The Energy Challenge We Face
and
The Strategies We Need

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Senator Jeff Bingaman, Chairman
Committee on Energy and Natural Resources
United States Senate

Our nation is the world leader in science, technology and innovation. The students and the faculty here at MIT, both past and present, deserve much of the credit for that leadership. And anyone who pays attention knows that if we, in this country, have something akin to a war room where our energy challenges are being confronted, it is here at MIT. Karl Compton himself said, “nowhere in the country [is there] such a concentration of scientific and engineering laboratories and personnel.” I compliment President Hockfield and all of you who have worked to establish the MIT Energy Initiative, and I thank President Hockfield for her generous invitation and introduction. It is an honor to be here.

One of the greatest lessons that I have learned in life is to seek advice from people who know more about a subject than I do. One of those people whose advice I sought before coming here today is former MIT President Chuck Vest, who now serves as President of the National Academy of Engineering. He urged me to say a few words about the factors that have resulted in me—a lawyer and a politician—being so involved and interested in science, technology, and energy policy.

The most important factor was probably my father’s lifelong commitment to science. Both my parents were teachers. My mother taught elementary school and my father was the chemistry professor and head of the Science Department at Western New Mexico University in my hometown of Silver City, New Mexico. There is no way you can grow up in a house with a chemistry professor without gaining an appreciation for the importance of science.

Another important factor was undoubtedly my uncle, who was heavily involved in the politics of our state and ran the political campaigns for a long-time senator of New Mexico, Clinton Anderson.

Both my exposure to science and engineering through my father's career, and my exposure to politics through my uncle's avocation, came together to bring me to the Senate. Those influences are also responsible for my focused attention on the role of government and science and technology in meeting our energy challenge.

I know many of you have similar influences in your own lives. As you move forward with your education and your plans for future careers, I hope that you will carefully consider the ways in which you can use your MIT education to address the great challenges we will face as a society in this century. Government at all levels, but especially in Washington, will need to have people with your qualifications and abilities if we are to understand and respond intelligently to those challenges.

When we talk about those challenges in relation to energy, what do we mean?

The energy challenge we recognize today is different from and more encompassing than what we recognized as our energy challenge even a few years ago. Until fairly recently, at least in Washington, our energy challenge was seen largely as the need to reduce dependence on foreign oil. For the past quarter century we have seen the amount of the oil we import grow. And although relatively little has been done during these

years to reverse that trend, that issue has dominated energy debate in Washington.

Dependence on foreign oil remains a major concern, but today we see our energy challenge as larger than that and in many ways very different. Different in nature, different in scale and much more urgent.

The energy challenge we see today is global rather than national. It is to change the way the world produces, stores, distributes, and uses energy so as to reduce greenhouse gas emissions. It is to shift, not just our own economy, but the global economy from dependence on combustion of fossil fuels to use of non-emitting energy sources.

With the concentration of greenhouse gases in the atmosphere on a trajectory to unacceptable levels, our sense of urgency to take action has risen as well. Simply stated, it is not enough to commit to reducing greenhouse gas emissions beginning in 2025. We must act and we must act now.

With respect to the scale of the challenge – it is immense. We and the other nations of the world will need to overhaul the existing energy infrastructure on which we all depend. That infrastructure did not develop overnight.

Two hundred years ago, the combustion of fossil fuels, primarily coal, produced the steam that turned the turbines that powered the industrial revolution. Today our planet has more than 50,000 coal-burning power plants, accounting for nearly one-third of greenhouse gas emissions worldwide. The normal rate of turnover for this infrastructure is at least 40 to 50 years.

One hundred years ago, the decision was made to power our transportation sector by burning petroleum-based fuels in an internal combustion engine, rather than through the use of electric motors and batteries. Today, we have over six hundred million vehicles using some version of that internal combustion engine, producing 14 percent of greenhouse gas emissions worldwide.

But our challenge is not limited to just the power plants and vehicles we have today.

We live in a world of growing demand for energy as billions of people are rising out of poverty. As that demand for energy grows, it will require new energy production capacity. Today, that new capacity generally consists of coal-fired power plants with the same high carbon dioxide emissions as our current energy infrastructure. Just a couple of weeks ago, India announced that it is building a new 4 GW coal-burning power plant complex. These plants will emit more than 23 million tons of CO_2 a year. The justification? That the need to bring electricity to one of the world's poorest regions is more pressing than the need to limit carbon dioxide from burning fuel, and this is the least expensive way to do it. It is difficult to argue against such a statement, when most of us here have never known a life without electricity.

As we struggle to develop alternatives to our current energy infrastructure, we must recognize that in order to achieve sustainable use of those alternatives worldwide they must become cost-competitive, so that they are the option of first resort.

To accomplish all of this, we will need both a revolution in technology and major changes in our economy. Our past technological choices are

inadequate for our future. The solutions we need can only come from new technologies. And if the challenge of developing those new energy technologies, and implementing them worldwide, is immense, so too are the opportunities afforded by tackling this problem the right way. If we see our most pressing environmental problems as an opportunity to reassert U.S. leadership in science, technology, and innovation, we have the potential not only to resolve those problems, but also to revitalize our R&D enterprise and to rebuild our manufacturing base in the United States.

But how do we accelerate the development and widespread use of new technologies to address our energy challenge?

One promising place to start is to adopt policies that put a price on emitting CO_2 and other greenhouse gases. By levying a cost on putting greenhouse gases in the air, we will accelerate the private-sector development and use of technologies that avoid and minimize greenhouse gas emissions.

In the Senate we are working to design a regulatory framework in the form of a cap-and-trade system that will recognize the real costs of continued emission of greenhouse gases and shift development toward low-carbon energy production. In the past few years, we have seen a dramatic increase in private-sector entrepreneurs who want to develop clean energy technologies. Putting a price on the emission of greenhouse gases will stimulate that private sector involvement even more.

The proper design of a cap-and-trade system for greenhouse gas emissions is not the subject of my talk today, but I do want to say that this is not a simple matter. Having been in the Senate for 25 years, I can assure you that we in Congress have the ability to design and enact a totally

unworkable system. Without the help of this country's best minds we could wind up doing just that.

While putting a price on CO_2 emissions is an essential part of the solution, it is not the only tool we should be using to resolve this problem.

We should also change the way we pursue technology development and deployment. And it is here where I will focus my talk today.

I will cite 5 main areas where our policies to support technology development and use have fallen short.

1. Need to support our science and technology enterprise.

2. Need to set priorities for energy technology development and use.

3. Need to sustain support for those R&D priorities.

4. Need for a long term regulatory and tax framework to promote development of new technologies.

5. Need for a strategy for how to create the high wage jobs in the U.S. involved with manufacture of these clean energy technologies.

5 Areas Where Our Policies Have Fallen Short

1. Need to support science and technology enterprise

2. Need to set priorities for energy technology development and implementation

3. Need to sustain support for R&D priorities

4. Need for a long-term regulatory and tax framework to promote the development of new technologies

5. Need for a strategy on how to create the high wage jobs in the U.S. for the manufacturing of clean energy technologies

Our first key failing is in our support for the basic scientific and engineering enterprise in our nation.

The best recent analysis of this problem was in a report issued by the National Academies, entitled Rising Above the Gathering Storm. The report was a significant and well supported wake-up call for policymakers on the need for major sustained support of the basic sciences. We in Washington are beginning to respond. While we don't have major progress to report as yet, I believe we will make progress in the months and years to come. One aspect of our anemic and unreliable support for the basic science and engineering enterprise in this country has been the anemic and unreliable support for energy related science and technology development.

That brings me to the second point on this chart. We have failed to set priorities among the promising energy technologies that would lower our greenhouse gas emissions.

You can find government reports on climate change technologies – the Department of Energy put one out in 2006 that it labeled as a Strategic Plan. But these reports are basically only "shopping lists" of viable technologies -- with no concrete goals, no roadmaps for making progress, and no timelines for development. Such reports are not entirely without value, but what we have nationally now is far from being a strategy. And it is far from adequate to address the challenges before us. What we need is to formulate a strategic research and development plan that maps out a prioritized set of technological goals, the steps needed to achieve those

goals, and the time in which those goals should be met. I am not talking about a document that would limit scientific and technological exploration, but a roadmap with broad highways along which we could ensure that science and technology would be supported. Any energy R&D roadmap we design will need plenty of on- and off-ramps to incorporate the new knowledge, understanding, and breakthroughs that will inevitably occur.

Japan has recently begun to move along the path of developing such a strategic plan with the release last month of its “Cool Earth – Innovative Energy Technology Program.”

21 Key innovative energy technologies

Efficiency improvement ***Low carbonization***

Oil LNG Coal Nuclear Power Biomass Solar Wind

Supply side

Demand side

Cross sectoral

Electric Power

2. Efficient / near-zero emission coal-fired power plant

3. Carbon Capture and Storage

4. Innovative solar power

5. Advanced nuclear power

1. Efficient LNG-fired power plants

6. Superconducting power transmission

Transport

7. Intelligent Transport Systems

8. Fuel Cell Vehicles

9. PHEV / EV

10. Biofuels

Industry

11. Innovative materials / manufacturing process

12. Steel making process with Hydrogen

Residence / Building

13. Efficient house / building

14. Efficient lighting

15. Fuel Cell for residential use

16. Efficient Heat pumps

17. Efficient IT device / network

18. Energy Management Systems

19. Power storage

20. Power electronics

21. Hydrogen production / storage / transport

This document identifies 21 areas of technology development which meet two criteria. First, each is expected to deliver substantial reductions in carbon dioxide emissions in the world by 2050. Second, each is a technology area in which Japan believes it can lead the world. Technology roadmaps are being formulated for each of the 21 technologies, giving R&D direction and milestones on performance with timelines toward long-term goals.

Perhaps the closest parallel we have to the Japanese priority setting effort is a project to identify the "Grand Challenges for Engineering in the 21st Century," which were described in a report the National Academy of Engineering earlier this year. Among the "grand challenges" identified are two of the 21 technology areas covered in the Japanese innovative technology program:

- making solar energy economical and
- developing carbon sequestration methods.

While there is a significant effort underway at our National Academies to determine U.S. research and development needs in the energy area, it is clear that the systematic setting and maintenance of priorities for energy technology development is not something we have committed to at the highest levels of our government.

What do I propose as the solution?

I believe that we need to take 5 steps.

5 Steps Towards Establishing National Energy R&D Leadership

1. Strengthen S&T responsibility and authority at the highest levels of government

2. Prioritize critical, enabling energy technology areas

3. Develop roadmaps and assign responsibility for pursuing each technology area

4. Ensure sustained focus: Require the President to detail proposed energy R&D funding across agencies

5. Review and update our energy technology priorities regularly to reflect progress

The first step is to establish overall responsibility at those highest levels of our government for such an effort. Much of what is covered on the previous chart of innovative technologies is funded by the Department of Energy. But a number of key areas belong to other Departments of government, like the Department of Commerce. And even the Secretary of Energy and the Secretary of Commerce have a difficult time getting the research funding they need out of the White House budget process, which is run by the Office of Management and Budget. So, I believe that the President's Science Advisor needs to be given a stronger hand. One way to provide that enhanced authority would be to direct that the President's Science Advisor hold a concurrent appointment at the Deputy Director-level in the Office of Management and Budget. This would ensure that the same person with responsibility for overall science and technology policy in government has some real authority to ensure that the funds to support science and technology make it into the Federal budget.

As a second step, the President's Science Advisor, armed with his enhanced authority, should work with the key Departments and the National Academies to come up with a manageable set of energy technology areas that promise to aid us in meeting our energy needs and substantially reducing greenhouse gas emissions in coming decades. Some of these will be technology areas the Japanese or others have chosen as well. Others will be new to the list.

As a third step, in each of the chosen technology areas, a working group of academic, government, laboratory, and industry representatives should be convened and a broad roadmap developed to chart the way

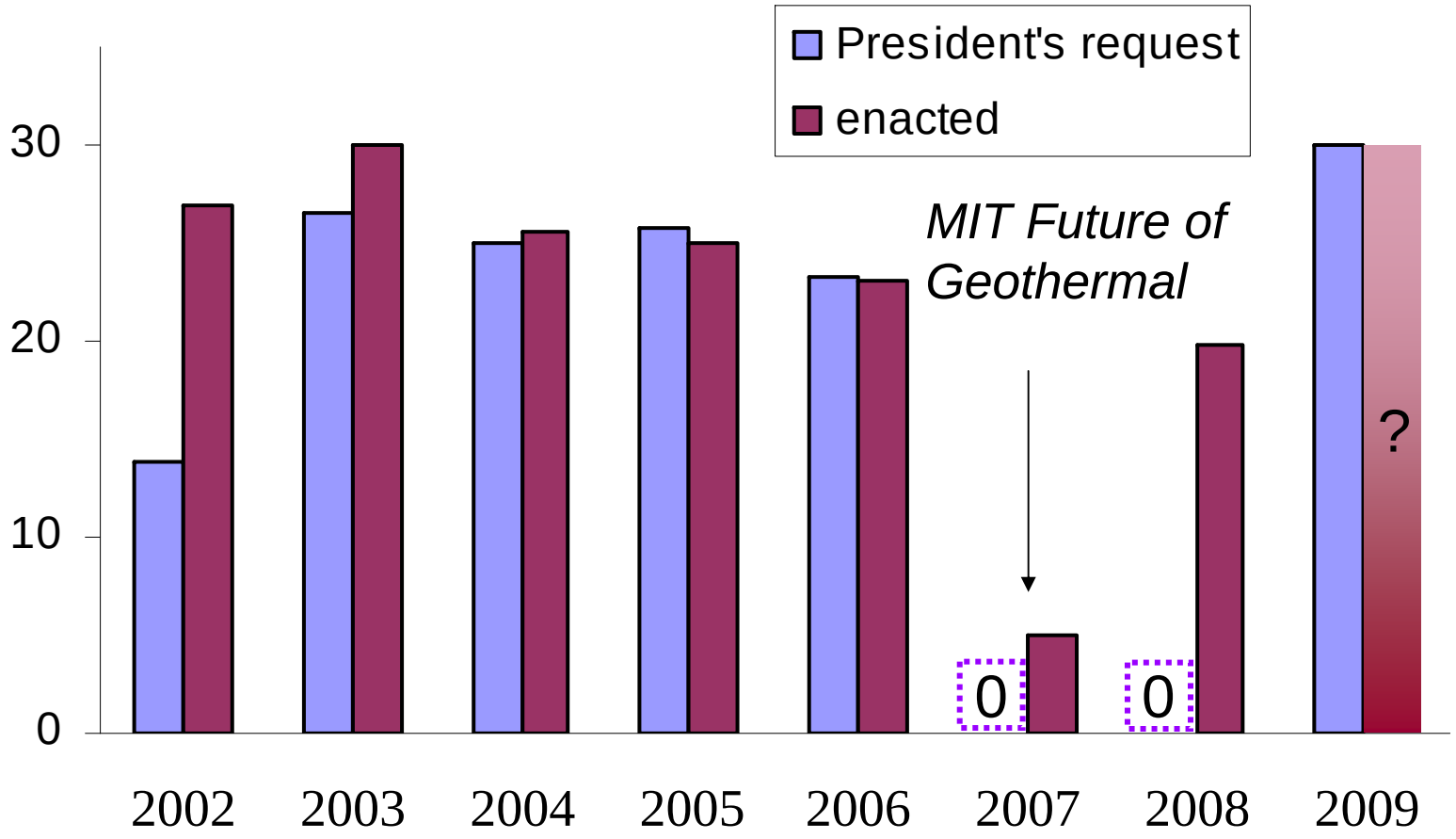
forward. Responsibility for pursuit of the roadmap in each technology area should be assigned to a particular government department or agency.

Fourth, to ensure an adequate degree of sustained focus and an adequate level of funding, the President should be required to submit to the Congress with his budget proposal each year a separate document detailing the funds being requested in support of each energy technology area across the agencies of the government.

And finally, to ensure that the areas being pursued continue to be those that hold the greatest promise, the National Academies should be directed to prepare an updated analysis of energy technology priorities every five years. We already do something very similar with our Defense policy by requiring a so-called Quadrennial Defense Review, every 4 years.

MIT has already begun to take the lead in prioritizing promising technologies with its reports on the future of nuclear power, coal, and geothermal energy. I am looking forward to your completion of a similar report on the future of solar energy. Your reports have a real impact. In fact, it is precisely because of the Future of Geothermal Energy Report that we have an Enhanced Geothermal R&D Program at the Department of Energy.

Funding For Geothermal R&D



This graph shows the lack of consistent support for geothermal energy development in recent years. In early 2006, the President proposed a budget for 2007 with zero funding for geothermal energy research. He did the same in early 2007 for the 2008 budget. But when the MIT report drew the attention of Congress in 2007 to the importance and promise of research on geothermal energy, Congress responded. As a result, the funding level went back to $20 million for 2008. The Department of Energy then took note of the report and Congress's interest and reinitiated its requests for funding for 2009.

But as we have learned from hard experience, it is one thing to set priorities and begin pursuing them. It is quite another to sustain the effort. This brings me to the third major policy failing on my earlier list. Our record for sustaining the effort at critical technology development has been poor. Once we set the course, why can't we stay on it?

One obvious problem is that each new administration feels a need to pursue something new. Instead of sticking with the difficult blocking and tackling required to move the ball down the field, we allow our attention and effort to be deflected, and comfort ourselves with the notion that some Hail Mary pass will nevertheless allow us to score the touchdown.

To this point, our stop-and-start efforts in regard to geothermal development unfortunately have been matched by similar efforts in the development of vehicle technology.

Vehicle Technology Programs—Reinventing the Wheel

"I am inaugurating a program to marshal both government and private research with the goal of producing an unconventionally powered virtually pollution free automobile within five years."
—Richard Nixon, 1970

- **Virtually Pollution-Free car (Nixon 1970)**
- **Reinventing the Car (Carter 1977-1980)**
- **Partnership for a New Generation of Vehicles (Clinton 1993-2000)**
- **FreedomCar (Bush 2003)**

In this country, we have seen a different story play out. Utility regulation and rate setting have historically been the job of public regulatory commissions at the state level. While some states have enacted progressive policies such as renewable portfolio standards and net metering, many have not.

We have tried for the last 3 Congresses to enact a renewable portfolio standard at the national level but those efforts have met strong resistance from utilities and from the current administration.

Similarly in the area of tax incentives for increased efficiency and renewable technologies, our record has not been stellar. We have enacted some renewable tax incentives but for budgetary reasons those were enacted for only short periods of time. And often they were allowed to expire before they were renewed.

As an example, the most significant tax incentive we have enacted to encourage alternative energy development has been the Renewable Energy Production Tax Credit. In the case of wind energy, this credit provides a reimbursement of nearly 2 cents per kilowatt-hour for electricity produced from a wind turbine, for a full 10 years after the turbine is put into service. The problem has been that the periods during which one is required to put the turbine in use to receive the tax credit were relatively short periods.

On February 10, 1970, before many of you in this room were born, President Nixon announced the following in a special message to the Congress:

> "I am inaugurating a program to marshal both government and private research with the goal of producing an unconventionally powered pollution free automobile within five years."

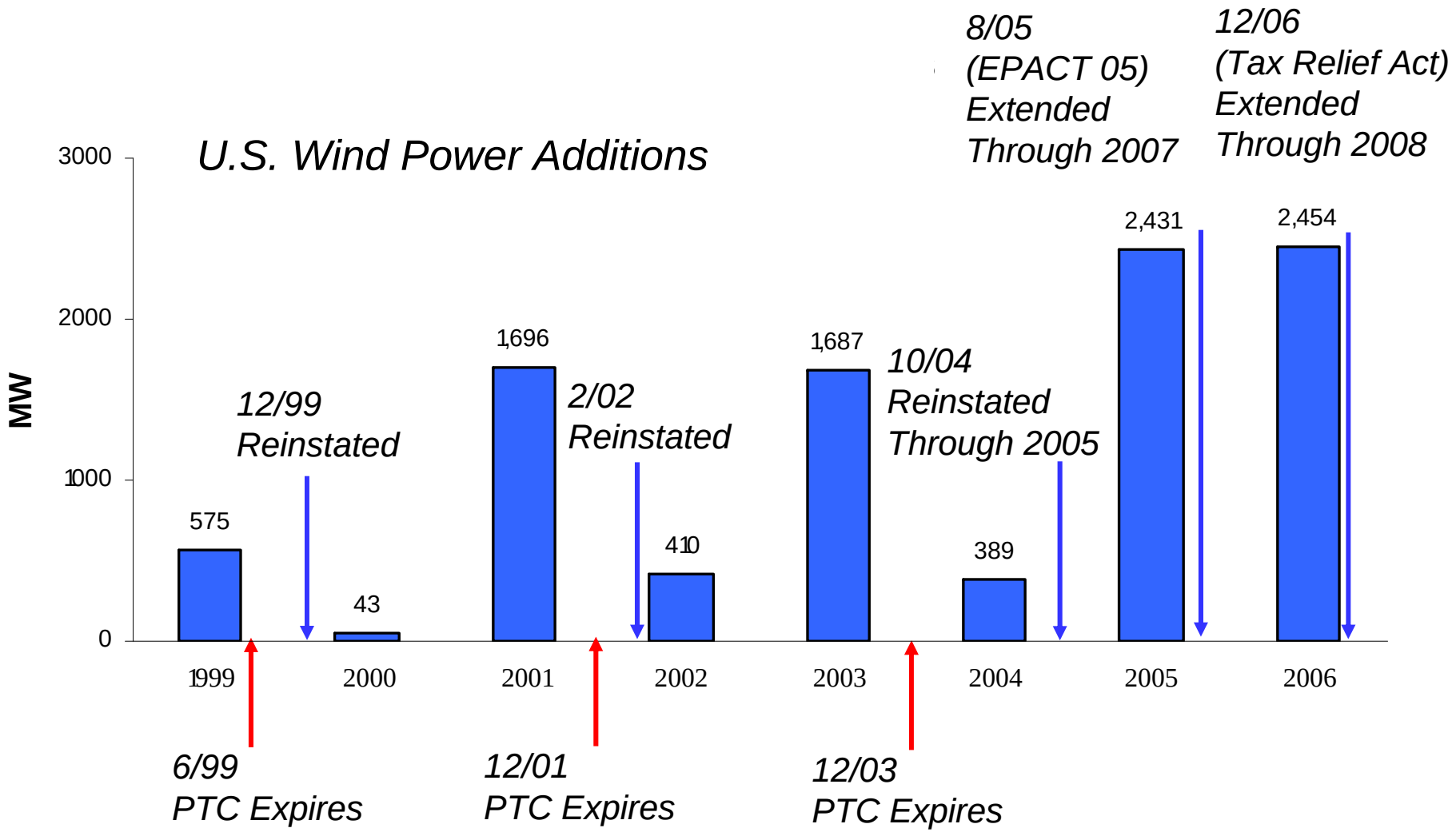
Seven years later in 1977, President Carter announced his program for "reinventing the car." 15 years after that, in 1993, President Clinton announced his Partnership for a New Generation of Vehicles, and 10 years after that, in 2003, President Bush announced his push for the Freedom Car.

Identifying the priority is obviously not enough. It is also necessary to develop a consensus on how to proceed -- a consensus that will survive from one Administration and one Congress to the next. The development of a national strategic plan for energy technology development, together with regular updating of that plan, will go a long way toward avoiding the stop-and-start approach that has plagued us in the past.

The fourth major failing in our science and technology policy happens after we discover or develop new science and engineering at places like MIT.

We don't have long-term regulatory and tax policies to promote development, manufacture, and widespread use of new technologies. As Germany has shown in the areas of wind and solar, providing such long term policies can create a booming renewables industry.

Intermittent Production Tax Credit



changes in the way we do business; it is more likely than not that we will buy these products from abroad.

In their 1990 book, The Breakthrough Illusion, Professors Richard Florida and Martin Kenney state:

"Although the commonplace impression that breakthrough innovations create permanent advantage for American companies may once have been true, it is just not the case anymore. A new reality is upon us: the U.S. makes the breakthroughs, while other countries, especially Japan, provide the follow-through."

Now, 18 years after that was written, I believe it is truer than ever, and the other countries include many besides Japan.

Here is a chart that shows what has happened to world production in photovoltaic cells since 1995. It is interesting to observe that until 1998, we were holding our own. In the last decade, though, while production in other countries has soared, the U.S. photovoltaic industry has remained stagnant.

This problem is clearly illustrated in this chart of U.S. wind capacity addition per year. In years when the production tax credit was fully available, there was robust development. In years when the tax credit was scheduled to expire, financial institutions were reluctant to invest in projects that were not certain to be producing before the expiration of the credit. The result was this boom-and-bust cycle that you see in the chart. Clearly, a more consistent tax policy would have put us much further along in our development and use of wind power. Government-driven boom-and-bust cycles send the wrong message to entrepreneurs.

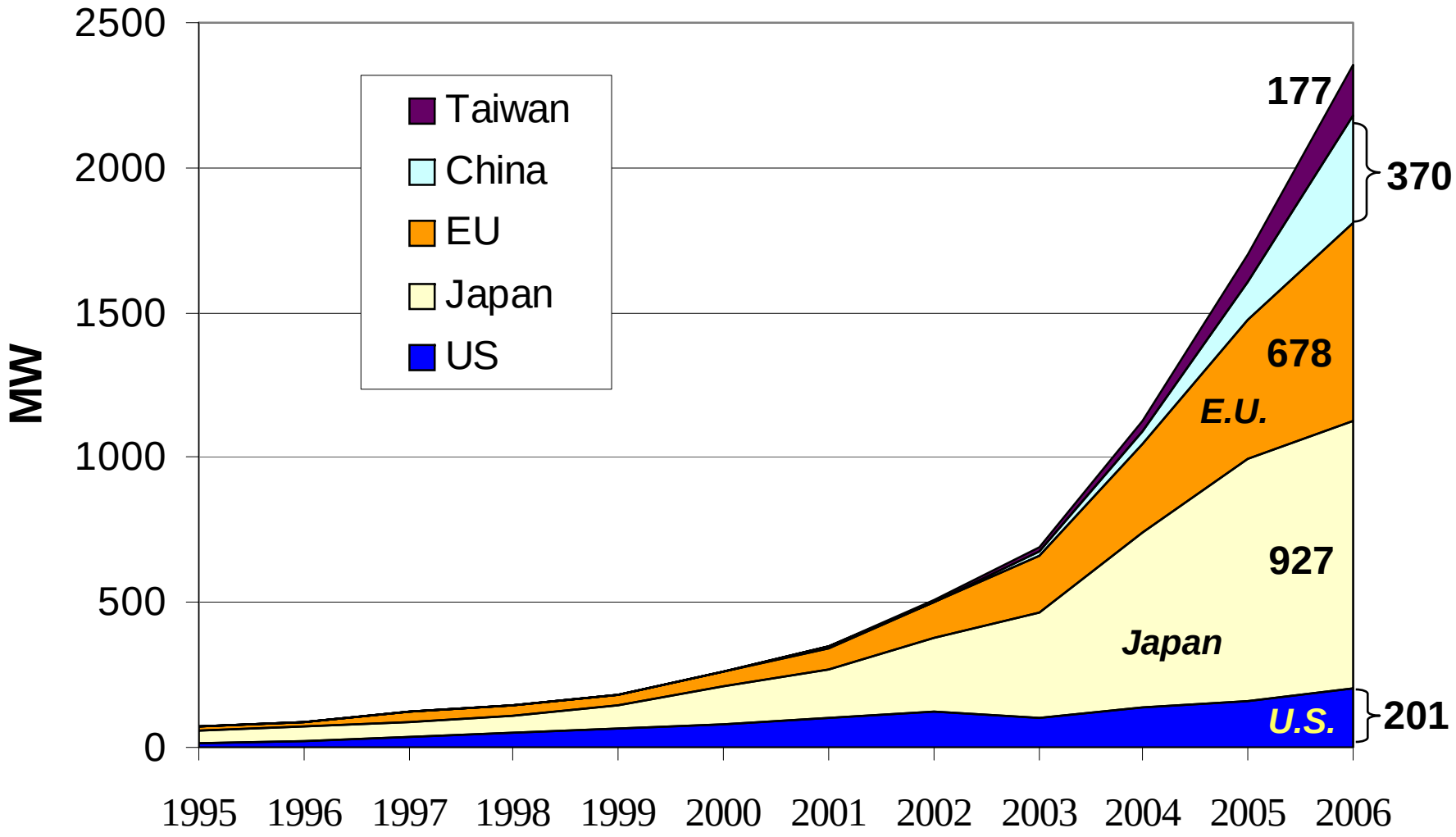
What we need is a way to provide long-term market stability for renewable electricity production. Part of that solution is to provide a long term extension of the tax credits for renewable electricity. I believe that Congress will, next year, with a new Administration in office, finally pass a much longer term extension of these tax credits.

The fifth and final policy area I will discuss is the need to claim the economic benefits from clean tech manufacturing.

First we need to acknowledge, at least in theory, that it is possible to meet the energy challenges I have outlined without creating the domestic manufacturing capability and domestic manufacturing jobs that ought to go with that. To use the current buzzword, we unfortunately could wind up "outsourcing" that manufacturing, particularly through inaction. Advanced energy storage devices, thin film photovoltaic cells, and highly efficient light emitting diodes will all be needed for clean, efficient energy production and use. But there is no assurance that these products will be produced in the United States. In fact, some would argue that unless we adopt substantial

Annual PV Production

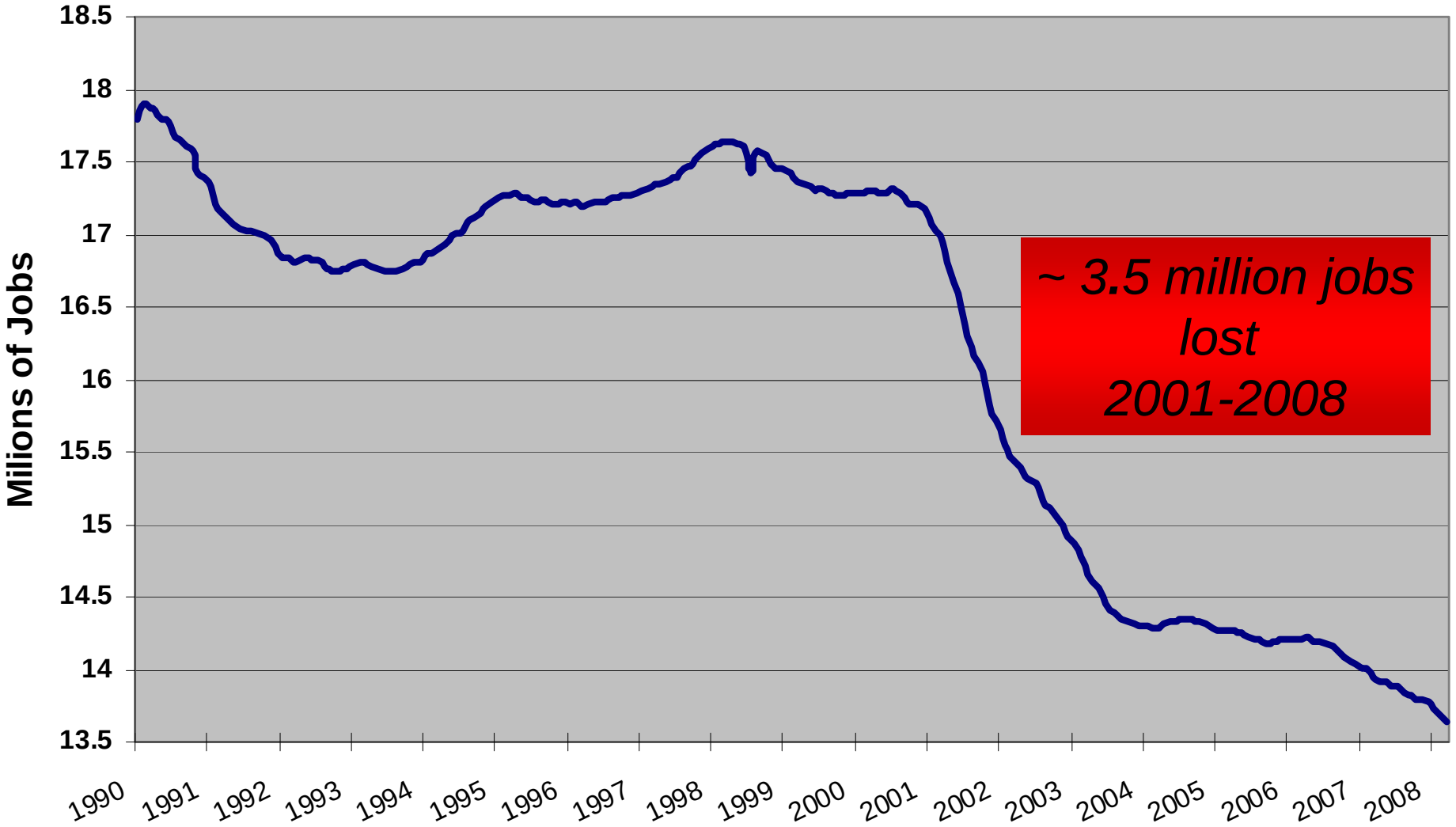
Select Countries and EU



And to once again point out that this is part of a larger problem of our declining manufacturing base, here is a chart showing the drop-off in U.S. manufacturing jobs over the last 7 years, not just in energy-related technologies, but in all sectors.

Manufacturing Employment Levels

January 1990 to March 2008



Source: Bureau of Labor Statistics

A strategy to revitalize U.S. manufacturing is the topic for another speech. Such a strategy will require developing a consensus on changes in tax policy, procurement policy, trade policy, and probably health policy and education policy as well. We have a real opportunity here to grow a high-tech, renewables manufacturing base if we commit to the right policies. We have the knowledge, the technology, the workforce, and the drive to make it possible. Germany has proven that such a transformation can occur in an advanced economy. Nearly 250,000 renewable energy jobs have been created in Germany, and it is expected that over 400,000 people will be employed by 2020. Imagine what is possible in an economy of our size and capabilities.

Tackling the policy challenges in the 5 major areas I have discussed is important to everyone here in the room -- as students, researchers, and innovators today, and as leaders in our clean tech and energy industries tomorrow. If you are wondering, “How does all this relate to students here at MIT?” I would suggest the following.

Each of the problems I have laid out also presents great opportunity—and I’m told that MIT students know the connection between problems and opportunities better than anyone. You at MIT have a critical role to play in solving our energy problems. Because of your knowledge, your abilities, and your persistence—it is you who will likely emerge as the leaders in meeting this global challenge.

Reengineering the way the world produces, stores, distributes and uses energy may in fact be the greatest challenge that we as a global community must face together. And to my mind, it is a worthy calling.

Addressing the energy challenge will require government, industry, scientists, and engineers to work together. I hope that some of you will come to Washington to help us structure the policies and programs that will facilitate that work. As it happens, two graduates of this great university work with me and do a wonderful job on the Senate Energy and Nature Resources Committee. I am proud that they are here today. Bob Simon is the Director of the Majority Staff, and Alicia Jackson is a AAAS Fellow. While some of you may choose to make contributions through government service, many others of you will make your mark on our future energy system through direct research and innovation. As Vannevar Bush, a former MIT Vice-President and a scientific advisor to Presidents Roosevelt and Truman said, “Without scientific progress, no amount of achievement in other directions can ensure our health, prosperity, and security as a nation in the modern world.”

The prospect for all of you to make a global difference is tremendous. Your enthusiasm and commitment to these issues are very encouraging. You have my pledge that I am committed to doing all that I can to ensure that you have the resources, support, and policies in place to achieve success.