developing country emissions, because industrial countries could disappear from the face of the earth and, as we see from the black line, CO₂ concentrations in the atmosphere would continue to increase.

So then the question becomes how can we identify the largest and least costly emission reduction options and how can we achieve them? The two actions that I want to talk about are

1. implementing policies to improve the greenhouse gas intensity of developing country economies through investment, technology transfer, and market reforms; and
2. implementing policies to stimulate research and development (R&D) that provides economic energy technologies with carbon-efficient emissions lower than the most cost-

effective ones today, and in particular technologies that would be attractive to developing countries without layering a Kyoto-like set of bureaucracies or incentives on top of the normal operation of their economies.

The second question is, if we can identify actions that have great potential, which I think we can, are these actions cost effective? I want to take a look at emission reductions that could come out of growth strategies for developing countries and compare their magnitude to the reductions that are anticipated from the industrial countries under the Kyoto Protocol to give an idea of magnitude. Next I will talk about the conditions under which these growth strategies actually could be cost effective. That is, the conditions under which they could be a win-win strategy both for the industrial countries, which could profit from making investments, and developing countries, which would have higher rates of economic growth and overall economic benefits. Finally I will examine what it takes to make that the case and what policies could bring about those changes.

In terms of policy design, the two areas I want to look at are policies that would remedy market distortions in developing countries that hinder investment and technology transfer and, conversely, policies in the industrial countries that would increase the amount of foreign direct investment, in cases where growth is constrained by a lack of capital in developing countries. Essentially, we need to determine what the constraints and market distortions in developing countries are whose removal is feasible and capable of opening up opportunities for a flow of profitable investment to investor countries. On the investor-country side, how can we ensure that that investment brings along with it the technology that gives rise to the most rapid emission reductions? This is going to require action in the Annex B countries, in the industrial countries like the US, and in non-Annex B countries. But the current nature of the problem is such that it does not require a global treaty or huge multinational efforts; progress can be made on a simple bilateral basis of countries that are willing to work with the US in order to move forward.

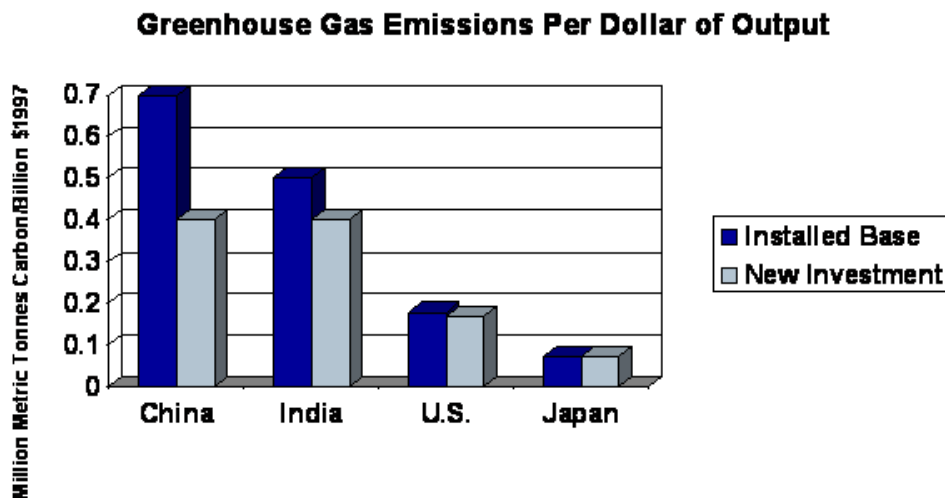


Figure 2: Unless Something Changes, Developing Countries Will Continue to Have Emissions Far Larger Per Dollar of Output than Industrial Countries

Let's think about the technology issue. The growth conundrum is that economic well-being is measured in terms of GDP. If developing countries are going to become better off, their GDP has to grow. But we think about emissions as being characterized as emissions per

dollar of GDP. If we are going to have growth go up, what we have to do at the same time is make emissions per dollar of GDP go down faster. The question is, is that possible? There are some pretty big opportunities. Figure 2 shows measures of greenhouse gas emissions per dollar of output. The dark blue lines are what we normally measure. We just take total emissions in China, divide it by China's total GDP and we see that it is about .7 million metric tons of carbon for every million dollars of Chinese GDP. That is about 30-40% higher than India, which is now putting out about 5.5 million metric tons of carbon for every dollar of GDP and it is three or four times the US, which is down below .2 million metric tons of carbon per dollar of GDP, and Japan is about half the US. That is what having an installed base of capital equipment in developing countries and the US does.

Then we do a little bit of fancy growth accounting with our models to ask ourselves, what does the new investment in China and India look like? The new investment in China is almost twice as good as the average of the installed base, but that is all. And the new investment in India is only about 20% better than the installed base. Both of these countries, in their new investment, are showing emissions per dollar of GDP that is about twice what the US is getting with its new investment, that is, every dollar of GDP we add through investment in the United States is associated with half the emissions that every dollar invested in China is associated with. And Japan of course is even lower than that.

That suggests two possibilities. If we just accelerated the replacement of the old Chinese capital stock with the new Chinese capital stock, we could cut China's emissions about in half. That would be a pretty good deal. But if we could replace it with US capital, we could cut their emissions by a factor of four and that makes a huge difference in what happens to the global carbon emissions. Following up on this, if we can arrange this kind of technology transfer and accelerated replacement of capital, we can reconcile solving the growth problem with solving the climate change problem.

It is important to recognize that new technology is embodied in new capital equipment, that aside from some housekeeping details, we change emissions in a dramatic way by using new equipment, by using nuclear power plants rather than coal-fired power plants, by using fuel-cell vehicles or just modern American cars rather than old, inefficient models. This suggests that higher rates of investment in a country, pushing more money in, will accelerate the replacement of the old capital with the current level of technology. So with more investment in China, we would see more replacement of the old capital, which has high emissions intensity, with new capital, which has lower emissions intensity (Figure 3). That's good. But if we can get even lower emissions in the new technology, that will push the emissions down further, so the issue becomes not just funneling more investment in, but getting technology transfer that moves from old to new Chinese technology, all the way to the new US technology or, depending on economic conditions, maybe even the new Japanese technology.

Combining higher rates of investment with better technology produces the biggest benefits. I have done some calculations using a model of economic growth which embodies technological change to see how much is feasible, given parameters we can be sure describe with reasonable accuracy the economies of China and India. If the EU met all of its Kyoto Protocol targets and did not buy any hot air from Russia, the EU would reduce its emissions by about 600 million metric tons cumulative between now and 2012, compared with a baseline,

and about 1,400 over the first two commitment periods, if the second commitment period had the same target as the first period.

	To 2012 (MMTCE)	To 2017 (MMTCE)
Adopt US technology for new investment in China and India	2600	5200
Adopt US technology with accelerated replacement in China and India	4200	7700
Adopt continuously improving technology with accelerated replacement in China and India	5000	9800
EU under Kyoto Protocol (without hot air)	600	1400
All Annex B countries under Kyoto Protocol (including US and hot air)	2800	7300

Figure 3: Emission Reductions Comparable to Kyoto Are Possible from Policies that Enhance Economic Growth & Environmental Quality in Developing Countries

If all of the Annex B countries including the US and Russia met their targets, then we would get about 2.8 billion metric tons cumulative to 2012, and about 7.3 billion metric tons cumulative to 2017. How do the numbers compare to China and India? If China and India, at their current rates of investment, were to move to US technology for their new capital equipment, we would get initial reductions that are far larger through 2012 than the entire Kyoto Protocol would get.

This is actually looking at it in a dynamic picture and saying: Suppose we start today with current rates of investment and move that new investment to twice the energy efficiency, how much can we save by 2012? Another way of looking at this is that there is a huge opportunity that will be lost in developing countries with every year that passes, because delaying action to bring this new technology in puts carbon emissions in the atmosphere. Therefore accelerating technology use is a very much faster process than the long-term targets and timetables we are looking at with Kyoto. And if we combine the US technology with accelerated investment in China to replace the existing capital stock faster, we build up to something that is about twice the total accomplishment of the Kyoto Protocol through 2012 and about the same as we could expect to get from the Kyoto Protocol all the way out to 2017.

Another important point is that, in the long run, once we get China and India and all the rest of the developing countries up to the level of technology in the US, then everybody is going to grow in emissions. So ultimately stabilizing emissions requires improving R&D to bring in new technologies that keep the energy per dollar of GDP ratio going down. If we get those technologies, and I assume a modest and continued improvement in technologies over time, we can then get very large emission reductions. I would like to illustrate what those paths looks like.

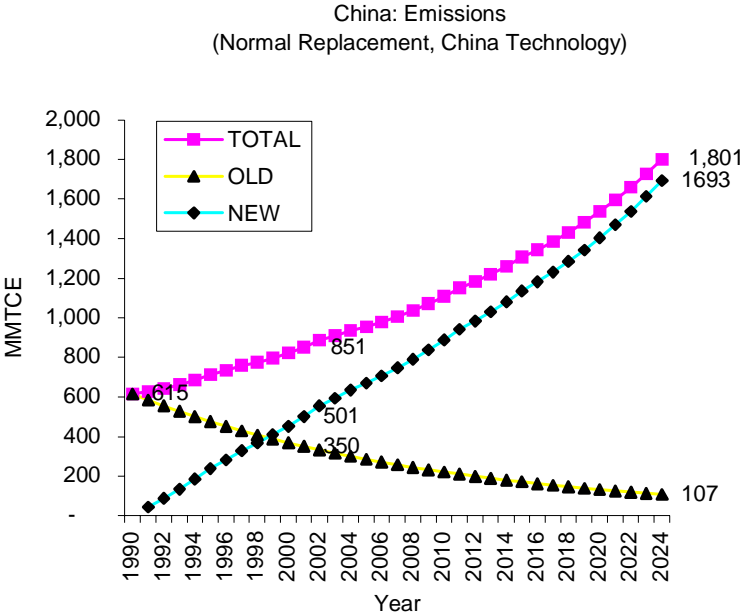


Figure 4

Figure 4 shows our baseline forecast for Chinese output, which shows China’s GDP growing from about \$1.5 billion currently to over \$5 billion by 2024. The dark lines show respectively how much of this output is going to be produced from old capital, since the old capital will depreciate away slowly, and how much from the new capital, which can have lower emissions.

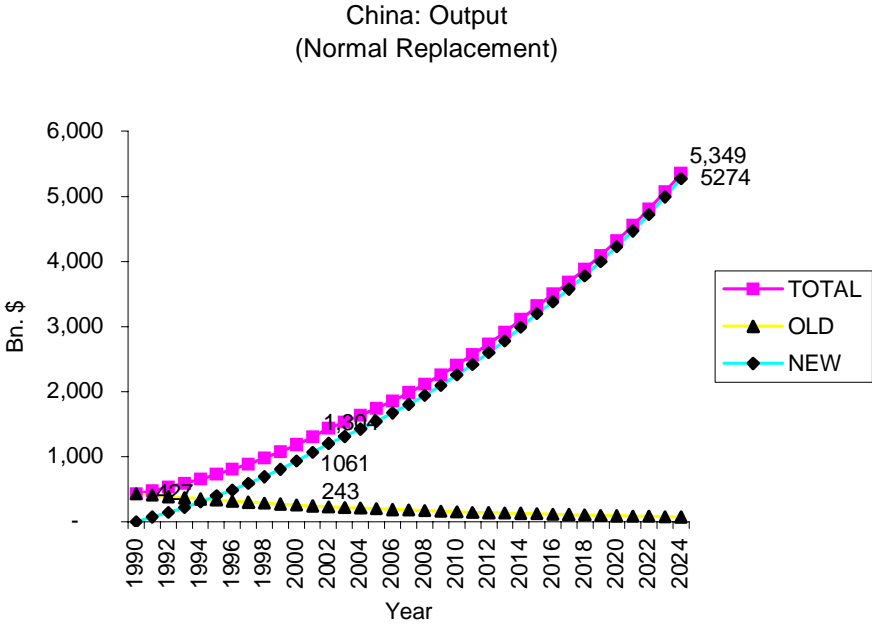


Figure 5

Figure 5 shows emissions. Chinese emissions now are about 600 million metric tons and they are predicted to triple by 2024. The darker lines show how much of those emissions are anticipated to come from old capital, which is going to go down over time, and new capital, which replaces the old. The base line here is for tripling emissions, even though China is actually improving its capital stock quite dramatically. What it is putting in today is much better than what it had in the past, but with some acceleration of technology transfer, we can do a lot better than that. We assume here that China moves to the US technology in its new investment and the US technology continues to improve over time with R&D.

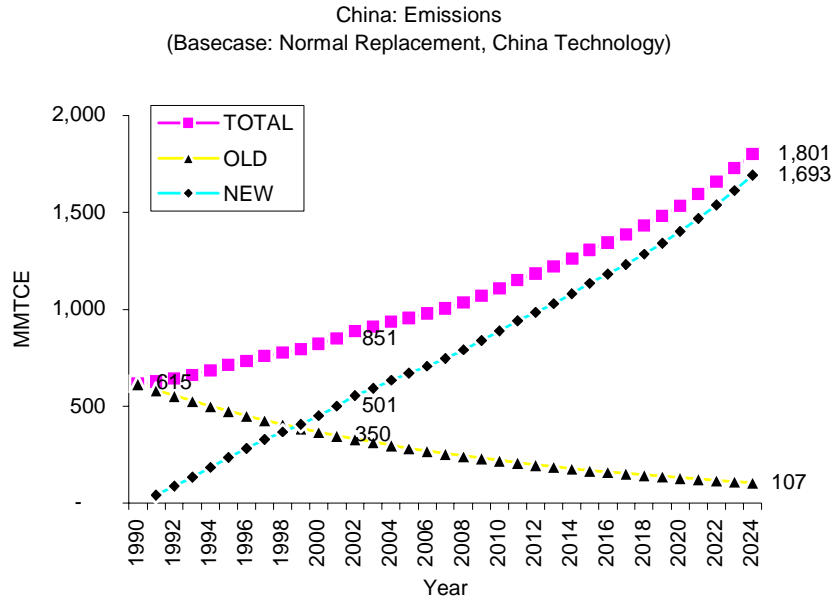


Figure 6

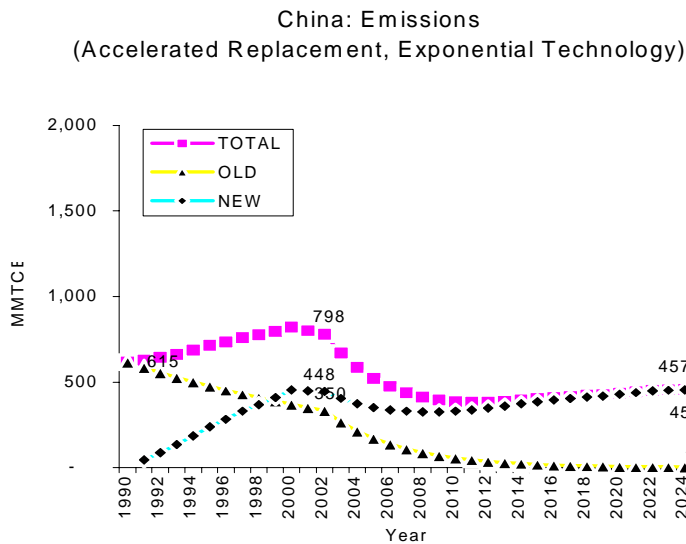


Figure 7

Figures 6 and 7 show the base case and what could be accomplished if China maintained the current level of investment, but technology transfer brought in the continuously im-

proving technology that started out at the US level. That essentially stabilizes China's emissions at today's levels for the next twenty-five years and accomplishes a reduction that is a little difference between the rising emissions chart on the left and the declining emissions chart on the right. Now if we combine that with higher rates of investment to replace the existing capital stock, we can actually take off a chunk of emissions in the year 2020 by accelerated replacement of the very high emitting capital that's there already and get some substantial improvement in emissions over the next twenty to twenty-five years.

So this is the promise, these are the opportunities. The question then becomes, is there a way to change conditions in the developing countries to bring about these emission reductions in a way that provides benefits for all? Developing a policy that can accomplish the scenarios I am talking about requires looking at how we can accelerate the retirement of older capital, how we can promote technology transfer that improves the greenhouse gas performance of new capital, how we can increase the rate of investment going into developing countries in a way that brings that technology along with it, and how we can keep the technology improving over time.

This requires some serious thought. Why do particular countries continue to use high greenhouse gas emitting technology? What changes in non-Annex B countries would be required in order to get them off that high-carbon technology in their new investments? What actions in Annex B countries would be effective in inducing this change?

I think there are at least two kinds of actions here: one is, what would be effective for Annex B countries to do to bring about changes in the non-Annex B countries, and the other is, what are Annex B countries going to do to provide incentives for their own corporations to get in there and do something? And finally, how can mutually advantageous actions be involved, where the developing countries and the Annex B countries, like the US, both play a part?

Now a deep question to start out with is whether the current technology choices that I was describing in China, India, and other developing countries are the best economic changes, given their local cost of labor and energy and raw materials, or are those choices driven by some set of market distortions? If it is the first—that the current choices are economic, that China is using coal because it has cheap labor and cheap coal and anything else is going to be very much more expensive—then there is going to be a cost to reducing emissions. If India is using particular types of fuel because of major market distortions, then remedying those market distortions could bring about both greater growth and improved environmental performance. So it is important to understand what the actual target is there to be fixed.

Concentrating on the market distortions in developing countries is important. Conversations I have had with companies that are involved in investing in developing countries suggest that the amount of investment they are willing to put in those countries is limited artificially by policies in those countries and that their willingness to put their best technology in those countries is also limited by policies of the developing countries. So I think there is potential there. One of the reasons why China has such high emissions today is its legacy of plant and equipment and infrastructure from both pre-industrial and pre-market eras that is totally incorrect for today's prices; it is quite inefficient, but they don't have the resources to replace it all at once. That is the big target of opportunity for increased investment. The other question is, what

about factor prices? To some extent, there are true differences in labor and raw material costs. These are not a market distortion, these are true costs, and we need to think about ways they can be overcome. Or we can develop new technologies to overcome this barrier, to make the new technologies attractive even at the factor prices that we observe in a country that is burning a lot of cheap, dirty coal.

But internal distorting mechanisms, like subsidies for fossil fuel, subsidies for burning coal, and the lack of markets to provide proper market signals, are distortions and those are things which, if they were fixed through institutional reform, could open up opportunities for economic growth and the adoption of new technologies.

There are also internal policies that make markets inhospitable to foreign investment with world-class technology. US and Japanese technologies will get into China through US and Japanese and other multinational corporations going in and building and transferring technology. But the lack of things like contract law, protection of property rights, protection for intellectual property, and political rights is a major constraint on moving in the direction that would reduce emissions in the developing world.

Lack of infrastructure could also be part of it. Certainly if we start with China, India, and Africa, the lack of infrastructure which forces reliance on traditional fuels is a major problem. Just being able to get kerosene to rural areas would probably produce an immense environmental benefit compared to gathering fuel, though infrastructure is not just someone selling fuel to the poor. Inadequate education in the labor force is another thing which can be addressed through policy and can make a difference.

What kind of framework could we think about for implementing a new approach to climate policy which concentrates on these opportunities in developing countries? I want to think about this now as a policy maker. I believe that this would take active cooperation from at least four sets of actors, between business and government, and between the US and other willing partners. It would require business and government in the US to work together, and business and government in China, India, and wherever else to work together in order to accomplish this. But there is nothing I can see here that takes anything more than that.

The kind of activities that we might look for in developing countries in order to make the technology transfer and higher rates of investment possible fall under the general rubric of legislative and judicial reforms.

Legislative/Judicial Reforms

- Intellectual property right protection to insure that innovation is protected and rewarded, and that if a company brings its best world-class technology into a country, it is not going to suddenly lose its competitive edge and its trade secrets;
- Effective contract laws, where partnerships can actually coexist;
- Development of a dispute resolution and arbitration system, because people are always going to disagree about something;
- Unambiguous repatriation laws so that foreign direct investment is profitable and the investors can actually get their money out; and
- An efficient and effective judicial system.

These are the fundamentals of a market economy and, to the extent that they are lacking, helping to build them can lead both to economic growth and to improved environmental performance.

Market Reforms

- Phasing out governmental ownership of corporate entities to avoid conflict of interest and to avoid maintaining the companies responsible for the current emissions;
- Removing distorting subsidies and taxes. We really have not looked anywhere near as thoroughly at developing countries as at investor countries in identifying subsidies and taxes that distort choices of fuel, but it is an area where it should be done. At least some of the work that we have done in particular countries indicates that there are major market reforms to be made there.
- Developing accounting practices, so you can figure whether you made money or not; and
- Developing good corporate governance within the countries.

Government reforms, corruption, capacity to develop human resources, basic educational development, all of these are areas that clearly relate to the ability of a country to absorb investment, to make investment profitable for outside companies, and to implement the world's best technology.

These are actions for the developing countries; on the developed countries side, there are several complementary kinds of actions to think about:

- The issue of private direct investment itself. We need to think about whether to provide incentives or some form of risk sharing for US companies that are prepared to take their best technology into developing countries, to make higher levels of investment, or to get that machinery off the ground.
- Incentives for appropriate R&D. We keep coming back to this, because for long-term emission reductions, and potentially even a leapfrogging of current technology to even cleaner technologies, R&D has to continue. In particular, some thought needs to be given to how to push that R&D in directions that will produce technologies that fit with the factor-price environment in developing countries, as opposed to the factor-price environment here.
- Using multilateral institutions to facilitate investment and encourage reform.

At this point I would like to open this up to discussion. Is there a way to put together partnerships between the US and developing countries that focus on these ideas of accelerating the replacement of polluting capital equipment, accelerating the rate of foreign direct investment overall, and bringing with it technologies that at least match what we use here in energy-intensive industries and in energy production and in transportation? Is there a way of combining those interests that goes beyond saying that we ought to get foreign aid right and spend lots of money on subsidizing US corporations to make investment overseas? There are fundamental problems in developing countries, but also opportunities for profitable investment by US companies if we can figure out a way to put together a set of agreements or arrangements about how to create a more hospitable environment in developing countries that will produce these changes.

Questions and Answers

Question: You make fairly clear that if you transfer the technology from the United States to China and India and so forth, you will get a reduction in emissions per GDP. However what doesn't seem so obvious is the assurance that in time, the global total of actual emissions per capita will go down. It is amazing to me that you can come to that conclusion because the emission per capita in the United States is much higher than it is in China or India, much higher. And if you transfer technology and they ramp up and their GDP goes up, their technology, their standard of living, you would think that their emission burden per capita would start approaching that of the United States and that would increase the global emissions by an enormous factor. So how do you reconcile these two ways of looking at the problem?

Montgomery: You reconcile them by actually doing all the calculations at once in doing the growth account. We need to differentiate between the short run and the long run. In the long run, you are absolutely right, that once there is a convergence in emissions per capita between the US and the developing countries, the only hope for reducing them is technology and it is technology that we will need here as much as they will need there. It is technology that we don't have today, that is, it requires continuous improvements until we ultimately move to nuclear technology, carbon sequestration, or something else that gives us essentially unlimited access to energy with no carbon emissions. You are absolutely right about that in the long run. But in the short run, emissions per capita may be a lot higher in the US, but that is because we are richer. One fundamental reason for this is that developing countries do want to be just as rich as we are, and they really don't care about the carbon emissions that come along with that. The challenge is to figure out a way to combine their desire for wealth with help in bringing carbon emissions down. You actually get most of the emission reductions from changing the technology that is being used in developing countries. That gives some stimulus to economic growth, but it gives a really big reduction in emissions per dollar of GDP. When you transfer the technology, you increase GDP growth by .1%, but you reduce emissions per dollar of GDP by 2%, so your net is a 1.9% gain and that is the basic arithmetic behind that.

As far as accelerated investment goes, you are right; there are limits to the absorptive capacity of a developing country to begin with. They are not going to suddenly go from investing 20% of GDP to investing 50% of GDP, but to the extent that the investment is profitably replacing existing capital, that is going to make the economy more efficient and more productive. But since it is going to be taking some capital away, it won't provide a total stimulus to growth. It will basically clean up what is already there. That is another challenge for figuring out how to tie new investments to replacement of existing capital. We don't just want to start building lots of gas-fired power plants in China; we really would like to shut down some existing coal plants and replace them. In the short run, Chinese demand for electricity is limited. If somebody went in and started building gas-fired plants all over the place, they would drive the coal-fired power plants out of business. That trade-off also helps to give us the improvement in emissions without sacrificing economic growth. It is not an iron law that emissions have to grow in lockstep with GDP. What we are trying to do is break that lockstep as dramatically as possible through technology transfer.

Question: Is there then an underlying assumption that the technology is also going to reduce the emission per capita, like in the United States? It must be something like that in your model.

Montgomery: Would it reduce emissions per capita? It would essentially stabilize emissions per capita as income per capita is going up. That is a conclusion, not an assumption.

Question: Thanks for your presentation, it is very enlightening. I think one way of doing this is to take the amount of foreign aid that the US and other nations now pay out and offer that help direct, for instance, to China, to deal with end use energy consumption. In China they burn coal to cook food and heat houses; replace that with electricity or natural gas or something else. We should identify the big gains that can occur in the short term and try to break it into pieces to try to demonstrate what can be done. This would be an existing mechanism that wouldn't require more money.

Montgomery: That strikes me as being a really good argument, the idea of taking the immediate steps that clearly can do something. I think that infrastructure for delivering natural gas or electricity rurally to replace what's being used now is something that's really important. Moving direct foreign aid into that goes directly at the problem. The one thing that I think may take a bit more negotiation is getting it actually delivered. Probably all of this requires some discussions with the host countries about identifying the particular institutional barriers that they would have. In China, it may be rolling over some local governments that have a vested interest in using coal.

Question: Is what you were talking about foreign aid or foreign investment?

Montgomery: No, we have been looking at foreign direct investment. One of the things we are looking at now is the magnitude of current foreign direct investment flows relative to the magnitude of investment that is required to make the kind of transformation of capital stock that we are looking at. But that strikes me as really being the only way to go; governments may need to provide incentives or risk sharing or insurance for the US and other companies that are going to make the investment. But I don't see any effective way of carrying that technology into developing countries, unless it is being brought along by foreign direct investment. I think that is the major route through which we would see the results of the industrial countries helping out with this. I see foreign aid being more part of a process of negotiating market reform, that is, that we will use our foreign aid to help you reform your legal institutions, or the other way around—you will not get foreign aid unless you reform your legal institutions and your educational system and your system of property rights.

Question: What do you see as the role of private companies and other organizations to enable or facilitate the inflow of capital?

Montgomery: I think enabling is a good idea. I think that reorienting those organizations toward the delivery of technology through investment could be very effective and it would be a way of moving resources that are already earmarked into, at least from this policy perspective, what could be a more effective use. We need to look at investment by US companies in developing countries, which is a difficult subject. This is running against a lot of current political correctness, both on the right and left. It is a good idea to have manufacturing facilities outside the US; it is good for us and it is good for the country that those facilities are being built. It allows China, for example, to assemble vehicles in a world-class GM production facility which has essentially zero emissions from production and to produce cars that are highly efficient, rather

than, say, the current generation of Chinese vehicles. If OPEC and other organizations could swallow that, I think they could help move things in that direction.

Question: Back to your issue about the factors of production. It is obvious that labor and energy and materials are important. I was wondering if you had done any case studies of some of these advanced technologies to find out what the show-stoppers are, or to what extent market reforms might be able to overcome these barriers. There is a different technology in those markets than what we have here, where labor is very expensive compared with globally, so we have to have a lot of capital to have a very efficient company. It is the opposite over there; a steel producer in China has over 400,000 people in his company. 400,000 people in one company, in one location! We only have 200,000 steelworkers in the entire United States.

Montgomery: First, let's try peeling that one apart, because I think first it has to be looked at industry by industry and resource by resource. I am not sure there is a general answer. A few things do make the point; one of them is your example that there are 400,000 people in the Chinese steel industry. There are also a god-awful number of people in the oil industry in Saudi Arabia, most of whom aren't doing anything, and I suspect that's true of the 400,000 people in the steel industry, too. This is more an issue of institutions and maybe even market distortions; that is, if you are going to run a steel mill, you have to hire ten times as many people as you really need in order to get the host country to allow you to come in. That's a serious barrier and something the host country needs to fix. Maybe OPEC or the US government could help by using a little leverage: Now if you want us to invest, you're going to have to open up your markets up so we can invest on economic terms.

Now as far as the factor prices go, I read a really interesting article a month or two in *The Wall Street Journal* about General Motors. That's why I picked that example. GM was building a world-class production facility in China, fully automated, and they were asked the question, why are you building this when labor is so cheap in China? They said it has nothing to do with labor, it has to do with product quality. In order to get the product quality that will let China produce a car that they can sell on world markets, you have to use the same technology you use everywhere else. That's the good side. I also talked to chemical companies. They said, "We are not going to use our most advanced chemical processes in China because they are going to steal the processes." Again, in chemical facilities, unless you are being required to hire everyone's brother and cousin, you don't have an issue of labor costs. I don't think in most cases it's labor costs we are worried about here. It is probably very directly the price of coal, which requires some work.

Question: David, I think this is a wonderfully creative and constructive approach, but I think that many of the things you are talking about starting with are not easy problems. The less developed countries have subsidies for fossil fuel use and production for reasons that are deeply engrained in the politics of the societies and presumably they know that those are bad economically; they have known that for a long time, yet they still have them. Don't the solutions come down to the US and other developed countries, in effect, making side payments to them in order to attack these intractable distortions that they have built into their economies for fundamentally political reasons, and is that politically salable in the developing world?

Montgomery: I prefer to say yes and stop there because you are right. They are very difficult problems and the primary responsibility has to be in the developing countries. We have had

uniformly dismal success with foreign aid in changing anybody's behavior about anything, except fighting wars. That is good, but it is not enough. But I think that there are also indications that there are a fair number of developing countries that are looking at these issues. We are developing an energy policy for Jordan. The first questions they asked were: What are the problems with the way we price oil and products, and could we go to a new pricing system for gas and electricity and oil, and how will going to market pricing policy improve the performance of our economy? As far as intractable problems go, yes, there may be intractable problems, and again global climate change is an intractable problem too. Maybe if we can try to address two intractable problems with one solution, we will have a little bit more success. Maybe it does take using side payments, like you said. But there are two kinds of side payments. One side payment is pouring in tons of money into CDM projects to buy very small emission reductions in an economic environment that makes them totally unviable, versus using targeted amounts of money to try to buy off the political opposition to a fundamental market reform that can open things up to everybody. I like the latter as being the more practical approach.

Question: Would you comment briefly on incentives to help to make clear that what you are suggesting is not a big expansion of pork-barrel taxpayer subsidies to industry?

Montgomery: No, that's the last thing I would suggest. In fact, it's not clear to me that we need any taxpayer funding to provide incentives for US companies to do anything at all in this regard. Because if you remove the barriers that we are looking at in developing countries, that opens up the profit motive that will suck them right in there with nothing more from us. Where you do need incentives is moving R&D currently in a direction that is going to produce long-term, low-cost, low-carbon sources of energy that are appropriate for the factor prices in developing countries. But that's money that we spend already; the question is, how do you go about spending it well? The program that Exxon and others have set up at Stanford to design a long-term research program that takes private sector money, puts it into academic institutions to cook the basic research in a direction that is going to get you somewhere is the kind of thinking that we need. My personal opinion is that we waste most of the money we spend now on government-funded R&D. We could take that and put it into a more effective program of targeting toward where it is needed that does not necessarily require an increase in budget or money from the taxpayer.

O'Keefe: Thank you, and thank you all for coming today.

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