Summary of Testimony

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Before the
Committee on Energy & Commerce
United States House of Representatives

April 22, 2008

Introduction

I am honored to be here today as this Committee begins consideration of a comprehensive energy and climate bill that will put a cap on greenhouse gas pollution. This is an urgent issue for our children and grandchildren, for if we fail to act we will leave them a much different planet and a much diminished future. But it is also an urgent issue for our own communities today and in the next few years. What those of us in this room do in these short weeks will help determine the course of the American economy. You have the chance to help continue America's tradition of technological leadership and economic growth – to revitalize and reinvigorate the American economy – and to provide a strong, clear, and true signal to drive investment in clean energy generation and energy efficiency and reward entrepreneurial vision and innovation in a low-carbon future. Thank you, Chairman Waxman, Ranking Member Barton, and distinguished members of the Committee for holding this hearing.

My testimony makes five points.

1. Inaction on climate change is the most expensive policy

The consequences of unchecked global warming will be severe. The Intergovernmental Panel on Climate Change projects temperature increases of roughly 2 to 4 degrees Celsius (4 to 7 degrees Fahrenheit) above current levels by the end of century unless concerted action is not taken. The consequences of such temperature changes will be catastrophic. They include putting billions of people at risk of severe drought, decreased crop productivity throughout the world, increased damages from coastal flooding and more severe hurricanes, severe heat waves and the spread of insect-borne tropical diseases such as malaria.[1] Within the United States alone, climate change could cause large declines in the value of agricultural output and in fish and waterfowl populations, put strains on public sector budgets and infrastructure, and require hundreds of billions of dollars annually from increased water and energy costs, coastal flooding, and more severe hurricanes. As former Federal Reserve Chairman Paul Volcker has remarked, "If you don't take action on climate change, you can be sure that our economies will go down the drain

[1] Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez, 2007: Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 811-841, page 828. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter20.pdf

in the next 30 years." The most expensive policy we could pursue would be the one we have been following for the last eight years and more — which is doing nothing.

2. <u>We have the technologies we need to get started right away</u>

Studies by the consultancy McKinsey & Company estimate that the abatement potential in the United States — using technologies that either exist or are already in the development pipeline — will amount to between 1,245 and 2,000 million tons of greenhouse gas reductions (MMTCO2e) by the year 2020, and between 3,000 and 4,700 million tons by the year 2030. Those figures alone would be sufficient to meet the abatement targets for covered sectors that are contemplated in draft legislation. In addition, EDF analysis shows that another 570 to 930 MMTCO2e of emissions reductions from reduced deforestation in tropical rainforests could be available to entities in the United States by the year 2020, as a cost-effective means of offsetting their emissions. These estimates demonstrate that the abatement potential exists right now to meet ambitious goals for emissions reductions.

3. <u>The U.S. can afford deep cuts in greenhouse gas emissions</u>

Credible economic forecasting models show that the U.S. economy will grow robustly with ambitious cuts in greenhouse gas emissions. At the level of the economy as a whole, the estimated impact of climate policy amounts to just a few months of growth over twenty years. Under business as usual, according to a range of models, the total output of the U.S. economy will reach roughly $26 trillion in January of 2030. With a cap on greenhouse gases, the economy will reach that level by April of 2030. Moreover, these projected impacts turn out to be far smaller than the variation in business-as-usual projections over the same period — suggesting that any aggregate impact of climate policy is essentially "in the noise" of macroeconomic models. At the household level, the estimated impact of climate policy amounts to *less than half a penny per dollar of household income* for the average American family — much less than what we already spend on household protection and security.

The past record of economic forecasting shows that *ex ante* estimates of the cost of environmental regulation — made before the regulation takes effect — have typically greatly exceeded the actual costs. This is particularly true for market-based regulations, as in the case of the cap-and-trade program for sulfur dioxide established by the 1990 Clean Air Act Amendments. A prime reason for such overestimation is that economic models are unable to account for the full scope and pace of technological innovation that is unleashed in response to well-designed environmental regulation.

Finally, in evaluating the results of macroeconomic models, it is important to stress that these models consider only one side of the ledger: the costs of taking action, but not the benefits. I have already discussed the most important benefit from taking action — that is, preventing the catastrophic damages that will result if we fail to change course. The failure of the macroeconomic models discussed here to incorporate the damages from climate change means that the business-as-usual path these models use as a baseline simply does not exist. There is simply no possible future in which we continue to emit greenhouse gases at current rates, and yet climate change does not take an enormous toll on the country's economy.

4. Cap-and-trade is a proven approach

Under Title IV of the 1990 Clean Air Act Amendments, emissions of sulfur dioxide from fossil-fired electric power plants have been capped since 1995. That program has shown how well a cap-and-trade system works. Total emissions have fallen to just half of their 1980 levels — achieving the goal three years ahead of schedule and at a fraction of the predicted cost. The estimated benefits of the program, meanwhile, have been roughly 40 times greater. The secret to the program's success has been the technological change made possible by a market-based approach — in ways that were entirely unexpected before the program began.

5. Leadership on climate change can help to secure American prosperity

The next major economic revolution will be the clean energy revolution. A cap-and-trade system that drives American investment and inspires American innovation will position the United States competitively for growth in the global transition to a low-carbon economy. The choice facing us is a stark one: Will we develop and export the coming wave of low carbon technologies — like carbon capture and sequestration, next-generation solar panels, and powerful lightweight batteries — so that jobs and businesses stay in America? Or, will we do nothing and find ourselves importing these technologies from overseas? Failure to act on a cap-and-trade policy would withhold the signals and incentives that can empower the American economy to modernize jobs, services and technologies, and allow the country to emerge from this next phase of global change and competition in the leadership position it holds today.

Now — when our economy is in a deep recession — is *precisely* the time when bold action is needed most. If climate legislation is passed during this Congress and takes effect in 2012, the impact on energy prices will be zero this year; zero in 2010; zero in 2011. On the other hand, passage of legislation will help to unleash a flood of investment, by sending a clear signal of what the price of carbon will be. Electric utilities and manufacturing companies are waiting for legislation before they invest in new power plants or factories that will last forty years or more. A cap on carbon will drive investment right away.

And investment is what our economy needs most right now. Once the investment begins to flow, orders will come in to steel mills and cement factories, to manufacturers of wind turbines and energy-efficient windows and retrofit equipment to improve fuel economy of long-haul trucks. Right now our factories are idle, labor and capital are underemployed. The economy needs a source of demand beyond the stimulus package. Where is that demand going to come from? A cap on carbon will not create money out of thin air. But it will unleash capital that is sitting on the sidelines, and channel it towards clean-energy investments that will revitalize our economy while ensuring a prosperous future.

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Introduction

I am honored to be here today as this Committee begins consideration of a comprehensive energy and climate bill that will put a cap on greenhouse gas pollution. This is an urgent issue for our children and grandchildren, for if we fail to act we will leave them a much different planet and a much diminished future. But it is also an urgent issue for our own communities today and in the next few years. What those of us in this room do in these short weeks will help determine the course of the American economy. You have the chance to help continue America's tradition of technological leadership and economic growth – to revitalize and reinvigorate the American economy – and to provide a strong, clear, and true signal to drive investment in clean energy generation and energy efficiency and reward entrepreneurial vision and innovation in a low-carbon future. Thank you, Chairman Waxman, Ranking Member Barton, and distinguished members of the Committee, for holding this hearing.

Environmental Defense Fund is a leading national nonprofit organization representing more than 500,000 members. Since 1967, we have linked science, economics and law to create innovative, equitable and cost-effective solutions to society's most urgent environmental problems. We have long championed market-based approaches to environmental issues, and helped design the highly successful acid-rain program created in the Clean Air Act Amendments of 1990. As Director of Economic Policy and Analysis, I oversee EDF's economic analysis of climate change policy and help to shape our advocacy. Before coming to EDF nearly two years ago, I was an Associate Professor of Economics at the Yale School of Management, where I taught for six years. I have published a number of peer-reviewed academic articles on a range of subjects on the economics of environmental policy, and have authored or edited two books on market-based environmental policy and the economics of environmental law.

My message is a simple one: Strong action to reduce U.S. greenhouse gas emissions is an economic imperative. The most expensive policy would be doing nothing: unchecked climate change will result in enormous damages to our economy and to our planet. The good news is that we have an historic opportunity to act — and by acting, to help transform the American economy and ensure our prosperity in the twenty-first century. Not only can the American economy begin reducing greenhouse gas emissions right away; we can do it while growing at a very low cost to the overall economy and to American families, according to the best available economic modeling studies to date. Moreover, for a variety of reasons those studies are likely to overestimate the costs to the economy while underestimating the benefits. Finally, both in the next few years and over the coming decades, strong climate legislation is the key to a strong American economy.

1 INACTION IS THE MOST EXPENSIVE POLICY

The fact that I — an economist — am here at all is significant because it is a concrete sign that the scientific debate about global warming is over. Although there will always be naysayers, there is no longer any question within the scientific community that human-caused climate change is real and is already happening — in fact, is happening much faster than anyone had predicted or anticipated.

The consequences of unchecked global warming will be severe. The Intergovernmental Panel on Climate Change projects temperature increases of roughly 2 to 4 degrees Celsius (4 to 7 degrees Fahrenheit) above current levels by the end of century unless concerted action is not taken.[2] Some recent projections, incorporating the latest available data, are even more dramatic: for example, scientists at the Massachusetts Institute of Technology forecast a temperature increase of 3.5 to 7.4 degrees Celsius (6 to 13 degrees Fahrenheit) under business as usual by the year 2100.[3] The upper end of that range is comparable in magnitude to the change in temperature from the last Ice Age — 10,000 years ago — to the present day.

The consequences of such temperature changes will be catastrophic. They include putting billions of people at risk of severe drought, decreased crop productivity throughout the world, increased damages from coastal flooding and more severe hurricanes, severe heat waves and the spread of insect-borne tropical diseases such as malaria.[4] Recent events like Hurricane Katrina, the 2003 heat waves in Europe blamed for 52,000 deaths, and the 6-year drought in Australia are symptomatic of what lies in store, even if those individual events cannot be conclusively linked to global warming. If these global impacts seem abstract, consider the concrete consequences that lie ahead for the United States according to a range of recent studies:

- declines as high as 70% in the value of U.S. agricultural output[5] [as measured by farmland values for the US east of the 100th meridian];
- a decline in trout and salmon populations in many areas of over 50 percent, including losses of more than 90 percent in some prime areas in the high-mountain West and in Appalachia[6];
- large declines in waterfowl populations, including 40 percent in the Upper Great Lakes, 70 percent in the prairie pothole region, and up to 99 percent in the Chenier Plain marshes of Louisiana[7];
- "immense strains on public sector budgets"[8];

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[2] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22, page 17

[3] Sokolov, A.P., P.H. Stone, C.E. Forest, R.G. Prinn, M.C. Sarofim, M. Webster, S. Paltsev, C.A. Schlosser, D. Kicklighter, S. Dutkiewicz, J. Reilly, C. Wang, B. Felzer, H.D. Jacoby. "Probabilistic Forecast for 21st Century Climate Based on Uncertainties in Emissions (without Policy) and Climate Parameters." MIT Joint Program on the Science and Policy of of Global Change, Report 169, 44 pages, January 2009. http://globalchange.mit.edu/pubs/abstract.php?publication_id=990

[4] Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez, 2007: Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 811-841, page 828. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter20.pdf

[5] Schlenker, W., Hanemann, W.M., Fischer, A. "The Impact of Global Warming on U.S. Agriculture: An Econometric Analysis of Optimal Growing Conditions." *The Review of Economics and Statistics*, February 2006, Vol. 88, No. 1, Pages 113-125.

[6] Season's End, a program of the Bipartisan Policy Center. Global Warming Fact Sheet Series: Freshwater Fish Fact Sheet, http://www.seasonsend.org/

[7] Season's End, a program of the Bipartisan Policy Center. Global Warming Fact Sheet Series: Waterfowl Fact Sheet, http://www.seasonsend.org/

[8] *The US Economic Impacts of Climate Change and the Costs of Inaction.* Center for Integrative Environmental Research, University of Maryland, October 2007.

- threats to "roads, rail lines, ports, airports and other important infrastructure"[9]; national security implications from widespread political instability[10];
- hundreds of billions of dollars annually from increased water and energy costs, coastal flooding, and more severe hurricanes[11].

As former Federal Reserve Chairman Paul Volcker has remarked, "If you don't take action on climate change, you can be sure that our economies will go down the drain in the next 30 years."

Unchecked global warming in the next few decades will also set into motion fundamental and irreversible changes in our planetary systems, including the melting of ice sheets in Greenland and western Antarctica that will raise sea levels by several meters; large-scale weather shifts that will threaten the world's tropical forests; and the weakening of ocean circulation patterns that make Western Europe habitable. As for natural ecosystems, even a modest warming of 3 ºC — which we are likely to see within a few decades — would put 20 to 30 percent of the world's species at increasingly high risk of extinction; while warming on the order of five degrees would likely cause major extinctions around the world. Meanwhile, warmer and more acidic waters (another consequence of carbon dioxide emissions) will likely conspire to kill coral reefs around the globe before the century is half gone. [12]

We simply lack the tools to fully measure the significant damages from such changes. The IPCC cites estimates of global mean losses equal to 1 to 5 percent of world GDP for 4ºC of warming — but as the IPCC points out, many of those estimates on which that figure is based exclude damages to nonmarket sectors, or the effect of large-scale discontinuous changes in earth systems. The *Stern Review of the Economics of Climate Change* estimated an impact on global per capita consumption of at least 5 percent, with a high-end estimate as high as 20 percent.[13] While the latter figure in particular has been controversial among economists, Stern's numbers faithfully reflect a sense of the urgency that emerges from reading the scientific evidence on the pace and scope of climate change. As Professor Geoffrey Heal of Columbia University, in the *Review of Environmental Economics and Policy*, concludes, "I am inclined to think that Stern is much nearer the mark: it is impossible to read the IPCC reports and believe that the consequences of climate change along the business as usual path are only 1 or 2 percent of national income."[14]

A similar assessment of the *Stern Review* is offered by Professor Martin Weitzman of Harvard, who criticizes the specific methodology and assumptions in the *Review* but nonetheless endorses

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[9] National Research Council, National Academy of Sciences, Committee on Climate Change and U.S. Transportation. *Potential Impacts of Climate Change on U.S. Transportation: Special Report 290,* 2008. http://www.nap.edu/catalog/12179.html

[10] Center for Naval Analysis, *National Security and the Threat of Climate Change,* 2007.

[11] *The Cost of Climate Change: What We'll Pay if Global Warming Continues Unchecked*, by Frank Ackerman and Elizabeth Stanton, Tufts University (NRDC: May 2008). http://www.nrdc.org/globalwarming/cost/cost.pdf

[12] Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez, 2007: Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 811-841, page 828. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter20.pdf

[13] Stern, Lord Nicholas. *The Economics of Climate Change: The Stern Review*. Cambridge University Press (Cambridge: 2007)

[14] Heal, Geoffrey, "Climate Economics: A Meta-Review and Some Suggestions for Future Research," *Review of Environmental Economics and Policy*, Winter 2009, 3(1): 4-21.

the urgency of its recommendations.[15] Weitzman's main concern is the "fat tail" of climate damages — in other words, the small but still significant probability of a truly catastrophic worst-case scenario. An example is the MIT researchers' assessment of a 5% chance that temperatures will increase by as much in the next hundred years as they have in the 10,000 years since the last Ice Age. This possibility of catastrophic damages adds weight to the urgency of acting now to reduce greenhouse gas emissions, since such action preserves our option to act even more aggressively in the future if the worst-case scenarios turn out to be even more likely than we expect.[16]

In summary, an economic assessment of the literature on the damages from global warming strongly supports the case for action. The most expensive climate change policy is not having one at all.

2 WE HAVE THE TECHNOLOGIES TO GET STARTED RIGHT AWAY

The severity of the climate crisis demands urgent action. The good news is that we have the technologies and abatement opportunities we need to get started right away, and to meet or beat near-term emissions reduction targets for the next ten to twenty years.

Available abatement opportunities within the U.S.: Evidence from McKinsey & Company analyses

I start by reporting on an analysis by EDF staff that used two recent studies by McKinsey & Company to estimate the available abatement opportunities within the United States. In 2007, McKinsey published a survey of abatement opportunities in the U.S. that could be available at a cost under $50 per ton by the year 2030. McKinsey's survey catalogued 250 abatement options grouped in 75 categories in 5 sectors: buildings, industry, power, transport, as well as agriculture, waste and forestry. In its mid-range case – which does not assume aggressive deployment of technologies or envision the price on carbon that would arise from an economy-wide cap-and-trade program – McKinsey estimated that U.S. emissions could be reduced by 3,000 $MMTCO_2e$ in 2030.

Because McKinsey did not make estimates for abatement opportunity that might be available in 2020, we had to derive those numbers from McKinsey's analysis for the mid-range case, for which we have access to the underlying data. We removed both carbon capture and storage and expansions in nuclear power from the list of abatement opportunities in the power and industrial sectors because we cannot assume these opportunities would necessarily be available by 2020.

We then estimated available abatement opportunities by 2020 in two ways—

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[15] Weitzman, Martin L. "A review of the '*Stern Review* of the economics of climate change.'" *Journal of Economic Literature,* 2007, 45: 703–24.
[16] Yohe, Gary, Natasha Andronova, and Michael Schlesinger. "To hedge or not against an uncertain climate future?" *Science,* October 2003, 306 (15): 416–17; Jon Anda, Alexander Golub, and Elena Strukova "Economics of climate change under uncertainty: Benefits of flexibility." Energy Policy, 2009, 37: 1345–1355.

a. First, we simply divided the remaining abatement opportunities for 2030[17] in half (taking 2020 as the midpoint of the period 2010-2030) and found that **1,245 MMTCO_2e** of available annual abatement opportunities would be available each year by 2020.

   We believe this is a conservative estimate because it assumes that the low or no-cost abatement opportunities identified by McKinsey — such as increased lighting efficiency in the residential and commercial sectors — would be deployed in a smooth, linear fashion (so that only half of the full range of opportunities were taken advantage of by 2020). It seems more likely, however, that much of this abatement would happen in the near term. Of the 2,490 MMTCO_2e available by 2030, McKinsey estimates that 60%, or 1,500 MMTCO_2e, are available at costs below $10/T$CO_2$e; over 70% or 1,860 MMT$CO_2$e would be available under $25/T$CO_2$e. Some fraction of those reductions would be accompanied by cost savings as the reduction in energy costs outweighed the upfront purchase cost. As a result, we would expect to see early deployment of many of these abatement opportunities as market participants seek to reduce their exposure to the possibility of higher energy costs.

b. In a second approach, we considered each of the 75 McKinsey abatement categories individually and excluded all that do *not* represent low-cost, readily available technologies. We were left with four categories of near-term abatement opportunities: offsets in the agricultural and forestry sectors; energy efficiency gains in residential and commercial buildings; fuel economy improvements in automobiles, and process changes in industrial and power sectors. These total **1,600 MMTCO_2e** of annual abatement opportunities. And because these opportunities appear to be low-cost, *early availability* technologies, we think their full annual abatement potential should be available by 2020. Excluded entirely from this total were *all* new alternative power sources, *all* industrial processes assumed to require major capital expenditures, and *all* ambiguous categories.

Recently McKinsey and Company published a new survey of global abatement potential. In that study McKinsey updates its estimates for total abatement opportunity in the U.S.: According to McKinsey the U.S. is capable of providing **2,000 MMTCO_2e** of abatement potential per year by 2020 at a cost below €60/TCO_2e (or now about $75/ton) and **4,700 MMT$CO_2$e** by 2030 for the U.S.[18] These projections reinforce our confidence in our estimates above.

Based on these two McKinsey analyses, therefore, the United States is likely to have the necessary technologies available, at reasonable cost, to meet and even exceed the *total* abatement that would be required by the cap-and-trade program envisioned in the Waxman-Markey discussion draft. Moreover, that is true despite the fact that these studies assume little innovation in the application of low-carbon technologies and methods. Indeed, the McKinsey analysis includes only those abatement opportunities that are either already available, or are under active development and judged by McKinsey to have a high likelihood of being available. While it is also true that some low-carbon technologies may take longer to deploy than currently

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[17] 2,490 MMTCO2e available abatement opportunities in 2030 at a price below $50/TCO2e excluding CCS and nuclear.

[18] Exhibit A.V.1 of McKinsey & Company, *Pathways to a Low-carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve,* 2009.

anticipated, a greenhouse gas emissions trading program will provide an incentive never before experienced in the U.S. economy.

It is also important to remember that the abatement opportunities McKinsey identified are *entirely* domestic. As we show below, opportunities for reducing emissions outside the U.S. are significant.

Abatement potential from reductions in tropical deforestation

Emissions reductions outside the cap have the potential to contribute to meeting short-term targets: one example is reductions from reduced tropical deforestation.

At the international level, there is growing support for awarding credits to tropical forest nations for emissions reductions achieved by slowing tropical deforestation and degradation. Such credits, known as REDD credits (for Reductions in Emissions from Deforestation and forest Degradation), have considerable potential in helping regulated entities in the United States meet ambitious short-term targets. To analyze the potential contribution of REDD credits, we have developed a simple model drawing on estimates of tropical deforestation and degradation developed by Brent Sohngen of Ohio State University, used by EPA in its own modeling.[19]

We estimate that emissions reductions from tropical deforestation, if allowed to be used for compliance in the United States, could contribute roughly **930 $MMTCO_2e$** of abatement by 2020 (at an allowance price of $30/ton) and **604 $MMTCO_2e$** by 2030 (at a price of $49/ton).

We should note three things about this estimate. First, these numbers represent only the share of REDD credits that would be used for compliance by entities in the United States, accounting for the demand from the European Union and other industrialized nations.[20] Including credits purchased in those countries as well as in the United States, we estimate that avoided tropical deforestation would reduce emissions by 1,500 $MMTCO_2e$ in 2020.

Second, the actual volume of REDD credits will depend upon a number of factors – most importantly, the market price of credits. As with any source of abatement, there is expected to be an upward-sloping "supply curve." The higher the price, the more abatement will occur. At higher prices, we would expect greater emissions reductions through REDD, up to a maximum of 2,000 $MMTCO_2e$ available in that year.

Third, these estimates assume that tropical forest nations around the world can start reducing deforestation (and creating corresponding REDD credits) within the next decade. While Brazil is widely seen as ready to do so, other major sources (e.g. Congo and Indonesia) are somewhat further behind. So, using a conservative assumption that REDD credits are available *only* from Latin America, our analysis suggests that by 2020 the volume of REDD credits available to

[19] We use Sohngen's curves from the Energy Modeling Forum 21 based on rising carbon price scenarios. This data is available at: http://www.stanford.edu/group/EMF/projects/group21/EMF21sinkspagenew.htm.

[20] For the purposes of this memo, we assume that the EU and other industrialized countries currently participating in the Kyoto Protocol reduce emissions to 20% below their 1990 levels by 2020. Although the EU ETS does not currently allow such credits to be used for compliance, this is widely expected to change by 2020 – possibly as soon as the next phase of the ETS, which will start in the year 2013.

entities in the United States (again accounting for demand in the EU and elsewhere) would be **570 MMTCO_2e** annually by 2020.

While fairly rough, these estimates are based on the most comprehensive assessment available of emissions reduction opportunities from forestry. Moreover, the broad conclusions are supported by other analyses of REDD relying on completely different data. For example, a recent in-depth analysis of tropical deforestation in the Brazilian Amazon estimated potential emissions reductions of over 900 MMTCO_2e annually once the program was in full swing, after about ten years.[21] This estimate – which is for the Brazilian Amazon alone – is in line with the figures from our analysis cited above. Another independent assessment of global abatement opportunities by McKinsey, estimated that avoided tropical deforestation in Africa and Latin America combined would account for roughly 3,000 MMTCO_2e by 2030; this figure is also broadly consistent with the numbers presented here.[22]

Table 1 — Estimated abatement opportunities within the U.S. and from reduced tropical deforestation.[23]

ABATEMENT (millions of metric tons CO2 equivalent)	2020	2030
Required abatement relative to BAU forecast (AEO2009)	1,379	3,154
Available domestic abatement opportunities		
McKinsey (2007)	n/a	3,000
EDF conservative interpretation of McKinsey (2007) mid-range estimate	1,245 - 1,600	n/a
McKinsey (2009)	2,000	4,700
Available credits from tropical deforestation		
EDF estimate of REDD credits available to U.S. entities	570 - 930	604

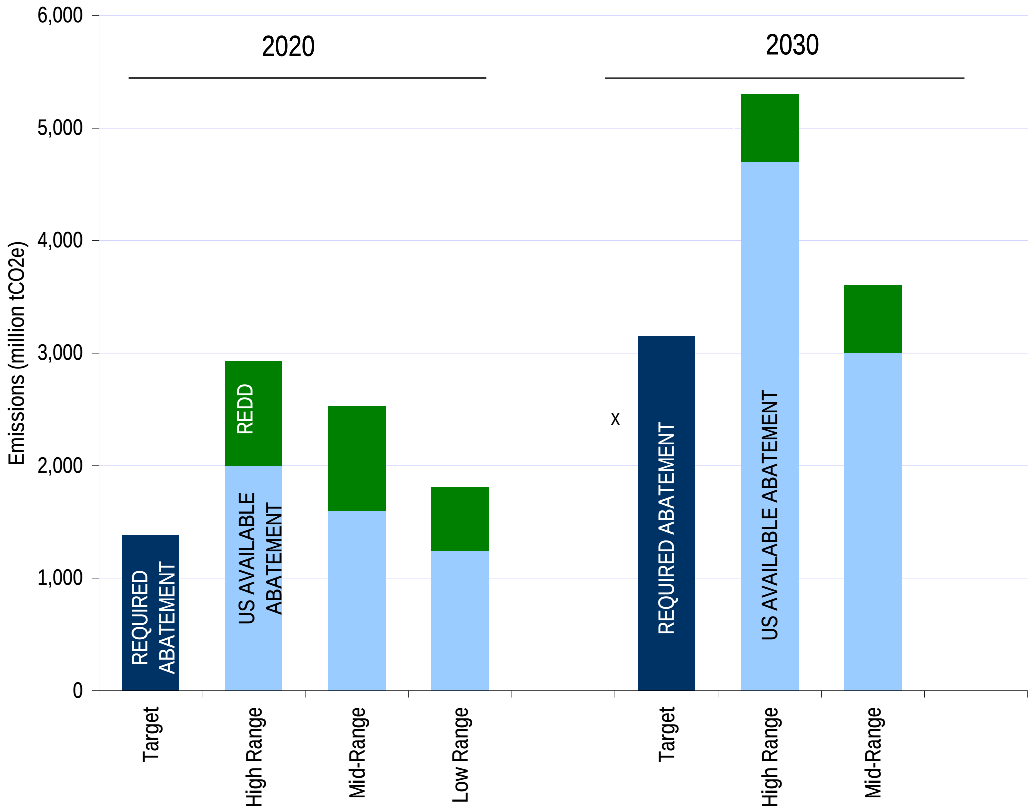
Figure 1 — Available abatement opportunities relative to required abatement.[24]

[21] Daniel Nepstad et al., “The Costs and Benefits of Reducing Carbon Emissions from Deforestation and Forest Degradation in the Brazilian Amazon,” http://www.whrc.org/BaliReports/assets/WHRC_Amazon_REDD.pdf. EDF was involved in the preparation of that report. Note that in the original report, emissions reductions are expressed in tons of carbon, rather than tons of CO_2 as presented here.

[22] Per-Anders Enkvist, Tomas Naucler, and Jerker Rosander, “A cost curve for greenhouse gas reduction,” *McKinsey Quarterly* (2007).

[23] Energy Information Administration, Annual Energy Outlook 2009; McKinsey & Company, *Pathways to a Low Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve*, 2009; McKinsey & Company, *Reducing US Greenhouse Gas Emissions: How Much at What Cost?*, 2007.

[24] Internal EDF analysis; McKinsey & Company, *Pathways to a Low Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve*, 2009.



3 THE U.S. CAN AFFORD DEEP CUTS IN GREENHOUSE GAS EMISSIONS

Earlier in my testimony, I mentioned the strong consensus that has emerged among scientists that human-caused global warming is real, is already happening, and will have potentially catastrophic impacts on human populations and the natural environment if we do not take action to avert it.

There is a similar consensus emerging among economists who study climate policy that even if we focus only on the costs to the U.S. economy of reducing greenhouse gas emissions, that cost will be a very small fraction of economic output or household income.[25] Indeed, all models show that the U.S. economy will grow robustly with ambitious cuts in greenhouse gas emissions. The projected impacts of climate policy over the next two decades turn out to be far smaller than the variation in business-as-usual projections over the same period — suggesting that any aggregate impact of climate policy is essentially "in the noise" of macroeconomic models. At the household level, the estimated impact of climate policy amounts to *less than half a penny per dollar of household income* for the average American family — much less than what we already spend on household protection and security.

Moreover, the past record of economic forecasting shows that *ex ante* estimates of the cost of environmental regulation — made before the regulation takes effect — have typically greatly

[25] Pooley, Eric. *How Much Would You Pay to Save the Planet? The American Press and the Economics of Climate Change*. Joan Shorenstein Center on the Press, Politics and Public Policy, Kennedy School of Government, Discussion Paper Series #D-49 (Harvard University: January 2009).

exceeded the actual costs. This is particularly true for market-based regulations, as in the case of the cap-and-trade program for sulfur dioxide established by the 1990 Clean Air Act Amendments. A prime reason for such overestimation is that economic models are unable to account for the full scope and pace of technological innovation that is unleashed in response to well-designed environmental regulation.

Finally, in evaluating the results of macroeconomic models it is important to stress that those models consider only one side of the ledger: the costs of taking action, but not the benefits. I have already discussed the most important benefits from taking action — that is, the catastrophic damages that will result if we fail to change course. The failure of the macroeconomic models discussed here to incorporate the damages from climate change means that the business-as-usual path those models use as a baseline simply does not exist. There is simply no possible future in which we continue to emit greenhouse gases at current rates, and yet climate change does not take an enormous toll on the country's economy.

Apart from the averted damages of climate change, two other categories of benefits deserve particular mention as well. First, reducing greenhouse gas emissions from power plants, factories, and cars will also reduce conventional air pollutants that contribute to poor air quality and severe health problems in our cities. Second, reducing greenhouse gas emissions will reduce our dependence on foreign oil, enhancing national security.

What do the models project?

Last year, I wrote a report with Peter Goldmark called "What Will It Cost to Protect Ourselves from Global Warming?"[26] We examined a range of policy scenarios modeled by five highly respected, nonpartisan economic modeling groups in government and academia, to find out what the state-of-the-art economic modeling had to say about the potential economic impacts of climate policy on the U.S. economy. In my testimony here I will summarize the modeling results for the legislation considered in the Senate last year (S.2191, "America's Climate Security Act"). While that legislation is no longer current, the general conclusions remain instructive going forward as the current Congress writes its own climate legislation.[27]

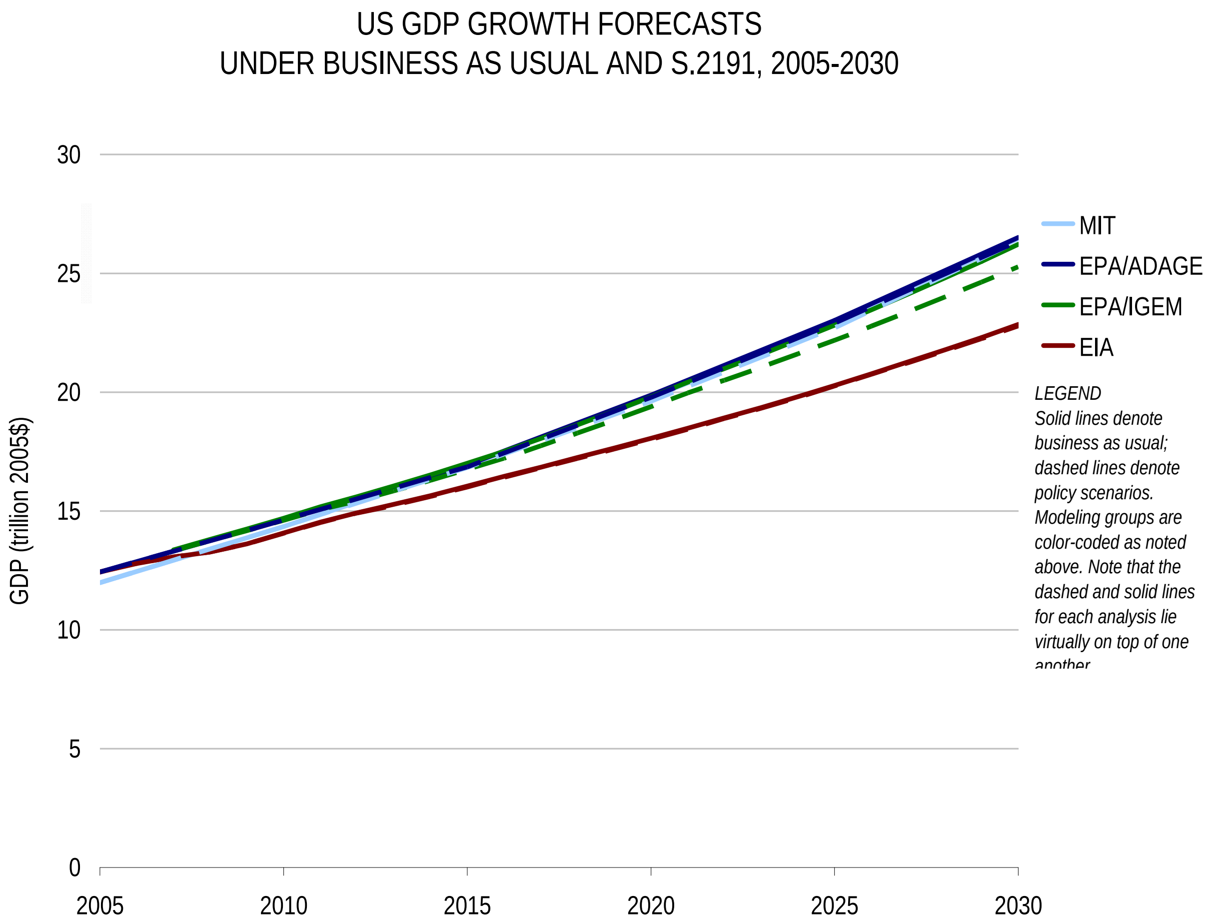
All the models show that we can enjoy robust economic growth while achieving deep reductions in greenhouse gas emissions. In the analyses we looked at, the U.S. economy was projected to grow by 83 to 120 percent from 2005 to 2030 under climate policy, versus growth of 84 to 121 percent over the same period under business as usual.

In other words, the U.S. economy will roughly double in size over the next twenty years with or without climate policy.

[26] Goldmark, Peter and Nathaniel Keohane, PhD. *What Will it Cost to Protect Ourselves From Global Warming?* Environmental Defense Fund, 2008. www.edf.org/climatecosts
[27] The numbers cited in this testimony are updated to include the EIA's analysis of the Lieberman-Warner bill (S.2191) rather than the Lieberman-McCain bill (S.280); the analysis of S.2191 was not available when our report was released.

Figure 3 — GDP growth forecasts with and without climate policy over the period 2005-2030.[28]

[28] EDF compilation of analyses of S.2191 by MIT, EPA, and EIA: *EPA Analysis of The Climate Stewardship and Innovation Act of 2007 S. 280 in 110th Congress*, July 16, 2007; Sergey Paltsev, John M. Reilly, Henry D. Jacoby, Angelo C. Gurgel, Gilbert E. Metcalf, Andrei P. Sokolov and Jennifer F. Holak. *Assessment of U.S. Cap-and-Trade Proposals*. MIT Joint Program on the Science and Policy of Global Change, Report No. 146, April 2007; Energy Information Administration, *Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007*, April 2008.



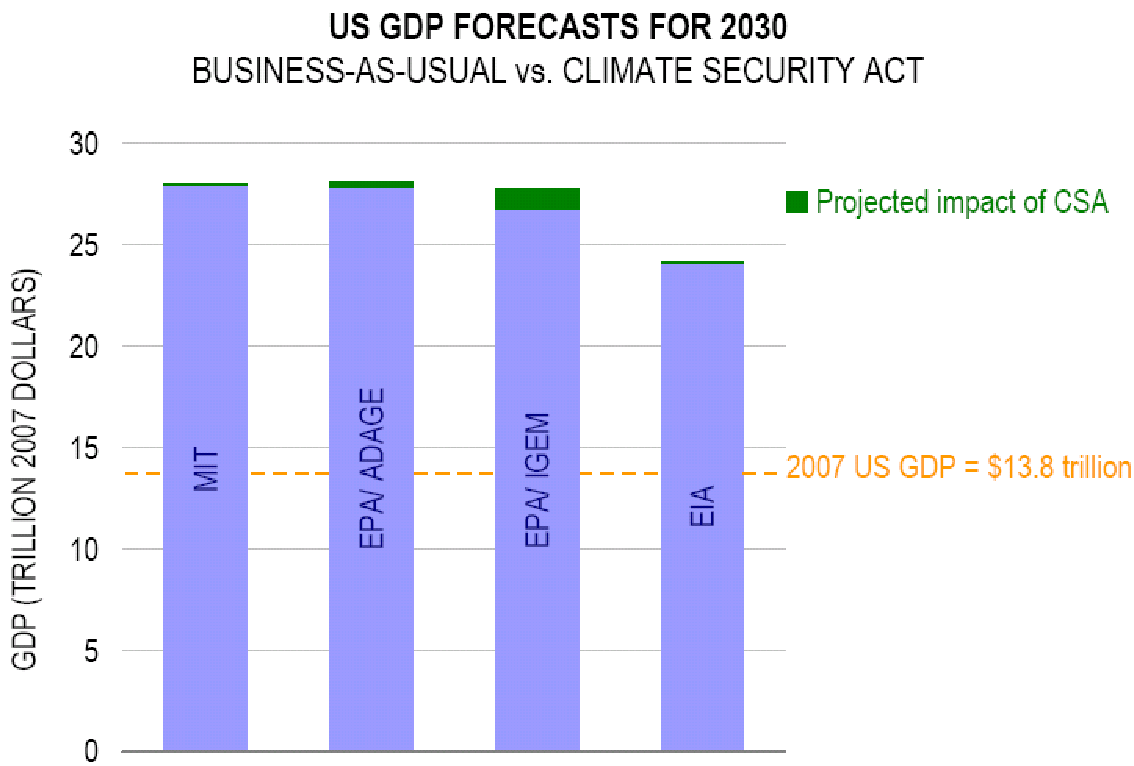
At the aggregate level, the projected impact of climate policy on the U.S. economy amounts to a tiny fraction of economic output. For example, the median impact of climate policy on projected GDP in the year 2030 is just 0.75 percent. Considering that these models expect the U.S. economy to grow at just under 3 percent per year, the estimated impact of climate policy amounts to three months of growth — over twenty years.

The estimates can be thought of this way: Under business as usual, according to these models, the total output of the U.S. economy will reach roughly $26 trillion in January of 2030 (measured in 2005 dollars). With a cap on greenhouse gases, the economy will reach that level by April of 2030. The projected difference in GDP is so small, it is like two cars driving from Washington to Los Angeles, with the second car arriving eighteen minutes after the first.

It is also worth comparing this projected impact to the variation in the models' projections of economic output under business as usual. Those projections vary because every model must make assumptions about labor productivity, population growth, economic policy, energy prices, and a whole host of other parameters — all of which are unknown. In fact, the business as usual projections for U.S. GDP in the year 2030, for the models we analyzed, vary by as much as 16% ($3.6 trillion) — more than twenty times the 0.75 percent impact of climate policy. Indeed, these economic models don't agree on much. The one thing they *do* agree on is that the effect of climate policy on the growth of the American economy will be tiny.

A similar observation holds even for the same models at different points in time. The Energy Information Administration of the Department of Energy, for example, issues economic growth projections every year as part of its *Annual Energy Outlook*. In its 2006 report, the EIA projected that the US GDP would be $25.2 trillion; in its 2008 report, that forecast had fallen to $22.9 trillion (all measured in constant 2005 dollars) — a difference of more than 9 percent. By comparison, the EIA's projected impact of the Senate bill in 2030 was only 0.30 percent — just one-thirtieth of the difference in BAU projections from one report to another.[29]

Figure 4 — Forecasted GDP in the year 2030, with and without climate policy.[30]



Household costs

While aggregate impacts are important to consider, household-level impacts are much more relevant to the average family. Here too, the projected impacts are modest. For example, according to the EIA's analysis, the Senate bill would have increased household utility bills for electricity, natural gas, and fuel oil by about a dime a day. Other studies typically do not estimate household-level consumption; however, using the best available estimates on the elasticity of demand for household energy use, their projections also work out to just a few dollars a month for the average household.

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[29] Energy Information Administration. *Energy Market and Economic Impacts of S. 2191, the Lieberman-Warner Climate Security Act of 2007*. April 2008, SR/OIAF/2008-01.

[30] EDF compilation of analyses of S.2191 by MIT, EPA, and EIA.

It is worth noting, moreover, that legislation can be designed to help cushion the impact of higher prices on consumers, especially during a transition to cleaner energy and greater energy efficiency. Allocating allowances to local distribution companies, who could pass the value onto energy consumers in the form of lower rates or investments in energy efficiency, would make the small impacts cited above even smaller.

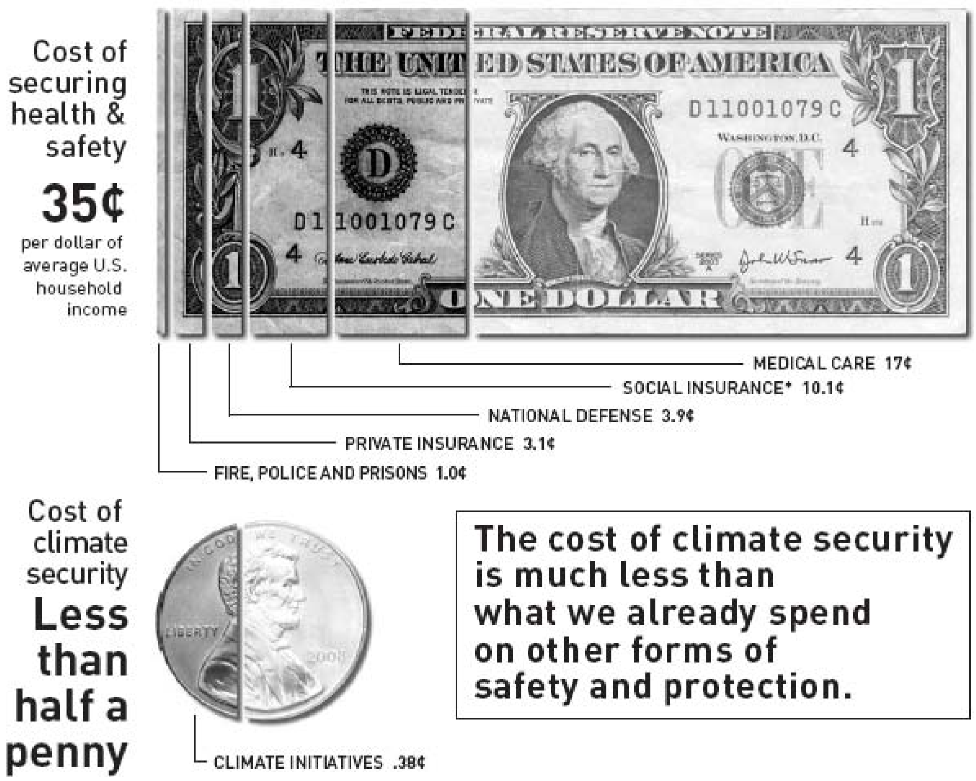
Impacts on transportation costs are also likely to be modest, especially in the context of the sorts of week-to-week price variation we are already familiar with. For example, the analyses of the Senate legislation by the EIA and the EPA projected increases in retail gasoline prices of around 15% (about 40 cents in 2005 dollars) in the year 2030 relative to business as usual. To put that number in context, the average retail gasoline price has risen by more than 40 cents per gallon just since the end of last year — while it is more than two dollars lower than the high reached last summer. The point is that gasoline prices are extremely volatile. Rather than worrying about the small increases over twenty years that might result from a cap on carbon, we should be worried about how we may be held hostage to much more significant increases in oil prices for other reasons – and we focus on how to make the American economy less dependent on foreign oil. Capping carbon can be an important step towards reducing that dependence — a point I will return to below.

The most complete measure of household impacts to come out of these models is the estimated effect on real consumption, which incorporates the direct effects on transportation and household utilities already discussed as well as other changes that may result from climate policy. The median consumption impact in the economic analyses of the Senate bill was just 0.42 percent. Expressed per dollar of household income, this amounts to 0.38 cents — less than half a penny. A useful way to put these forecasts in context is to compare them to what Americans already spend to protect themselves and their families. This may take the form of health care, or fire and property insurance, or tax payments that go to hospitals or police and fire services. Spending on climate security—protecting ourselves against potentially catastrophic climate changes—falls in the same category.

Figure 5 shows how much of every dollar of household income an American family spends on protection and security. On average, American households spend seventeen cents out of every dollar of income on medical care; ten cents on social insurance; four cents on national defense; three cents on private insurance; and a penny on fire and police. The effect of a cap on greenhouse gases will be just 0.38 cents out of that same dollar of income — less than half a penny.

Figure 5 — Estimated impact of climate policy on household consumption relative to current household expenditures on securing health and safety.[31]

[31] Goldmark, Peter and Nathaniel Keohane, PhD, *What Will it Cost to Protect Ourselves From Global Warming?* Environmental Defense Fund, 2008. www.edf.org/climatecosts



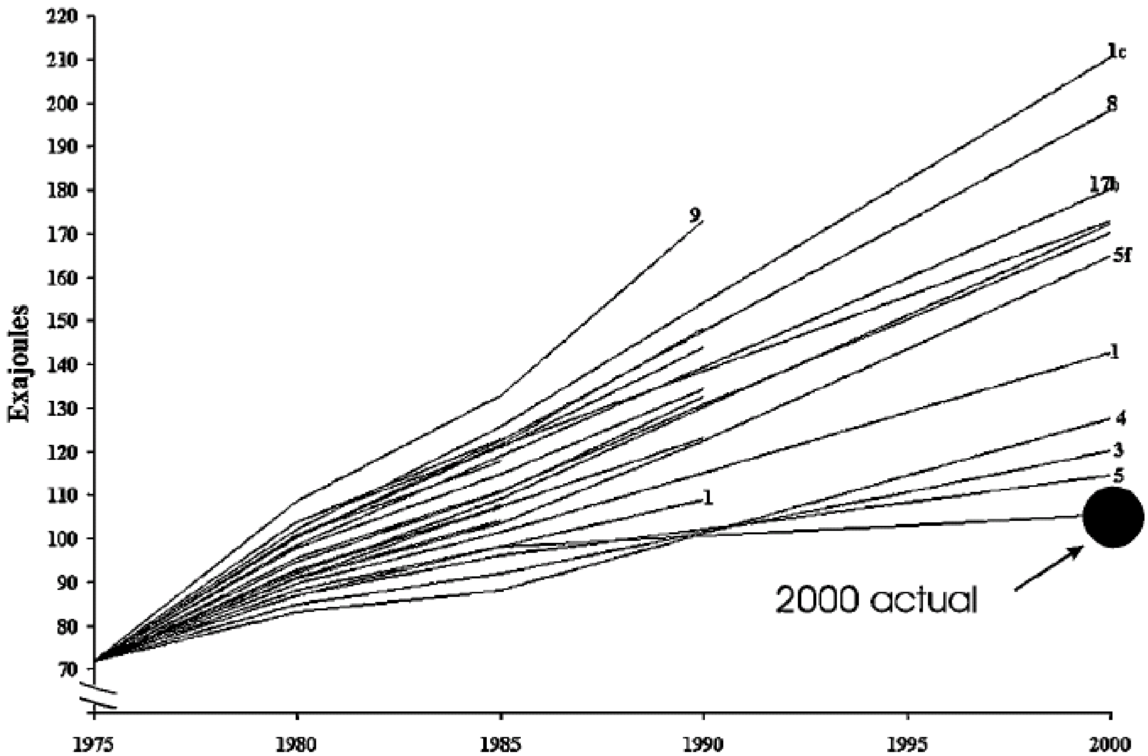
How good are the models?

Macroeconomic modeling analyses like the ones summarized above can be useful tools – but they are not crystal balls. Economic modelers are not endowed with an ability to predict the future: their models are simply collections of equations representing supply and demand in different sectors of the economy, and their results depend fundamentally on the assumptions used in the analysis. Since those assumptions are necessarily based on historical data and experience, models are inherently limited in their ability to forecast future conditions.

A good example comes from a study of long-term energy forecasts by two researchers at the Lawrence Berkeley National Laboratories and a co-author.[32] Figure 6, taken from their report, shows a range of U.S. energy demand forecasts from the 1970s included in a survey by the Department of Energy. As the graph makes clear, while there is a very wide variation in the models' predictions, virtually all of them predicted much higher energy demand than actually occurred. One may argue that the 1970-2000 period was a particularly hard one to forecast, given the two Arab oil shocks in the first part of the period, which helped usher in a new focus on conservation. And yet with hindsight we can *always* identify why a particular set of forecasts went wrong. The more general lesson is that long-term modeling exercises are always severely limited in their prediction ability. As the authors point out, while they list seven uses for which energy modeling is appropriate, accurately forecasting the future is not among them.

[32] Craig, Paul, Ashok Gadgil, and Jonathan Koomey. 2002. "What Can History Teach Us?: A Retrospective Analysis of Long-term Energy Forecasts for the U.S." In *Annual Review of Energy and the Environment 2002,*. Edited by R. H. Socolow, D. Anderson and J. Harte. Palo Alto, CA: Annual Reviews, Inc. (also LBNL-50498).

Figure 6 — Long-term energy demand forecasts for the United States. Actual demand in the year 2000 is superimposed at bottom right.[33]

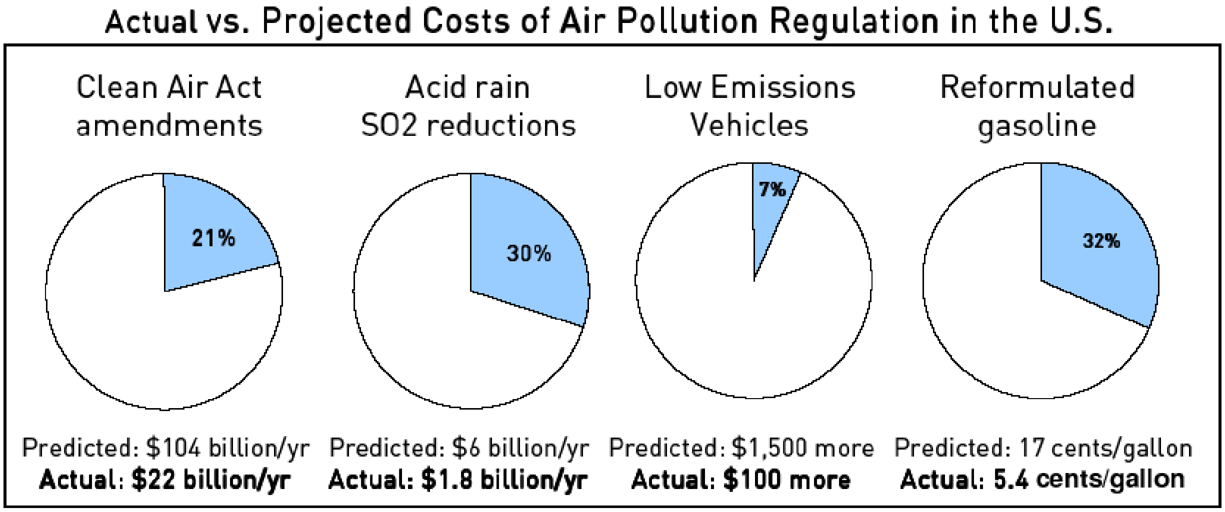


Similar caution in interpreting modeling results comes from a comparison of *ex ante* and *ex post* estimates of the cost of environmental regulations. Figure 7 shows such a before-vs.-after comparison for four major environmental regulations: the 1990 Clean Air Act amendments as a whole; Title IV of the 1990 CAAA, which established a cap-and-trade program for sulfur dioxide (SO_2) from electric utilities; and regulations on low emissions vehicles and reformulated gasoline. As the figure shows, in each case the actual costs were much less than had been predicted – from 70 percent less, in the case of the Acid Rain program, to over 90 percent less in the case of low emission vehicles. Nor is this a case of industry deliberately overestimating the costs of regulation: the forecasts in Figure 7 were all made by government agencies.

Figure 7 — Comparison of actual vs. projected costs of air pollution regulation in the United States.[34]

[33] Craig, Paul, Ashok Gadgil, and Jonathan Koomey. 2002. "What Can History Teach Us?: A Retrospective Analysis of Long-term Energy Forecasts for the U.S." In *Annual Review of Energy and the Environment 2002,* Edited by R. H. Socolow, D. Anderson and J. Harte. Palo Alto, CA: Annual Reviews, Inc. (also LBNL-50498).

[34] EDF fact sheet with sources from: Business Roundtable. "Clean Air Act Legislation Cost Evaluation." January 18, 1990; E.H. Pechan & Associates, Inc., contracted by EPA. "Clean Air Act Section 812 Prospective Assessment-Cost Analysis Draft Report." September, 1995; National Acid Precipitation Assessment Program. "Report to Congress: An Integrated Assessment," 2005. Available at: http://www.al.noaa.gov/AQRS/reports/napapreport05.pdf; Materials sent to editors and writers by the Edison Electric Institute describing the impact of the Clean Air Act Amendments on the electric utility industry. December 17, 1990;



The pattern illustrated in Figure 7 turns out to hold more generally for a wider range of regulations. A team of researchers at the nonpartisan think tank Resources for the Future (RFF) found that *ex ante* estimates of cost by government agencies exceeded actual costs in 12 out of 25 rules they examined, while the reverse was true in only 6 cases.[35] More strikingly, of the eight market-based regulations included in the survey, costs were overestimated in at least seven cases (and possibly in the eighth as well). While these findings do not guarantee that current estimates of the cost of capping carbon will be too high, they do show that if the estimates turn out to be accurate, it will be a first.

Why do economic models systematically overstate the true costs of environmental regulation? The RFF researchers focus on technological innovation as the primary explanation. Assessments made prior to regulation necessarily include only the abatement methods and technologies that are foreseen at the time. But the regulation itself is typically a powerful spur to innovation – especially in the case of market-based policies that create a strong economic incentive to find or develop the most cost-effective means of reducing pollution. As I shall discuss in more detail below, unexpected technological innovation played a central role in driving down the costs of the SO_2 trading program.

While we have already seen that we have the technologies to get started on reducing emissions, over the long term technological innovation will be critical to solving global warming. As a result, the failure to adequately incorporate technological change represents the Achilles' heel of economic modeling. To be more precise, these models ignore technological change that is driven by the policy itself. A cap-and-trade program for greenhouse gases will put a price on carbon, creating a powerful driver for investment and innovation in areas such as energy

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Sierra Research, Inc., "The Cost Effectiveness of Further Regulating Mobile Source Emissions," February 28, 1994.; *The New York Times,* "Honda Meets a Strict Emission Rule," August 30, 1995; W. Harrington, R. Morgenstern, P. Nelson (Resources for the Future), "On the Accuracy of Regulatory Cost Estimates," January 1999. Citing Cackett, "The Cost of Emission Controls on Motor Vehicles and Fuels: Two Case Studies," presented at the 1998 Summer Symposium of the EPA Center on Airborne Organics, MIT Endicott House, Dedham, Mass. July, 1998.

[35] Morgenstern, R., Harrington, W. and Nelson, P. 2000. "On the accuracy of regulatory cost estimates." *Journal of Policy Analysis and Management* 19 (2): 297 – 322.

efficiency and renewable energy generation. Exactly how this process of "induced technological change" works, however, is complex and poorly understood. As a result, most models assume that technological change is "exogenous"---that is, unresponsive to prices and policies. A typical approach is to assume that technological improvement will unfold smoothly at a predetermined rate---often chosen to match historical improvements in productivity. While this crude approach is an improvement on a static model, it cannot capture the dynamic process of investment and exploration that will be spurred by a cap on carbon.

Moreover, such a smooth process is ill-equipped to model the "jump processes" that often characterize technological change. Over short time periods, a smooth approach may be a reasonable approximation. But over the course of two decades or more, its shortcomings become acute. For example, imagine trying to predict the current state of technology in 1970 or even 1990 – before the advent of the Internet, the ubiquity of personal computers, the widespread use of mobile communications, and so on. While predicting such individual innovations may not be crucial in forecasting aggregate economic growth, it was crucial to forecasting the costs of electronic communications and the explosion of the information technology as a crucial economic sector. In the same way, our fundamental inability to see ahead to the next generation of low-carbon and energy-efficient technologies is likely to bias our projections of the costs of curbing greenhouse gas emissions.

As an illustration of the limitations inherent in modeling technological change, consider how different models treat energy generation. Because carbon constraints will have a direct impact on the price and consumption of fossil fuels, the share of electricity that can be generated from renewable sources will be a crucial factor in determining the cost of reducing greenhouse gas emissions. Hence, the assumptions a model makes about the availability and cost of renewable energy sources are critical, even though they often are buried in a morass of technical detail.

As it turns out, different models answer these questions in dramatically different fashion. In the MIT EPPA model, the share of electricity from renewable energy under business as usual is constant over the next several decades, hovering around 8 percent. Even more striking is the lack of response to climate policy: for the year 2030, for example, the model projects that renewable sources will account for 7 percent of electricity generation under business as usual, but just 10 percent under ambitious climate policy.

This lack of a response to policy stems from the basic structure of the MIT model. Like most models, MIT's model is calibrated to a single base year – in this case, 1997. This means that key parameters in the model must be chosen to replicate the energy sector (and the rest of the economy) in that year. One such parameter concerns the substitutability between renewable generation and electricity produced from conventional sources---that is, how readily electricity generated from wind and solar sources can replace electricity from fossil fuel and nuclear energy. The MIT model assumes a low value for this parameter, as a crude way of reflecting the intermittency of wind power, the dependence of solar power on sunlight, and so on. While the parameter value may fit the facts in 1997, however, it ends up being severely limiting for the purposes of forecasting the future. In fact, MIT's future projections are even below *current* renewable electricity generation.

The point is not to pick on the MIT researchers, who in many respects have built an excellent model. Rather, the point is to underscore the inherent drawbacks of economic forecasts – and to serve as a reminder of why those forecasts should not be taken as reliable predictions of the future.

Only one side of the ledger

In assessing the results from economic models of climate policy, it is also crucial to account for what is missing from those models. I have already mentioned that all the modeling results discussed so far – like nearly all the results in the literature – completely ignore the damages from climate change. As a result, they look only at one side of the ledger when it comes to reducing greenhouse gases.

Two other categories of omitted benefits are also worth mentioning. The first is the ancillary benefits from reductions in conventional air pollutants. Emissions of SO_2, nitrous oxides (NO_z), and particulates (PM10) from power plants, factories, and cars contribute to ground-level ozone (smog) and suspended particulate matter in downwind areas. The consequences of poor air quality, especially in the densely populated cities of the Northeast, include substantial morbidity and mortality, resulting in enormous economic damages valued in the trillions of dollars.[36]

One important side effect of reducing greenhouse gases would be to reduce ambient concentrations of these conventional air pollutants. For example, reductions in gasoline consumption as a result of greater fuel economy and changes in driver behavior would translate into lower NO_z emissions, hence less ground-level ozone and fine particulate matter. Estimates of such ancillary benefits from climate change mitigation vary, but they could be of the same order of magnitude as the cost of reducing greenhouse gas emissions.[37] Although there has been little work focusing on the ancillary benefits from U.S. climate change policy, two preliminary analyses by EDF staff in conjunction with researchers at the Harvard School of Public Health and at Middlebury College suggest that the economic value of such "ancillary benefits" from cleaner air will be of the same order of magnitude as the estimated costs of reducing greenhouse gases.[38] For example, preliminary analysis by Professor Nicholas Muller of Middlebury College of the emissions reductions that would have been required by last year's Senate legislation (S.2191) has found that the associated ancillary benefits are as high of $9 per ton of CO_2 abated when all sources are included – of which just over $2 per ton is due to mobile sources alone. By comparison, the average cost of abatement in the EPA's analysis of S.2191 is about $9.30 per ton. In other words, even before we take into account the benefits from addressing global warming, the reductions in CO_2 from a cap on greenhouse gases will almost pay for themselves simply through better air quality. While these results are still in progress they suggest that

[36] Muller, N and Mendelsohn, R. July 2007. "Measuring the damages of air pollution in the United States." *Journal of Environmental Economics and Management*, 54 (1): Pages 1-14.

[37] Michelle L Bell, Devra L Davis, Luis A Cifuentes, Alan J Krupnick, Richard D Morgenstern and George D Thurston. "Ancillary human health benefits of improved air quality resulting from climate change mitigation," July 2008, *Environmental Health*, 7:41; Devra Lee Davis, Alan Krupnick and Gene McGlynn, "Ancillary Benefits and Costs of Greenhouse Gas Mitigation: An Overview," In *Workshop on Assessing the Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies*, Washington, DC: Organization for Economic Cooperation and Development (OECD), Intergovernmental Panel on Climate Change (IPCC); 2000.

[38] John M. Balbus, MD, MPH (Environmental Defense Fund), Ramya Chari, MPH, (Johns Hopkins Bloomberg School of Public Health), Kristie L. Ebi, PhD, MPH, (ESS LLC, Inc.) "Health Co-benefits of specific US Climate Activities," forthcoming

overlooking the cobenefits from cleaner air will lead to a serious underestimation of the benefits of climate change legislation.

A second benefit of climate policy that is overlooked in the macroeconomic models is national security. From a wide-angle perspective, national security would be enhanced by reducing the link between climate-induced environmental stress and geopolitical instability[39]. At a more immediate level, a cap on carbon would encourage conservation and more efficient use of petroleum products, leading to a reduction in imports of foreign oil. Consider how vulnerable the current U.S. economy is to swings in oil prices: every $30-per-barrel increase in oil prices reduces real income by roughly 1 percent of GDP[40]. A cap on carbon would increase energy efficiency and clean energy here at home — reducing our dependence on foreign oil and thus our vulnerability to such price swings. For example, MIT researchers estimate that a cap-and-trade program would reduce oil imports by $20 billion per year in 2015 and $45 billion in 2025.[41]

4 CAP-AND-TRADE IS A PROVEN APPROACH

A cap-and-trade program for greenhouse gas emissions is sometimes portrayed as if it is novel idea. In fact, it is a proven approach for environmental regulation that has been in operation in the United States for nearly fifteen years. Under Title IV of the 1990 Clean Air Act Amendments, emissions of sulfur dioxide from fossil-fired electric power plants have been capped since 1995, with the level of the cap declining to a long-term level equal to half of emissions in 1980.

That program has shown how well a cap-and-trade system works. Under the program, fossil-fired electric generating units with capacity of at least 25 MW — over two thousand in total — must submit allowances for their SO_2 emissions in each calendar year, with one allowance corresponding to one ton of emissions. (Units in the eastern half of the country must also submit allowances for their NO_x emissions, under a parallel trading system instituted by rule.) Emissions are measured in real time by continuous emissions monitors (CEMs) installed for that purpose. The combination of real-time monitoring, regular reporting, a central electronic allowance registry, a simple requirement ("submit as many allowances as emitted tons"), and a stiff fine for noncompliance have produced a stellar compliance rate of over 99%.

The program's performance has greatly exceeded expectations. Total SO_2 emissions reached their long-run target in 2007, three years ahead of schedule – thanks in part to a provision that allows regulated entities who can reduce their emissions by more than required to bank the

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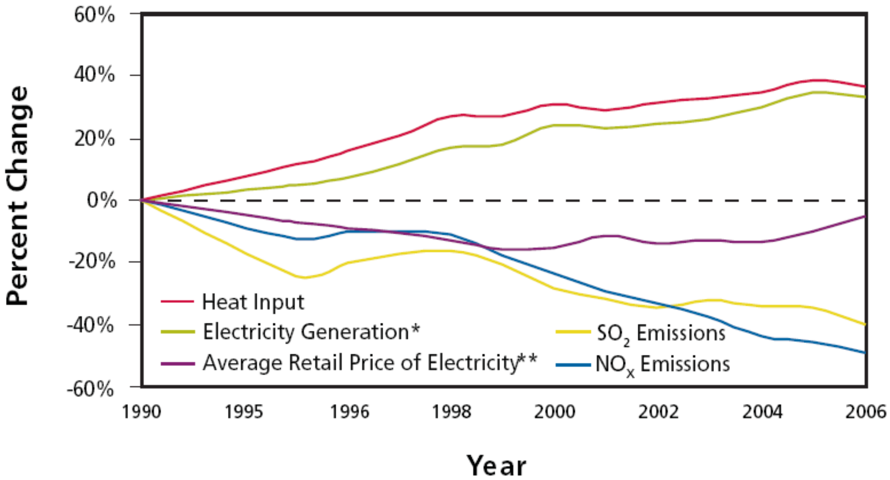
[39] Center for Naval Analysis. *National Security and the Threat of Climate Change,* 2007.
[40] Council on Foreign Relations. *National Security Consequences of U.S. Oil Dependency, 200.6* Independent Task Force Report No. 58, John Deutsch and James Schlesinger, Chairs, 2006.
Note: adjusted for current GDP of $14 trillion
[41] Sergey Paltsev, John M. Reilly, Henry D. Jacoby, Angelo C. Gurgel, Gilbert E. Metcalf, Andrei P. Sokolov and Jennifer F. Holak. *Assessment of U.S. Cap-and-Trade Proposals*. MIT Joint Program on the Science and Policy of Global Change, Report No. 146, April 2007.

resulting allowances for future use. As a result, acid rain in the eastern United States has been reduced dramatically, as have ambient concentrations of sulfur dioxide and particulate matter.

The simplest testament to the program's performance is given by Figure 8. Even as emissions of SO_2 and NO_x have fallen sharply, electricity generation from fossil-fired electric plants has risen.

Perhaps most strikingly, the average retail price of electricity (in real terms) is *less* than it was in 1990 when the law was passed.

Figure 8 — Changes in pollution emissions, heat input, electricity generation, and retail electricity prices since the passage 1990 Clean Air Act Amendments. The emission trading system for sulfur dioxide took effect in 1995.[42]



* Generation from fossil fuel-fired plants.

** Constant year 2000 dollars adjusted for inflation.

Source: Energy Information Administration (electricity generation, retail price); EPA (heat input and emissions, representing all affected ARP units), 2007

[42] Environmental Protection Agency, 2007.

Indeed, the cost of the program has come in far below expectations. The total cost of the sulfur dioxide program is estimated to be $1 to $2 billion annually – a fraction of the $6 billion that EPA projected in 1990.[43] (Controls on nitrous oxides (NO_x) are estimated to add another $1 billion in annual costs.)

The use of a market-based policy, rather than conventional command-and-control regulation, has led to billions of dollars in cost savings. In the first phase of the program alone (from 1995-1999), emissions trading reduced aggregate annual compliance costs by an estimated $150 million, or 17 percent, relative to an emissions performance standard — and saved a staggering *$1.8 billion* each year relative to a technology standard requiring the use of scrubbers.[44]

A major reason for the Acid Rain Program's lower-than-expected costs was technological change. Some of the relevant changes involved more efficient scrubbers that can remove as much as 95 percent of SO_2 from flue gases (rather than 80 to 85 percent as had been more common) – and can do so without the expensive and redundant design features (such as entire extra "trains" or spare modules) that were included to ensure continuous operation of a scrubber in the era of command-and-control regulation, when a scrubber breakdown could mean shutting down the unit. Other changes were "Eureka moments," as when a team at General Electric working to improve methods of scrubbing sulfur dioxide out of smokestack emissions figured out how to oxidize the gas all the way to gypsum that could be sold for fertilizer or sheetrock.

But the most important and unexpected innovation was also the most mundane. Before the emissions trading program began, conventional wisdom among power plant engineers was that boilers built for high-sulfur bituminous coal from the Illinois Basin and Appalachia could never burn more than a small percentage of the less energy-rich but low-sulfur coal from western mines in places like Wyoming's Powder River Basin. That conventional wisdom was turned on its head. Soon anonymous power plant operators were figuring out how to adapt boilers designed for high-sulfur Eastern coal to burn low-sulfur Wyoming coal – sometimes switching completely over. Wyoming coal, it turned out, was plentiful enough – and cheap enough – that it became cost-competitive throughout much of the Midwest once the price of sulfur dioxide was factored in. The market-based approach played a key role here: not only did it create an economic incentive to reduce emissions, but it gave electric power plants a great deal of flexibility in figuring out how to achieve those reductions in the most cost-effective way possible.

In the end, the most impressive single measure of performance for the Acid Rain Program is its estimated net benefits. While total costs (of SO_2 and NO_x combined) have been roughly $3 billion annually, estimated benefits are more than <u>forty times larger</u> — $122 billion each year.[45]

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[43] United States Environmental Protection Agency. National Acid Precipitation Assessment Program. *Report to Congress: An Integrated Assessment*. 1990.

[44] Keohane, Nathaniel, "Cost Savings from Allowance Trading in the 1990 Clean Air Act: Estimates from a Choice-Based Model" in Charles E. Kolstad and Jody Freeman, eds., *Moving to Markets in Environmental Regulation: Lessons from Twenty Years of Experience* (New York: Oxford University Press, 2006).
Note that the total compliance cost in Phase I, which covered fewer units, was estimated to be $750 million annually.

[45] Chestnut, L.G., and Mills, D.M. "A fresh look at the benefits and costs of the US acid rain program." November 2005. *Journal of Environmental Management* 77(3): Pages 252-266.

5 LEADERSHIP ON CLIMATE CHANGE CAN SECURE AMERICAN PROSPERITY

While the evidence presented so far provides assurance that ambitious reductions in greenhouse gases are compatible with robust economic growth, a broader perspective suggests that passing well-designed climate legislation will be a crucial step in putting the American economy on a sound long-term footing, and ensuring our future prosperity.

A leadership role in the next economic transformation

The engine of progress in the U.S. economy is technological innovation. We have led the way in the major economic transitions of the past century: the emergence of wide-scale mass production; the development of semiconductors; the space age; the Internet age. The story of the semiconductor era captures the vital importance of technology to U.S. economic growth. From the invention of the transistor at Bell Laboratories in 1948, to the introduction of silicon and the development of integrated circuits in the 1950s and 1960s, to the emergence of logic chips in the 1990s---at each stage, the United States has led the world, and our technological leadership in this area has been the foundation for postwar growth.

The next major economic revolution will be the clean energy revolution. A cap-and-trade system that drives American investment and inspires American innovation will position the United States competitively for growth in the global transition to a low-carbon economy. It is an advantage for the United States that it will be starting before China, India and other emerging economies. Europe and Japan have already started down this road. But eventually all countries will join the international system to limit carbon emissions. The nations that take the lead in the hunt for low-carbon technologies will find that an enormous market awaits them. The choice facing us is a stark one: Will we develop and export the coming wave of low carbon technologies — like carbon capture and sequestration, next-generation solar panels, and powerful lightweight batteries — so that jobs and businesses stay in America? Or, will we do nothing and find ourselves importing those technologies from overseas? Failure to act on cap-and-trade policy would withhold the signals and incentives that can empower the American economy to modernize jobs, services and technologies, and allow the country to emerge from this next phase of global change and competition in the leadership position it holds today.

Why now?

Some observers are understandably concerned about whether the time is right for a cap on carbon, given the deep economic recession we find ourselves in. The answer is that this is *precisely* the time when bold action is needed. If climate legislation is passed during this Congress and takes effect in 2012, the impact on energy prices will be zero this year; zero in 2010; zero in 2011. On the other hand, passage of legislation will help to unleash a flood of investment, by sending a clear signal what the price of carbon will be. Electric utilities and manufacturing companies are waiting for legislation before they invest in new power plants or factories that will last forty years or more. A cap on carbon will drive investment right away.

And investment is what our economy needs most right now. Once the investment begins to flow, orders will come in to steel mills and cement factories, to manufacturers of wind turbines and energy-efficient windows and retrofit equipment to improve fuel economy of long-haul trucks. Right now our factories are idle, labor and capital are underemployed. The economy needs a source of demand beyond the stimulus package. Where is that demand going to come from? A cap on carbon will not create money out of thin air. But it will unleash capital that is sitting on the sidelines, and channel it towards clean-energy investments that will revitalize our economy while ensuring a prosperous future.

Now is precisely the time to pass climate legislation. This committee, and Congress as a whole, stands at the cusp of an historic achievement. Thank you for inviting me to testify.