S. HRG. 109–358

# PACE–ENERGY ACT

# HEARING

BEFORE THE

# COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

ON

## S. 2197

TO IMPROVE THE GLOBAL COMPETITIVENESS OF THE UNITED STATES IN SCIENCE AND ENERGY TECHNOLOGY, TO STRENGTHEN BASIC RESEARCH PROGRAMS AT THE DEPARTMENT OF ENERGY, AND TO PROVIDE SUPPORT FOR MATHEMATICS AND SCIENCE EDUCATION AT ALL LEVELS THROUGH THE RESOURCES AVAILABLE THROUGH THE DEPARTMENT OF ENERGY, INCLUDING AT THE NATIONAL LABORATORIES

FEBRUARY 15, 2006

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# PACE–ENERGY ACT

**WEDNESDAY, FEBRUARY 15, 2006**

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
*Washington, DC.*

The committee met, pursuant to notice, at 10:38 a.m. in room SD–366, Dirksen Senate Office Building, Hon. Pete V. Domenici, chairman, presiding.

## OPENING STATEMENT OF HON. PETE V. DOMENICI, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. The hearing will please come to order. Senators, I did not get a chance to do much other than to see this front page here, but I look forward to reading it and see how it compares with the Augustine Report. I do not know if you noticed. It says "Is America Flunking Science?" It apparently is an in-depth analysis of that question.

With that, let me say this is our first committee hearing on the PACE-Energy legislation. I am hopeful that February 15 at 22 minutes of 11 will be a date we can mark and look forward and say, starting on this day, this PACE legislation, Protecting America's Competitive Edge through Energy Act, also known hereafter as the "PACE-Energy Act," that it will be a formidable American effort to rise above the gathering storm, as the great group of Americans labeled the current state of affairs regarding math, science, engineering, research and technology innovation.

So in the report that I just alluded to, prepared at the request of Senators Bingaman and Alexander, that request concurred in by me and then put together by Norm Augustine on short notice, which now we are going to implement—we are hoping that the start of that this day and the end of it when we finish the bill and then when we fund it, that we can look back and say that, much like—and I borrow this from Senator Bingaman—much like Sputnik, it stirred an American awareness that we can do a lot better developing the brain power of American men and women in these fields that are so important to maintaining our material wealth and our national security and our lifestyles.

The report enumerates all of the items that make up the gathering storm. Anybody who wants to read them, they are there and they are innumerable. It focuses on some areas that people might have thought just were not really part of this, but that was basic education way down through the grade school and junior high and high school, wherein they have concluded that, while many young people are getting great, great starts, many, many are faltering ter-

ribly at the basic skills and brain power development during those days.

So they are even recommending—all of this is not coming to this committee, but some of it is—that we try to have a dramatic effect on how math and science is taught at the high school and grade school level. That is a rather terrific conclusion for a body of national science, of engineers and National Academy of Science people to say. They want us to go way down there and they want to be helpful.

We are going to try to do that. Part of our bill provides for harnessing this brain power by retooling our teachers using our national laboratories for that, and other items of interest are in this part of the bill. It does contemplate a large number of new math and science teachers being given scholarships and then given fellowships to supplement the pay so they will be excited enough to stay on the job. Those are interesting suggestions. They are in this bill, this part of the bill.

Present today are Senators who have had a terrific influence on this and pledge to continue.

Senator Bingaman, I will yield to you and thank you again for all you have done.

**STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO**

Senator BINGAMAN. Thank you very much, Mr. Chairman, for your leadership on this issue and for having this hearing so early in the legislative session. I think is very important. Thanks also particularly to Senator Alexander for all his leadership in getting us to this point.

This is a very useful hearing, I hope, in trying to allow us to better understand how we implement the recommendations of the National Commission. We put out some legislation, as you indicated, that tries to put in place a set of some structures and assigns to the Department of Energy, Office of Science, a lot of responsibility to do what is contemplated here. I look forward to hearing from Dr. Orbach as to his thoughts on the appropriate role of the Department of Energy and his office in this endeavor.

I also look forward to hearing from Dr. Vest and Dr. Proenza about their thoughts on this. Dr. Vest is particularly qualified because of having been part of this National Commission and part of the group that put the recommendations together.

The other issue that I hope we get a better understanding of is this recommendation to establish a DARPA-like entity within the Department of Energy, and whether that makes good sense. I know there has been some discussion that maybe something different should be established instead of that. We need to hear from the witnesses on that subject.

But again, thanks for having the hearing.

The CHAIRMAN. Thank you very much, Senator.

Before I move to the next witness, I do want to make sure the record reflects that—and I should have said it—the President of the United States in his State of the Union did address the issue. We are very thankful and grateful to him. Some of us went and talked to him and urged him. We were not the only ones. So you

will hear throughout these various hearings some of the notions expressed by the President regarding our competitiveness shortcomings and some of the ideas to do them, to accomplish them.

Some of the things we are going to do were not recommended, and I do not think it is that he would not agree. One of them is how many scholarships, new scholarships in math and science, should there be in this proposal. He left that to another approach. He is going to use other ways to fund it, Senator Allen, putting it in other current programs that are scholarships for college. But most of the thinking here, which will go to another committee for finalization, is this ought to be over and above that, ought to be a special kind of emphasis, much like Sputnik scholarships, so that you get momentum, but some of those things are not in.

But again, when you speak with the President, like I had the chance yesterday, he ties this very much into energy because the science and breakthroughs are also the technology of science and breakthroughs that are going to help energy. That is the emphasis on science.

So we need to find ways to pay for more than the President found in his budget and we are going to have to work hard on that together, and we are pledged to try to do that.

Now, according to my notes, the next Senator would be on our side. That would be Senators Allen, Alexander, Thomas, and Salazar.

Senator Allen.

## STATEMENT OF HON. GEORGE ALLEN, U.S. SENATOR FROM VIRGINIA

Senator ALLEN. Thank you, Mr. Chairman, and I thank our witnesses for being here. But I particularly want to applaud your leadership in holding this hearing on an issue that I think is so important for the future of this country.

We care about the security of our country. We care about its competitiveness and we care about preserving our values. When one thinks of some of the key issues and goals we need for our country, one is energy independence and the other is education. This fits into security. This fits into the issue of competitiveness. Particularly in our energy needs, I think there is a very good convergence here on why, for our energy security, we need to be the world capital of innovation.

The President and of course everyone on this committee, as we went through the energy policy measures last year, talked not only about development of more resources here in this country of oil and natural gas, but also ideas such as clean coal technology, advanced nuclear, biofuels, and other approaches. We need to understand that we are in competition with the rest of the world insofar as a lot of issues, but if we are going to be the world capital of innovation we need to do more.

One thing that Senator Wyden and I have worked on over the years is the National Nanotechnology Initiative. Nanotechnology is a multifaceted field that is going to affect everything from materials engineering to life sciences, health sciences, microelectronics, and energy. I was talking with Dr. Orbach before our hearing on how in the area, for example, of solar photovoltaics or solar power

that shingles can be made using nanotechnology, not having people look like they have got sliding glass doors on their roof, but architecturally pleasant shingles that, with nanotechnology, make solar photovoltaics much more effective, efficient and practical, as we try to diversify our energy policies.

I will note, Mr. Chairman, that the President's funding of the National Nanotechnology Initiative in this upcoming budget proposal, where this initiative is to have the Federal agencies work with colleges, universities, States and the private sector with Federal agencies. The Department of Energy is getting a big increase in that and I think that is going to pay off.

As far as the competition is concerned, we are in competition with India and China and other countries. China insofar as nanotechnology, particularly in the materials engineering, not only do they graduate eight times as many engineers and India graduates three or four times as many engineers, they are like the George Steinbrenner in nanotechnology and materials engineering. They will pay to get the best scientists in the world, particularly in these carbon nanotubes, which are the key ingredient, so to speak, in materials engineering and these lighter, stronger materials.

So we need to make sure that in this country we are enticing, incenting, and encouraging more young people to get interested in science and engineering and in technology. The others are graduating multiples more.

Then when you look at our engineers who are going to be the ones designing the inventions, the innovations, the intellectual property of the future, one-third to 40 percent of our engineering graduates are from another country, which is fine, I want America to be the magnet for the best minds in the world. But for places like India, those young kids talking to the India Institutes of Technology leaders, those young kids, by the time they are in middle school, they are focused on passing their end of high school exams, and they look at that as their ticket out of poverty.

Now, I grew up in sports, and that is fine. And people may want to get scholarships in baseball and football and basketball, and that is a one out of a million. But I guarantee you that you will have a much better paying job, make this country more competitive and more secure if you actually are in the fields of engineering or science or technology.

So what we need to do—and this is why I like this PACE Act and this hearing that we are having, is it is a step in the right direction. We need more investment. We need clearly more talent in this country, in that out of our engineers only about 15 percent are women, 6 percent are Latino, 6 percent are African American. So we need to entice all people in this country regardless of gender or race or ethnicity to get interested in these areas. Some of us have all worked together in those regards.

But in addition, we need to have the investment in that talent. I also believe that we need leadership. Working with Senator Alexander and you, Mr. Chairman, Senator Bingaman, and others, I aim to provide that leadership, because I think this is clearly one of the most vital areas for the future success, competitiveness, and ultimately our standard of life and our security in this country.

So thank you for this hearing. I look forward to the testimony of all these witnesses, who I think will help propel this issue into the future and not just talk, but we need action, and that action needs to be taken now. We need to be doubling the number of engineers in this country in the next 10 years. It is that urgent.

Thank you, Mr. Chairman, and I thank our witnesses.

The CHAIRMAN. I have just been thinking about the time here and I regret that I made a calculating mistake here. I will not be able to get these witnesses if Senators give opening remarks and then questions. So, Senator, you have been fortunate.

Senator ALLEN. Before you figured it out.

The CHAIRMAN. Once I figured it out, I did not want to stop you. So we are going to go now. Everybody will get their turn, Senators, but I am going to go to the witness. Your statements are now a part of the record. You will talk to us. We gave you an allotted time, if you would please try to use it. Tell us, in your capacity representing the administration, what you think about the bill and what you recommend. Please proceed.

**STATEMENT OF RAYMOND L. ORBACH, DIRECTOR, OFFICE OF SCIENCE, DEPARTMENT OF ENERGY**

Mr. ORBACH. Senator Domenici, Mr. Chairman, Ranking Member Bingaman, members of the committee, thank you for the opportunity to appear before you to discuss the Pace-Energy Act. As you noted, the President's American Competitiveness Initiative, unveiled in his State of the Union message, demonstrates his commitment to strong and continued U.S. competitiveness through a national effort in basic science research and education.

He said: "Our greatest advantage in the world has always been our educated, hard-working, ambitious people, and we are going to keep that edge."

The State of the Union message and the subsequent release of the President's fiscal year 2007 budget contained substantial increases for basic research in the physical sciences and that is part of that strategy. America's competitiveness, as you have already noted, is a result of the ingenuity of the American people and this native ingenuity can be nurtured and brought to fruition through the application of the President's American Competitiveness Initiative.

That the Office of Science has been entrusted with this responsibility is a wonderful statement of confidence in our ability to support the President's initiative. We are fully aware that the substantial increases in the Office of Science budget request for fiscal year 2007 makes us indebted to the President for his foresight in recognizing the vital importance of America's continued leadership in the physical sciences.

We are committed to holding up our end of the bargain by delivering truly transformational science and technologies, breakthrough advances that will provide new pathways to energy security and ensure America's continued global economic leadership in the years ahead.

If I can take Senator Allen's reference to sports, in tennis the dictum is you never change a winning game. For 50 years our country has benefited from the investment in science and technology and

given us the greatest economy in the world. We do not want to change that. We want to continue.

The Office of Science trains our next generation of scientists and engineers. Roughly half of the researchers at our facilities are university faculty or graduate or postdoctoral students. The Office of Science is the steward of government funding for the physical sciences in this country.

The administration welcomes the opportunity to discuss with you methods to accelerate progress in promising energy technologies, some of which may well require breakthroughs in basic science research. These important concerns were articulated clearly in the Augustine Report.

I wish to thank you again and the committee for the opportunity to be here and to testify, and I look forward to answering any questions you may have.

[The prepared statement of Mr. Orbach follows:]

PREPARED STATEMENT OF RAYMOND L. ORBACH, DIRECTOR OF THE OFFICE OF SCIENCE, DEPARTMENT OF ENERGY

Good morning, Chairman Domenici, Ranking Member Bingaman, and members of the Committee. I am pleased to appear before you to discuss S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006—also known as the PACE-Energy Act—which you introduced on January 26th.

The President's American Competitiveness Initiative (ACI), unveiled in his State of the Union message, demonstrates the President's strong commitment to continued U.S. competitiveness through a renewed national effort in basic scientific research and math education. To repeat the President's own words: "We must continue to lead the world in human talent and creativity. Our greatest advantage in the world has always been our educated, hardworking, ambitious people—and we're going to keep that edge. Tonight I announce an American Competitiveness Initiative, to encourage innovation throughout our economy, and to give our nation's children a firm grounding in math and science."

The State of the Union message, and the subsequent release of the President's FY 2007 budget that contains substantial increases for basic research in the physical sciences, are all part of the strategy. America's competitiveness is truly a result of the ingenuity of the American people. This native ingenuity can be nurtured and brought to fruition through the precise application of the President's ACI.

The FY 2007 budget includes a $505 million increase in DOE's Science programs, which is part of a commitment to double funding for certain high-leverage science agencies over the next ten years. The ACI recognizes that scientific discovery and understanding help drive economic strength and security. Developing revolutionary, science-driven technology is at the heart of the Department of Energy's mission. The increase proposed for the Department's Science programs reflects the significant contribution DOE and its world-class research facilities make to the Nation.

The President's ACI will encourage American innovation and bolster our ability to compete in the global economy through increased federal investment in critical areas of research, especially in the physical sciences and engineering, in large part through DOE's Office of Science. This initiative will generate scientific and technological advances for decades to come and will help ensure that future generations have an even brighter future. The Office of Science is educating and training our next generation of scientists and engineers. Roughly half of the researchers at Office of Science-run facilities are university faculty or graduate or postdoctoral students (who work side by side with scientists and researchers employed directly by the labs), and about a third of Office of Science research funds go to institutions of higher learning.

Finally, the Administration welcomes the opportunity to discuss with Congress methods to accelerate progress in promising energy technologies, some of which may well require breakthroughs in basic science research. These important concerns were articulated very clearly in the Augustine Report. The specific proposal for the creation of an ARPA-E is not in the President's budget, and we have concerns about the creation of this additional mechanism, the resources that would be required to fund it, and whether there might be alternative and better ways to accomplish its goals. However, we are ready to work with you to explore these questions.

The DOE's Office of Science is the steward of government funding for the physical sciences in this country. We operate 10 national laboratories, and a number of scientific facilities, that provide superb facilities for the Nation's scientists, allowing them to perform multi-disciplinary scientific research at the frontiers of discovery. Yet, it falls to us to inspire our young people with the possibilities of science, mathematics, and engineering at DOE facilities, if we are to maintain our edge.

I thank the Chair and the committee for this opportunity to testify and look forward to answering any questions you may have.

The CHAIRMAN. You had written testimony in addition to that, did you not?

Mr. ORBACH. Yes, sir.

The CHAIRMAN. We will ask you some questions about that.

Now we are going to go to the Senators in order. Senator Allen, you have finished.

Senator Alexander.

**STATEMENT OF HON. LAMAR ALEXANDER, U.S. SENATOR FROM TENNESSEE**

Senator ALEXANDER. Thanks, Mr. Chairman.

Thank you for being here, Mr. Orbach. We have all been looking forward to your appearance and I have several questions about the PACE Act and I will submit them to you so that you can answer them in writing, if you would do that, please. But first let me thank Chairman Domenici and Ranking Member Bingaman and the members of the committee for their leadership in this. The PACE Act that we are talking about now has 34 Republican sponsors and 31 Democratic sponsors—that is nearly two-thirds of the Senate—and 20 of the 22 members of this committee are co-sponsors of the act. So the ownership of this idea is all over the Senate and has been for several years.

But we owe a great debt of gratitude to Dr. Vest and the other members of the National Academy's panel for giving us what has turned out to be a consensus document, a document that comes from the National Academy of Sciences and the Institute of Medicine and the National Academy of Engineering, that answers the question, what does America need to do over the next 10 years to keep our advantage in science and technology.

We know that that is the foundation for keeping our—our effort to keep good jobs from going to China and India, to be able to fight the war on terror, to be able to innovate our way so that we can reduce the cost of health care. It is the foundation for our preeminence in the world and our high standard of living. So we are grateful to you for that.

We are grateful to the President and the administration for working with us since early last fall. Most people did not see the homework sessions that you attended and Senator Domenici presided over and others attended, which involved many members of the administration as we worked through the 20 recommendations of the Augustine Commission. So while only a few of the recommendations are in this committee, many of the others are in the HELP Committee, which I am a member of, and we will begin hearings later this month on the parts of the Augustine Commission report that are in K-12.

My hope is that through this committee and the HELP Committee and the Commerce Committee and the Finance Committee

that we will find a way to take all 20 of the recommendations to the floor of the Senate. Senator Domenici and other committee chairmen and the leadership are going to have to figure out how to do that. It is a little bit above my pay grade, but I think we are on a track to do that.

I would like to make one other preliminary comment and then ask you questions. We talk a lot about having a pro-growth agenda in the Senate. We especially talk about that on the Republican side of the aisle. It is not our term exclusively. And then we go directly to low taxes. In my experience as a Governor, low taxes are a part of a pro-growth agenda, but not the only part.

I believe an indispensable foundation for a pro-growth agenda for the United States of America is to maintain our advantage in science and technology and that the Augustine Report provides a specific answer to the question on how to do that. So we need to do it as a whole, all 20 parts, and that is why it is so significant that we have 65 Senators of both parties supporting it.

Now, let me begin with this question and then when my time expires I will submit the rest of the questions in writing. In this, in the PACE Act, although it was not in the Augustine Report, is a provision that Senators Domenici and Bingaman and I put in which would create up to 100 distinguished scientists with joint appointments at national laboratories, of which there are 17 in our country, I believe, and our major research universities.

It is based on a model that the Department of Energy began 20 years ago at the University of Tennessee and Oak Ridge National Laboratory, which in my opinion has proved very successful. Our idea is that the Federal Government will put up $1 million each year for an academy-level distinguished scientist and that the State and the university would then apply to you, to your Department, and they would compete for these, and set up these little centers of extraordinary excellence headed by a distinguished scientist. We might do 10 or 15 a year as long as it continued to attract outstanding people.

Now, that was not in the PACE report, but what would be your attitude about that proposal and its effectiveness as you have looked at the last 20-year model at the University of Tennessee and Oak Ridge National Laboratory? I might add, this is for the whole country; this is not just for the University of Tennessee and Oak Ridge National Lab?

Mr. ORBACH. I have to say that that model has worked extraordinarily well. Another feature of it was the introduction of specific fields both at the university and at Oak Ridge by picking individuals of exceptional caliber in areas of need. That led the way to major advances.

The administration has not yet taken a formal position, but I can say personally that bringing the very best people to our laboratories, giving them the opportunity to have the freedom to work on projects that are essential to our country, has been a proven vehicle for innovation and discovery.

Senator ALEXANDER. Thank you, Mr. Chairman. Mr. Chairman, may I submit questions in writing to Mr. Orbach and then ask him to provide answers? Senator Domenici is on a pretty fast track here and we would like to have your comments on our legislation so that

we can incorporate your ideas in addition to the suggestions you have already given us.

Thank you for your time.

The CHAIRMAN. I thank you for that, and I think that is correct and we would like you to do that.

Mr. ORBACH. I would be pleased.

The CHAIRMAN. I do not know whether you can right now figure out how long that would take, but could you advise us when you get back to your office with your staff how long before you could do what we are asking you?

Mr. ORBACH. Yes, we will work as quickly as possible.

The CHAIRMAN. I understand, but then could you give us a 2 weeks or 10 days, just for our own work? Just tell us what you think it is?

Mr. ORBACH. Yes, we will.

The CHAIRMAN. Thank you.

Now we are going to proceed. We are going to stay on this side a little bit longer because they were here for a long time, if you do not mind.

Senator Thomas.

**STATEMENT OF HON. CRAIG THOMAS, U.S. SENATOR FROM WYOMING**

Senator THOMAS. Thank you, Mr. Chairman.

The CHAIRMAN. Then we will go to you, Senator Salazar.

Senator THOMAS. I guess it is fairly apparent that we are all very much oriented and supportive of moving forward in this area. It is part, of course, with respect to energy what we did in our energy policy last year, and that is to say we have to be looking forward to what happens, and I certainly support that.

I must confess, however, that as we look at research, why, I get a little concerned about how are we going to make sure we orient this toward the needs that we have here? Research sort of becomes just sort of an academic function from time to time and goes on and on, as opposed to being oriented. So how would you suggest that we at least put priorities in some of this to actually accomplishing some of the things we need to do for our energy independence?

Mr. ORBACH. The PACE Acts actually are helpful in that regard in that they are focused on the energy needs of our country. There has been a groundswell of enthusiasm and interest on the part of both our researchers and our students in energy, exactly as you said, and I believe that we can attract the very best of our young people into this field by providing support, research support and opportunities for innovation and development leading toward energy security.

I think a targeted program of that sort will produce hopefully the breakthroughs that we need. We call them transformational opportunities for energy.

Senator THOMAS. What will be the basis for your targets?

Mr. ORBACH. We have chosen two primary areas in the Office of Science. One is biological, interestingly enough, what we call systems biology, to mimic what nature does, but do it synthetically in order to arrive at new energy sources, for example taking solar en-

ergy and producing fuels, mimicking in a way what happens in photosynthesis.

We also have a focus on solar energy. Solar is a huge resource which we use relatively inefficiently and the idea of not only electricity, but, as I just said, fuels, which brings together the physical and the biological sciences in an integrated fashion, to me and to our Secretary I believe are some of the most exciting opportunities.

Senator THOMAS. I am going to run out of time here shortly. I hope that we can have some direction because research can go on forever, and we have some needs here that has to be resolved. So how do you, or do you, intend to involve the industry, for example?

We have at least two areas here. One of them is out 50 years and that is one thing. Another is 5 years from now as to how we do some things differently than we are doing now. So I guess my question is how do we bring in specifically the needs of the industry to supply our needs into what you are doing.

Mr. ORBACH. It needs to be a staged operation. For example, I would say in the near term nuclear energy would be a great opportunity for the production of electricity, for example. The cellulose to ethanol that the President addressed specifically, we think we can do proof of principle, but it is going to take—it is a tough business—5 to 10 years before it is truly competitive. But if we do not start now, we will not arrive at that point.

Senator THOMAS. I understand. I just am urging that we have some sort of diversity in research so that we deal with more than one problem out there and that we bring the industry in a little bit and other people in to what the needs are, so that research just does not go on forever without pointing at some fairly specific objective.

Mr. ORBACH. My understanding is that industry is very keen to work with us and is looking for opportunities that come from research.

Senator THOMAS. The other thing, when you continue to talk about getting people into the industry, that is part of the function of the marketplace, is when there is more demand for those kinds of people there ought to be more movement in that direction. You do not have to go down to the third grade necessarily as much as you do to provide good opportunities for people to be able to see those opportunities in order to make things happen.

So I am a little reluctant to be totally into the academic here. We have some purposes that we have to really resolve. So thank you.

The CHAIRMAN. Are you finished?

Senator THOMAS. Yes, sir.

The CHAIRMAN. All right, we are going to go now to the other side. Senator Salazar. First might I say that we all are very pleased that you are such a participant. You do come to all our meetings and work on this and I am very proud to have you on the committee and I thank you for your effort. In particular yesterday when we met with the President, I thought your comments about your ideas were excellent and I wanted to share that with you.

**STATEMENT OF HON. KEN SALAZAR, U.S. SENATOR FROM COLORADO**

Senator SALAZAR. Thank you very much, Mr. Chairman.

Let me first say, Mr. Chairman and Ranking Member Bingaman and members of the committee, I think that the bipartisan approach that this committee took last year on the National Energy Policy Act is again reflected here in our support of the PACE Act. It is my fervent hope that we continue to work on a new chapter of national energy policy, and I think, with the President's leadership and the bipartisan leadership of this committee, that we can see a whole new chapter of energy policy for our country.

Let me also say that as we look at part of that energy policy I think all of us recognize that renewables are going to be a part of that and, with the President's visit to the National Renewable Energy Lab in Golden next week, it may be possible for some of you to participate in that event since we will be on recess.

Now to the PACE Act, let me just say I think the outpouring of support that we have seen for this legislation in the Senate I think speaks to the unity that we have with respect to the importance of this program and this legislation that we are considering.

My question to you, Dr. Orbach, has to do with the national labs and how the program would work with respect to the training of teachers in the math and sciences. That is a key component of the act. We have a shortage obviously of the training of teachers in math and science, and I am wondering whether you could respond to the opportunity of how we hook up our DOE labs to the training of teachers in our K-12 system.

Mr. ORBACH. This is something that we are committed to. Our national laboratories already do have summer institutes to bring K-12 teachers to the laboratories and their students, and we have pretty firm evidence that it has worked well on a modest scale. I think the opportunity to enhance the number of teachers that we bring—indeed, the fiscal year 2007 budget would triple the number of teachers that we bring to our laboratories, but it is still small. It is about 300.

The laboratories themselves have expressed significant interest. NREL for example that you made reference to is an example of a laboratory that works with K-12. We see that across the spectrum, and I think this is a resource really for our country to take advantage of. So I would support that part very strongly.

Senator SALAZAR. If you were to describe the funding that is being proposed in the President's budget for that component of the program, is it sufficient, insufficient? Do we have to do a lot more? At some point it seems to me that the 17 labs reach a capacity limitation in terms of what they can do relative to training, or maybe I am wrong on that assumption.

But what do you—if money was not a barrier, what is the capacity, if you will, of the DOE labs to provide this kind of training to math and science teachers across the country? Three hundred teachers is not very much, I will tell you, because if you look at the number of teachers that we have just in my little old State of Colorado, we have about 30,000 teachers. So we are not training very many teachers.

So I guess the question is what is the capacity?

Mr. ORBACH. I do not know if we know the answer to your question. I should say that these teachers who go through our programs have become the mentors of their colleagues in their districts. We follow up on the ones who went through the program and they stand out in their district. So there is a multiplier effect that occurs.

The budget that we submitted will, as I say, triple the number. I cannot answer your question in terms of how many we could in fact absorb. We are learning how to do it, but I think the opportunities in the laboratories are significant and I am very pleased to pursue that, just given the success that we have had.

We have had some quantitative estimates of the impact. At Thomas Jefferson Laboratory, for example, there is a program called BEAMS and this is primarily for schools with a very diverse student body and relatively low income students. We followed the students through the Virginia examinations in both science and mathematics for those who went through the program and then measured that performance against students who had not. They do better by almost a factor of two in mathematics.

So we think that these are proven programs and we have quantitative evidence of how well they have worked. So we are very supportive and, as I said, the President's budget will triple the number that we currently have.

Senator SALAZAR. I appreciate your leadership and we very much look forward to working with you, Dr. Orbach.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Senator.

All right. We will go to you, Senator Craig. I think you were first.

**STATEMENT OF HON. LARRY E. CRAIG, U.S. SENATOR FROM IDAHO**

Senator CRAIG. Thank you, Mr. Chairman. I will be very brief.

We are pleased to have you before us, doctor. I guess I will only make a brief statement. You can respond to it if you wish, but I am here to listen to, obviously, the other witnesses, and have been a bit of a student of the Augustine Report, find its value, and am extremely pleased that we are moving as aggressively as we are to shape this legislation. I want to thank the chairman, Senator Alexander, and others who have been up front on this.

My question to you is this. I look around the room today, there are a variety, a fair number of young people sitting in the back audience listening. What do we do to turn them on? We are a wealthy, comfortable society today. We bask in our wealth. We have phenomenal free time. We luxuriate in it. What turns on a young person to achieve as aggressively as we will need them to achieve in the future to be what we want to continue to be?

I say that for this simple fact. If a student graduating from any high school today entering a State university and becoming a freshman student in engineering cannot deal with university calculus upon entry but has to take a refresher course, only 15 percent of them will make it through and graduate as an engineer. But if they can start at university level and go on and not take the refresher course in calculus, 80 percent of them will graduate as engineers.

I know what we are attempting to do with PACE. I will support it and applaud it. But I as a very young person remember the beep, beep, beep of Sputnik and the panic our country went into because someone was in front of us, ahead of us, and beating us. In the early 60's we established the National Defense Education Act and we challenged young people to get with it, and boy, did they ever, and the rest is history.

I do not sense that emergency today. I sense an urgency. I believe we are in a national energy crisis that is sapping our economy and ultimately destroying the luxury and the wealth that these young people bask in today.

How do we turn our country on? Just by spending money or by a national movement, a cause, a deadline? You see, I do not think we ought to be just energy sufficient. I think it really ought to be a national goal that we are independent. Now, I am a wonk on energy and I will sit here and say, well, gee, Senator, you really cannot get there, you cannot do that. I mean, we can do this and we can do that, and we have got all these new technologies, but we really can never be independent.

Why not? Well, how do you define it? Less than or a lack of dependency, that is what independence is.

Well, that is a frustration I have, and I know we strive and we will spend billions of dollars getting there somehow. We are going to try. But I want to know what is going to make a young person study harder. I want to know what is going to challenge them to be better than they are today, what is going to make them prepare and be university-ready. Is it our educational system? Is it that we have not funded it well enough? Or is there a need for a national driver, a belief, an idea, a goal, a challenge, that somehow we just cannot quite get to yet because of our wealth and our sense of comfort today? I do not know and I am not sure that we get it here.

Mr. ORBACH. I am a child of the Sputnik generation.

Senator CRAIG. Likewise.

Mr. ORBACH. And I can tell you that the verve, the commitment of this country to catch up and surpass was what drove me and I suspect yourself as well. I believe that the energy crisis that we are in the middle of——

Senator CRAIG. Well, you just used the right word, "crisis." How many others are using that?

Mr. ORBACH. I think it is generally accepted it is a serious moment, and I think you outlined very beautifully the reasons why it is a crisis.

I believe that our young people are motivated and that if we can give them the opportunity to contribute they will. My own belief is that young people are excited by discovery and I want to make the discoveries here in the United States. So it is critical to me that our science is the best in the world and that we make the discoveries here with our graduate students and our undergraduate students and that kids in K-12 see it, sense the excitement, and join the movement.

It has happened before and I believe it will happen again.

Senator CRAIG. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Larry.

Senator Akaka.

## STATEMENT OF HON. DANIEL K. AKAKA, U.S. SENATOR FROM HAWAII

Senator AKAKA. Thank you very much, Mr. Chairman. I want to thank you and the ranking member for your leadership in energy across our country. I also want to thank my dear friend Senator Craig for his remarks because I feel that it is so important to our country, and also the remarks of my friend from Colorado.

I would like to put it in—what has happened since 2001. In 2001 the Hart-Rudman Commission did come out to say that there was a deep need for a workforce skilled in science, math, computer science, and engineering. That was in 2001, and what Larry Craig is talking about is what has happened since then. I would say that their note of the need in 2001 is the same need we have in 2006. What happened in 5 years?

So what is being expressed here is a deep concern that we have to move on this and, as Larry Craig was mentioning, we have to get to our young people, to inspire them to want to make a difference. That difference is being a global leader in energy in the world. The big question is can we do that? Do we have the skilled people that can do that? That is the question that we have to deal with today.

[The prepared statement of Senator Akaka follows:]

PREPARED STATEMENT OF HON. DANIEL K. AKAKA, U.S. SENATOR FROM HAWAII

Mr. Chairman, thank you for calling this hearing on S. 2197, the PACE-Energy Act. I am pleased that we are joined today by such a distinguished panel of experts to testify on this important initiative.

In 2001, the Hart-Rudman Commission said that America needs a workforce skilled in science, math, computer science, and engineering. They said that the failure to foster these skills was jeopardizing America's position as a global leader. The Commission also found that the maintenance of American power in the world depends upon the quality of U.S. government personnel. It requires employees with more expertise in more countries, regions, and issues. This includes a commitment to language education.

What has changed in five years? Very little. The Commission was right in 2001. The same Commission could reach the same conclusion in 2006. It pains me to say this because some of us in Congress have been trying to get action for years.

Four years ago, Senator Durbin and I joined forces with a bipartisan group of Senators to introduce legislation to strengthen national security by encouraging the development and expansion of programs to meet critical needs in science, math, and foreign languages at the elementary, secondary, and higher education levels. I also introduced legislation to strengthen education opportunities for federal employees in these critical areas, and improve the government's recruitment and retention of individuals possessing these skills. Last year, Senators Cochran, Dodd, and I introduced legislation to develop a national foreign language strategy. Right now, I am working with Senator Durbin to strengthen the Homeland Security Education Act from the 108th Congress, which we look forward to introducing shortly.

Some of these proposals have become law. Others were passed by the Senate, but the House refused to consider them. The Intelligence Reform Act of 2004 established two things promoted in our legislation. First, a rotation program to help mid-level federal employees in the Intelligence Community improve their skills. And second, a scholarship program for individuals who possess critical skills, especially those in science, math, and foreign language, in exchange for service with the federal government.

Still, America should rightly ask: why has it been so hard to make even these modest improvements? Especially when there have been numerous national studies and commissions that conclude we need to do better at educating Americans.

As many of my colleagues on this Committee know, I began my professional career as an educator. Fighting to ensure a prosperous future for our country and for

Hawaii's children is why I am in Congress today. That is one of many reasons that I signed on as a cosponsor to S. 2197. I believe that this bill is a timely proposal that can make a real difference, for both the short-and long-term, in the United States's global competitiveness in science and energy technology. By providing support for mathematics and science education at all levels through the resources available through the Department of Energy, including at the National Laboratories, I believe that this bill takes the important step of giving the next generation the tools they need to be successful in tomorrow's global economy.

Thank you Mr. Chairman. I have some concerns and questions that I will ask during the question and answer period.

Senator AKAKA. So Dr. Orbach, I want to tell you I am so happy to see you here this morning. You can in your position make a big difference in all of this, being Director of the Office of Science, and as you promote hydrogen, fusion, and other cutting edge energy initiatives. These are all important to our young people and our skilled workers in our country.

This is, as you mentioned, critical for America's competitiveness. I support the goals of the PACE bill.

I want to follow up on financing for these proposed education initiatives since I noted concerns in your testimony. If I understand correctly, three-tenths percent of the total Department of Energy appropriations would be set aside for a math, science, and engineering education fund. Second, there would be a revolving fund established in the Treasury Department that would help fund the Advanced Research Projects Authority for the Department of Energy, if I understand that.

I am interested in any comments you may have or additional thoughts you may have on these two provisions in particular about financing promising energy technologies and encouraging scientific education and teaching. I am asking for your comments and your thoughts. Thank you.

Mr. ORBACH. The administration has not yet thoroughly analyzed those parts of the bill and I will be pleased to respond for the record on the details of the questions you asked. With regard to the .3 percent, we also are looking within the Department of Energy at that particular issue. I should say that if you take the current expenditures on education directly from my office and the national laboratories, it actually exceeds that particular percentage. But we will get the details to you explicitly.

[The information referred to follows:]

The Energy Policy Act of 2005 already amended the Science Education Enhancement Act to include a provision for a "Science Education Enhancement Fund", composed of "not less than 0.3 percent of the amount made available to the Department for research, development, demonstration, and commercial application". The PACE-Energy Act would further amend the same section of the Science Education Enhancement Act to change the title of the fund to the "Mathematics, Science, and Engineering Fund", in the same amount as the Energy Policy Act provision.

The 0.3 percent set aside for the "Math, Science, and Engineering Education Fund" would amount to roughly $40 million dollars a year when applied against all research, development, demonstration, and commercial application funding within the Department. If you include all sources of funding for education, including direct funding by DOE as well as education programs funded by the national laboratories you will find that DOE funding exceeds the figure called for in the PACE-Energy and Energy Policy Acts.

Senator AKAKA. May I pose another question? I have previously spoken about the need to rely less on oil and natural resources—even the President has mentioned this—and look more toward the use of advanced technology to facilitate renewable energy re-

sources. The PACE-Energy bill includes a provision to establish the Advanced Research Projects Authority-Energy. This organization will be headed by a newly appointed director who will have authority to award competitive merit-based grants, cooperative agreements and contracts to public or private entities.

Given that this office will be charged with rapidly developing critical energy technologies, do you anticipate that the director would have any special acquisition authorities to expedite the research and development? And if so, will you ensure that the efforts of the ARPA-E office will not result in loosely managed resource projects that do not yield the desired results?

Mr. ORBACH. It would be premature for me to comment on that specific recommendation. Again, the administration is looking at it and would be pleased to respond for the record. The Energy Policy Act gives the Department additional tools for acquisition beyond the FAR in the Federal Government and therefore we have tools that I believe can address the issues that you raise. Certainly we would have every desire that that money be extraordinarily well spent.

[The information referred to follows:]

The Administration and the Department of Energy are in the process of evaluating the provisions of S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006—including the ARPA-E provisions. As our assessment proceeds, however we would be happy to discuss our views on ARPA-E or possible alternatives with you or your staff.

Senator AKAKA. Thank you very much for your response.

Thank you, Mr. Chairman. My time has expired.

The CHAIRMAN. Thank you.

Mr. Orbach, could I ask a couple of questions, please. I understand from your testimony that the Department has not yet formed an opinion on the proposal for an Advanced Research Program Authority.

Mr. ORBACH. Yes, sir, that is correct.

The CHAIRMAN. Is that correct? But I am pleased that you are open to discussing it, right?

Mr. ORBACH. Yes, we would be delighted to work with you on the definition of that and the primary reason for it, namely the rapid transmittal of true transformational technologies into the market, which I believe to be the driving force.

The CHAIRMAN. Yes. This year's budget represents an increase in the DOE Office of Science and that would be about a 14 percent increase over 2006. That would allow you to do what you can to increase your activities. From what you know, do you have a program capacity to handle that and spend it on valuable activities?

Mr. ORBACH. Mr. Chairman, first of all, we are blessed by the President's confidence in us. We believe we can spend those funds well for the purposes that you have so clearly articulated in your opening remarks. About half of that, that increase, would be used to operate our current facilities, to bring them up to as close to optimum as we can, and the other half is for research, to go into our universities and laboratories to fund research.

There is also in the core of the budget, we call it order of magnitude dominance, if I can use that phrase. We need to build the facilities for our scientists and students that are world leadership,

and we will be rolling out, as a consequence of the President's confidence in us and this budget increase, facilities that will dominate research for a decade at least and will give our scientists opportunities that no one else will have on a competitive basis, but it will be done here.

So we view this wonderful increase as an opportunity to, frankly, to show our stuff and show what we can deliver.

The CHAIRMAN. What is the acronym for the inflexible money that the Department of Energy uses through its laboratories?

Mr. ORBACH. It is called the alternate financing. I have forgotten the name.

The CHAIRMAN. LDRD.

Mr. ORBACH. Well, LDRD is a vehicle that all of our laboratories use to do very high-risk development and to, as you well know, move us into new areas of opportunity. I was actually referring to the acquisition——

The CHAIRMAN. I understand, but I am on another point. Now, you concur in the office you hold with the assessment by those who now are vested with that flexible money that that is a very exciting way to make—to apply resources so that you get real breakthroughs?

Mr. ORBACH. Absolutely, and it is quick and it is targeted. We review it as well. It has proven to be a major nourishment for innovation at our laboratories.

The CHAIRMAN. Now, I wonder—and I will ask the other two witnesses later. The report says we should continue that, but it also says that—and we are going to try in this legislation—that we should tell ever other major institution that funds science that they ought to have something like this LDRD. Call it something else, but 8 percent or 10 percent that is flexible, to be directed by the institution, as we are doing now.

I wonder what you would think if, in addition to that, we said that for the foreseeable future you have to direct as much of that as possible at energy technology, energy science and technology development. What would your thoughts be?

Mr. ORBACH. Well, I believe we are doing just that.

The CHAIRMAN. Well, you are, but what if we had everybody do it?

Mr. ORBACH. I can only speak, sir, for——

The CHAIRMAN. But you are a scientist and you know what is happening in the country. I am wondering, since we are kind of dancing around here wondering how much of this bill is for energy independence and how much of it is to develop our science base, and can there be a commonality, I am just wondering would you think it would be a good idea to apply it more broadly?

Mr. ORBACH. In answer to Senator Craig's question, I indicated that the young people of this country are really excited by opportunities, and the answer to your question, Mr. Chairman, I believe is yes. I think that you would find a resonance with young people and with senior researchers who would take advantage of these opportunities and really do some exciting things.

The CHAIRMAN. Thank you very much.

Senator Bingaman.

Senator BINGAMAN. Thank you very much.

Let me just understand. I believe I understood you correctly to say that in the budget proposal you are proposing to triple the number of teachers that you are able to train in summer institutes at the labs and you will be able to train under this new proposal 300, which means you are currently training 100?

Mr. ORBACH. That is correct, 108 to be precise.

Senator BINGAMAN. 108 nationwide?

Mr. ORBACH. Yes, sir.

Senator BINGAMAN. That hardly registers on the Richter scale compared to the size of the problem that we have to deal with here. I mean, I think it is a good thing to do. Obviously, I think it is a great opportunity for those 108 teachers and it will be for the 300 as well. But it is not a real solution to our problems of training science and math teachers for our public schools. Would you agree with that?

Mr. ORBACH. Well, I believe that it is a realistic estimate that we can make work in the President's fiscal year 2007 budget.

Senator BINGAMAN. I do not disagree with that and I compliment the President for asking for enough money to train 300. But I am just saying it is not a realistic solution to the magnitude of the problem. The magnitude of the problem requires a much, much greater effort than anything that we are discussing here, would you agree with that, or that is in your budget, I guess I should say?

Mr. ORBACH. The budget is a carefully crafted document. As the chairman indicated, it represents a 14 percent increase. It is our view that the balance that we have in the document is appropriate. The needs are indeed significant across our country, but I think that we know we can deliver on this.

Senator BINGAMAN. Let me tell you a sort of a gnawing concern I have got about us putting the additional responsibility that is called for in this act for math and science education in the Department of Energy. I have been here, most of my colleagues have been here, over a couple of decades now and we have watched the issue of science education, math education, in the Department of Energy sort of ebb and flow. I can remember when Admiral Watkins was our Secretary of Energy. He was committed to doing more through the Department of Energy to improve math and science education in the country and he spoke about it and he advocated for it and he was a great champion.

Some of the others who followed him have not had that same perspective. Not that they were anti-math and science, but just they did not see it as their primary job. It was someone else's job. We have a Department of Education and their view was that is their job, it is not our job.

Are we trying to put a square peg in a round hole here by saying, no, no, we are going to make this a significant mission of the Department of Energy? I mean, are we not running the risk that future secretaries, not Secretary Bodman but future secretaries, may or may not embrace this as a significant responsibility and may or may not have any real desire to do something here?

When you get into a period of constrained budgets, you have got to cut somewhere. This is a pretty good place to cut if you have got a lot of other responsibilities for the nuclear weapons program, for all sorts of other things. So how do you respond to that? Are we

trying to force-feed the Department of Energy to do stuff that the Department is not naturally designed to pursue?

Mr. ORBACH. Senator, I believe our Department is not only capable and eager to pursue it, but I think you have a constellation of stars that gives us in the next 3 years opportunities to really do something significant along the lines of Admiral Watkins. The President has made a personal commitment in the State of the Union. Secretary Bodman is a product of one of our finest universities and a faculty member at that university. He is committed to education. I believe that what we can do in the next 3 years is to lay such a successful initiative, using the resources of the Department to which you referred, that it will be self-sustaining. It is impossible to predict what will happen many years from now, but the need is here and I think the resources of the Department that you and your colleagues have correctly identified are opportunities for our country.

With the President's initiative and Secretary Bodman's support, I believe you will have a significant force for the future.

Senator BINGAMAN. Thank you very much.

The CHAIRMAN. Thank you, Senator Bingaman.

Senator Craig.

Senator CRAIG. Mr. Chairman, thank you very much.

I have no further questions, Doctor. We will look forward to working with you.

The CHAIRMAN. Doctor, we look forward to working with you and certainly we hope that personnel-wise that you are looking around to make sure that you have the capacity to get on with some of these things. I know you are going to change hats, but you are still going to be in the same area.

We note that in some of the projects that we put into the Energy Policy Act we said let us have loan guarantees for these projects and it turns out it takes an awful lot of time to go from the legislation to getting something. We are not on a slow path here. We cannot have you tell us in 8 months we will have three people hired to do this. You know what we are going to do. The President is going to get close to his and more. So we are urging that you push.

Thank you very much and we look forward to working with you.

Next panel, please.

Mr. ORBACH. Thank you.

The CHAIRMAN. Dr. Vest, president emeritus of MIT, you are a member of the commission that wrote the report, we thank you for your generous time. And Dr. Luis Proenza——

Mr. PROENZA. Yes, sir.

The CHAIRMAN [continuing]. President of the University of Akron, chairman of the Committee on Science and Math Education of the Secretary of Energy Advisory Board. We are very pleased to have you and we understand you have a special expertise related to what we are talking about as it pertains to the national laboratories, and that has been one of your areas of study. We found you and we are glad we did.

I want to just real quickly state five items. This bill doubles over 10 years the funding for the Office of Science in the Department. It improves the skills of 50,000 math and science teachers each year through summer institutes managed by the national labora-

tories. It creates opportunities for 50,000 math and science teachers to pursue master's degrees in teaching through programs hosted by the laboratories. It brings national scientists into the classrooms as teachers and mentors for tens of thousands of classroom hours and it creates an innovative new agency called ARPA-E, modeled after ARPA-E, and that is still in a state of development.

With that, each of you have testimony. It will be made a part of the record and then we will ask you, starting with you, Dr. Vest, to give us your oral testimony and then we will inquire.

**STATEMENT OF CHARLES M. VEST, PRESIDENT EMERITUS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

Mr. VEST. Thank you very much, Mr. Chairman, for the opportunity to be here today to discuss S. 2197, part of a comprehensive legislation package to help ensure America's future leadership and prosperity. Above all, our committee, the Augustine Committee, thanks all of you for your leadership in this regard.

The National Academies committee outlined a bold, comprehensive and strategic program for our Nation. We are pleased that so many of our recommendations are reflected in the PACE legislation and that the President's American Competitiveness Initiative is so consistent with them. America today leads the world in science and technology and is the most innovative nation on our planet. Our strong economy builds on two national assets: a firm base of science and technology; and a free market economy.

So why should we be worried about the future? Our committee believes we should be deeply worried because we have come to take our leadership and lifestyle for granted, and that can lead in only one direction, down. Our Nation must compete globally and simultaneously maintain our standard of living. This is a herculean task. It can only be achieved through concerted effort, the kind of concerted effort that can be driven by the PACE legislation.

What does competing in a knowledge-based economy require? Two things. First, that we educate a workforce and leadership that can create and perform the well-paying jobs of the future; and second, that knowledge from basic research move quickly and efficiently to markets with products, services, and jobs. That is indeed what we mean by the word "innovation." Our future economy, security, health, and quality of life require aggressive investment now in education and research and also improvement of the policy and tax environment that enable innovation and entrepreneurial activity to flourish.

I believe we must see globalization as an opportunity as well as a challenge. But leadership and economic strength are not birth rights. They must be earned every day. The recommendations of the Augustine Committee, the National Innovation Initiative, and other recent reports all point in the same direction.

The PACE Acts and the American Competitiveness Initiative address the urgent task of building a sound base for our future and that of our children and grandchildren. PACE is broadly consistent with the Augustine Committee's recommendations.

I also would like to state that I believe that it is fitting that much of this legislation has been spearheaded in the Energy and

Natural Resources Committee because energy, innovation, U.S. competitiveness are all intimately intertwined. I would cite four brief reasons for this.

First, supplying our Nation and indeed the world with safe, clean, affordable, secure, and sustainable energy is a prerequisite to prosperity.

Second, the Department of Energy is currently responsible for 40 percent of Federal investment in physical science, as well as about 14 percent of the Federal basic research investments in mathematics and computing, environmental sciences, and engineering.

Third, producing and distributing electricity, heat, and transportation while protecting our environment arguably is our most urgent challenge and it certainly is one, getting back to some of the things Senator Craig remarked upon, it certainly is one that can inspire, create, and draw upon a new generation of scientists, engineers, and innovators.

Fourth, if America grasps commanding leadership in clean and economical energy technologies there will be vast international markets for them. I am always astounded that that rarely makes it into the discussions of why we are so keen on these areas.

Permit me to make a blunt observation. In recent decades, many of our best minds were not attracted into energy science and technology. We in the universities allowed energy to slip into the academic backwaters. Neither our energy companies nor our national laboratories nor the entrepreneurial community applied enough intellectual and financial muscle to energy. We have grown complacent in the face of a monumental challenge.

I apologize for trampling on the toes of those few who have been dedicated to these issues, but on the whole I believe my observation is accurate. Today, however, the larger scientific and engineering communities are awakening to the challenge of our looming energy crisis. But concerted action and investment are necessary to enlist our most talented researchers and innovators.

One such investment, I believe and our committee believes, could be ARPA-E, and in discussion I would be happy to discuss my perspective with this on the committee.

Finally, I would like to briefly address the two arguments that have been directed by some against the recommendations of the Augustine Committee. First, some have stated that America's lead in science and engineering innovation is so great that there is no urgency for change. Our committee believes this proposition is both incorrect and dangerous. In my view there is a commanding urgency to these problems. Complacency is our enemy, not our refuge. I would refer you and your staffs to my written testimony, where I have fleshed this point out a little bit further.

Second, some critics have stated that there is no current shortage of engineers and scientists and therefore no reason to worry about increasing their numbers. Our committee believes that in a knowledge age we need more, not fewer, people who can generate and use new knowledge. We need more future engineers, scientists, mathematicians, and computer scientists because they will create new products, services, and new jobs. Jobs follow the investment in science, not the other way around.

Thank you very much for the opportunity to address PACE-Energy from the perspective of the National Academy's report, "Rising Above the Gathering Storm." I have further comments in my written testimony. It is a real privilege—and I sincerely mean that—a real privilege to work together to enable our Nation to prosper in the 21st century. Thank you.

[The prepared statement of Mr. Vest follows:]

PREPARED STATEMENT OF CHARLES M. VEST, PRESIDENT EMERITUS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, AND MEMBER, COMMITTEE ON PROSPERING IN THE GLOBAL ECONOMY OF THE 21ST CENTURY COMMITTEE ON SCIENCE, ENGINEERING, AND PUBLIC POLICY DIVISION ON POLICY AND GLOBAL AFFAIRS, NATIONAL ACADEMY OF SCIENCES, NATIONAL ACADEMY OF ENGINEERING, INSTITUTE OF MEDICINE

Chairman Domenici, Ranking Member Bingaman, Members of the Committee.

I am Charles Vest, former president of MIT. I was privileged to serve under Norman Augustine as a member of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine's committee on Prospering in the Global Economy of the 21st Century that produced the report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* I also am the past vice chair of the Council on Competitiveness that developed the National Innovation Initiative, and am a member of the President's Council of Advisors on Science and Technology. In 2003, I chaired the Secretary of Energy Advisory Board's Task Force on the Future of Science Programs at the Department of Energy.

INTRODUCTION

It is an honor to contribute to your discussion today of S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006, (the PACE-Energy Act) part of a comprehensive package of legislation you have introduced to help ensure continued American leadership and prosperity in the rapidly evolving global, knowledge-based economy of this new century.

Above all, on behalf of our committee, thank you for your leadership.

America today leads the world in science and technology, and I believe that we are the most innovative nation on the planet. Our economy, which is strong, builds on two great national assets—a strong base of science and technology and a free-market economy.

So why should we be worried about the future?

We must be deeply worried about the future, because we have come to take our leadership and lifestyle for granted, and continuing to do so will lead in only one direction—down. Our nation must not only innovate and compete globally, but we must do it in such a manner that we can maintain our American standard of living. This is a Herculean task that will not be achieved without a concerted effort—the kind of concerted effort that can be driven by the PACE legislation.

What does competing in a knowledge-based economy require? It requires that we educate a workforce and leadership that can *create* and *perform* the well-paying jobs of the future. It requires that new knowledge be continually generated and moved into the marketplace fast and effectively. This is what we mean by innovation. The knowledge that is required to produce new products, services, and jobs will in large measure be technical, spawned by basic research in science, mathematics and engineering.

Our future economy, security, health, and quality of life depend upon our aggressiveness in investing now in American education and research, and in maintaining and enhancing a policy and tax environment that will allow innovation and entrepreneurial activity to flourish in American and in our industries' operations throughout the world. We must see globalization as an opportunity as well as a challenge. But our leadership and economic strength are not a birthright. We must earn them day in and day out. The recommendations of the Augustine Committee, the National Innovation Initiative, and indeed several other recent reports, including those by the President's Council of Advisors on Science and Technology and the Secretary of Energy Advisory Board, all point in the same direction. The PACE bills and the American Competitiveness Initiative begin the urgent task of building a sound base for our future and that of our children and grandchildren.

The National Academies' recommendations outlined a bold, comprehensive and strategic program for the nation. Our committee is pleased that so many of our recommendations are reflected in the PACE legislation and that the President's Amer-

ican Competitiveness Initiative is so consistent with them. We further hope that our analysis of the issues facing the country, which draws upon and consolidates the work of many other dedicated groups, is helpful to you and you colleagues.

The PACE legislation package is harmonious with our recommendations for educating a new workforce and leadership in science and engineering. This critical challenge spans from K-12 through doctoral and post-doctoral education. We are particularly pleased that the PACE Acts include major programs across agencies to provide scholarships for students who study science, engineering, or mathematics and concurrently earn certification and commit to teaching. We believe that the bills' programs to strengthen skills of teachers through masters programs, workshops, and training for effective Advance Placement and International Baccalaureate instruction are excellent. I will not dwell on the bulk of these programs, because they are contained in

S. 2198 the PACE-Education Act, which will be the object of a subsequent hearing. However, I will note that our committee's primary hope is that such programs will be put in place quickly and effectively.

In my view it is especially appropriate that the legislative effort to protect America's competitive edge be spearheaded in the Energy and Natural Resources Committee because energy, innovation, and U.S. competitiveness are intimately intertwined. The following are among the reasons this is true:

1. Supplying this nation, and indeed the world, with safe, clean, affordable, secure, and sustainable energy is a prerequisite for prosperity, and is in large measure a technological challenge.
2. The Department of Energy currently is responsible for 40 percent of the federal investment in physical science as well as 14 percent of the federal basic research investments in mathematics and computing, environmental sciences, and engineering.
3. Producing and distributing electricity, heat, and transportation while protecting our environment is arguably our most urgent challenge, and it certainly is the one to inspire, create, and draw upon a new generation of scientists, engineers, and innovators.
4. If America grasps commanding leadership in new, clean and economical energy technologies, there will be vast new markets for our energy technology industries in the rapidly developing areas of the world such as China and India.

EDUCATION AND TEACHER ENHANCEMENT

PACE-Energy (S. 2197) authorizes three specific roles for the department of Energy associated with improving STEM education in primary and secondary schools, and with inspiring and assisting young men and women to pursue college education in science and engineering.

The first is the establishment of Summer Institutes at the DOE national laboratories to provide teacher training. They would emphasize K-8 education and would be of at least two weeks duration. This is certainly the type of program that we recommended in *Rising Above the Gathering Storm*. The DOE lab facilities and their scientists and engineers certainly could create inspirational and useful programs for K-8 teachers.

The second authorizes DOE National Labs to provide assistance and support to STEM specialty schools and that each Lab establish a Center of Excellence at one public school in its geographic vicinity. This is precisely the kind of action that our committee encouraged.

Third, PACE-Energy provides for the establishment of an internship program at the National Labs, with a $50 million annual budget beginning in FY2007. Our committee believes that such inquiry-based learning can be very effective in inspiring and educating middle school and high-school students. The Labs are a natural venue for such programs.

I personally believe that through these three activities, the DOE can and should play an effective role in improving aspects of STEM education in our nation. I would recommend that as such programs are implemented, as I hope they will be, the Department will establish coherence of purpose and execution across the participating laboratories, and identify and promulgate best practices.

RESEARCH

Federal support for basic research in the physical sciences and engineering has been essentially flat in real dollars for more than thirty years. During that time, the budgets for biomedical research have appropriately grown approximately four-fold. That four-fold investment will pay immense benefits to improved health as well as basic understanding of living systems. It has already done so, and also has stimu-

lated an entire new industry of biotechnology. The levels of discovery and innovation in life science and medicine are astounding. Today there are nearly 100 biotech companies in Cambridge, Massachusetts, where I live. They are a direct result of the farsighted federal investment in biomedical research and education, as are the many pharmaceutical research facilities that have located there.

But the nation faces other challenges including, first and foremost, energy and environment, but also the creation of new services, technologies, and manufacturing techniques that will enable us to be secure and economically vibrant in a world of knowledge-based economies and globalized production and markets. The Augustine Committee has concluded that meeting these challenges requires a substantially increased and sustained federal investment in long-term, basic research in the physical sciences, engineering, mathematics, and computer science. Specifically, we recommended that these budgets be doubled over a period of seven years.

We therefore are very pleased that S. 2197 authorizes such a doubling of the budget of the DOE Office of Science by increasing it by 10 percent annually through 2013. We are confident that such an investment can pay dividends of extraordinary importance to the nation.

In our deliberations, we concluded that it would be wise to create 200 early career research grants of $500,000 each annually, payable over five years. It frequently takes far too long for our bright young men and women to establish appropriately independent research programs. This is very inefficient, because it drains their time and attention away from the actual conduct of research and teaching during what often are their most creative years. S. 2197 authorizes 65 such early career grants per year for five years to be administered by DOE, and S. 2198 directs similar programs in several other agencies. We applaud this.

ARPA-E

S. 2197 establishes the Advanced Research Projects Authority—Energy (ARPA-E). This is a direct reflection of a recommendation made by the Augustine Committee. ARPA-E is the only major new organization recommended by our committee, so I would like to explain our intent.

We intend ARPA-E to provide a new field of opportunity to the Department of Energy as it works in new and reinvigorated ways to develop new technologies to supply this nation, and indeed the world, with safe, clean, affordable, secure, and sustainable energy. We simply must supply and utilize energy and transportation in new ways that will not degrade our environment. If we do not do this, there will be no future prosperity. We must derive new knowledge and technology from basic science and engineering research and reduce them to practice, and we must start now.

I wish to make a blunt statement that is based on my experience as an educator and an observer of the science and engineering communities. On the whole, in recent decades, many of our best minds were not attracted into the science and technology of energy. We in universities allowed energy to slip into academic backwaters, and neither our energy companies, nor our national laboratories, nor the entrepreneurial community have applied enough intellectual and financial muscle to it. We have grown complacent in the face of a monumental challenge. Of course there are counter examples, and I apologize if I am trampling on the toes of those few who have indeed dedicated their careers to these issues, but on the whole, I believe my characterization is accurate.

Today, however, the larger scientific and engineering communities are awakening to challenge of our looming energy crisis. But we must take concerted action and make the investments necessary to enlist our most talented researchers and innovators to address it. Our committee, therefore, conceived ARPA-E as an organization reporting to the DOE Under Secretary for Science that can achieve four objectives:

1. Bring a freshness, excitement, and sense of mission to energy research that will attract many of our best and brightest minds—those of experienced scientists and engineers, and, especially, those of students and young researchers, including those in the entrepreneurial world.
2. Focus on creative, out-of-the-box, potentially transformational research that industry cannot or will not support.
3. Utilize an ARPA-like organization that is flat, nimble, and sparse, yet capable of setting goals and making decisions that will allow it to sustain for long periods of time those projects whose promise is real, and to phase out programs that do not prove to be productive or as promising as anticipated.
4. Create a new tool to bridge the troubling gaps between basic energy research, development, and industrial innovation. It can serve as a model for how

to improve science and technology transfer in other areas that are essential to our future prosperity.

Our committee did not believe it appropriate for us to specify the organization and mission of ARPA-E in great detail. We believe that must be worked out by the Secretary of Energy and the Under Secretary for Science in rapid, but intense, consultation with experts from the scientific and engineering communities. Defense visionaries who realized that the military had to reach out to new communities for the technologies that would be required to counter the rapidly changing threats of the post Sputnik era established the original ARPA in the DOD. It was enormously successful. We believe that ARPA will provide the right general framework on which to design ARPA-E. It is a proven model.

CLOSING COMMENTS

I would like to briefly address two arguments that have been directed by some against the recommendations of the Augustine Committee.

First, some have stated that America's current lead in science, engineering, and innovation is so great that there is no urgency to addressing these matters. Our committee believes that this proposition is both incorrect and dangerous.

We are indeed on the pinnacle of science and technology R&D, but almost every trend is moving in the wrong direction. In just the last few years the U.S. has become a net importer of high-technology products, has invested more new money in foreign stock funds than in domestic portfolios, has seen its share of leading-edge semiconductor manufacturing cut in half, has dropped to 12th in the world in the number of broadband connections per 100 inhabitants, has dropped from number 1 to number 5 in Internet use and infrastructure, has had basically flat investment in physical science and engineering research, has less than one third of its 4th and 8th grade students performing proficiently in mathematics, has its 15-year olds ranking 24th out of 40 countries in assessments of applying mathematical principles to practical problems, has two thirds of its children learning science and mathematics from teachers who neither majored nor were certified in the subjects, and has only 15 percent of its university students studying natural science or engineering versus 38 percent in South Korea and 50 percent in China.

In my view there is a commanding urgency to these problems. Complacency is our enemy, not our refuge.

Second, some critics have stated that there is no current shortage of engineers and scientists, so there no reason to increase their numbers. Our committee believes that in a knowledge age we need more, not fewer, people who can generate and use new knowledge.

The need for more future engineers, scientists, mathematicians, and computer scientists is because these men and women will be the innovators who create new products, services, and jobs. Innovation is the key to productivity, which in turn is the key to a strong economy. Supplying and distributing energy, feeding the planet, building new industries around bio-based materials, continuing trends toward sophisticated service-based economies, keeping us secure, advancing medicine, developing new ways of learning, and responding to pandemics all require a technically competent workforce and scientifically astute leaders in business and government. Even today, over half of the CEOs of Fortune 500 companies have engineering backgrounds, and engineers and scientists dominantly create the newer entrepreneurial companies. The financial services industry is based on mathematics and information technology. Shipping companies and even retail businesses find the profit margins necessary for survival only through application of complex logistical science.

The argument that we have plenty of engineers and scientists is based on looking in the rearview mirror. The more people with sound engineering and scientific knowledge, the more connections among them, and the stronger the knowledge generation of long-term basic research to nourish them, the better will be our chances of prospering in the 21st century.

Chairman Domenici, Ranking Member Bingaman, and Members of the Committee, thank you for the opportunity to address PACE-Energy from the perspective of the National Academies report *Rising Above the Gathering Storm.* It is a privilege to work together to enable our nation to prosper in the 21st century.

I would be glad to respond to any questions.

The CHAIRMAN. Thank you very much.

Doctor.

**STATEMENT OF LUIS M. PROENZA, PRESIDENT, UNIVERSITY OF AKRON**

Mr. PROENZA. Mr. Chairman, Ranking Member Bingaman, members of the committee, thank you for your invitation and I echo Dr. Vest's thank-you to the committee for your leadership in considering the vitally important matters embodied in this legislation. I am here today indeed in my role as chairman of the Science and Mathematics Education Task Force, a subcommittee of the Secretary of Energy Advisory Board, because the work of our task force is not yet complete. I hope you will consider my remarks as my own, but I assure you that my comments reflect the discussions that we have had, and we will certainly be sharing the full report of the committee as soon as it is completed.

Much of what we have learned about competitiveness and innovation in recent years certainly speaks to the value of leveraging resources and to ensuring that the various components of our national innovation ecosystem are optimally linked, coordinated, and enhanced, a theme that runs through the PACE legislation. I am pleased that you have asked me to address specifically how we might leverage Department of Energy resources. That is precisely what our task force has been addressing.

The national laboratories, as you have indicated, represent exceptional scientific and engineering facilities and talent, 17 geographically distributed laboratories of unparalleled strength and importance, particularly in the physical sciences. Such major resources are assets that can and should be leveraged to help strengthen STEM education and leveraging is imperative because the labs must balance between their obvious and synergistic capacity to support STEM education and their need to maintain a mission focus. This means we cannot leverage simply by increasing access. We must create leverage by multiplying the impact of those who come to the labs, particularly teachers.

As a geographically distributed network of resources, the labs already have demonstrated the capacity to provide teachers with authentic experiences in the scientific enterprise, thereby transforming science teachers into teaching scientists. The challenge is to leverage these unique resources, the laboratories, as forcefully as possible through an intensive set of research experiences that yield teaching scientists capable of engaging students in STEM disciplines.

We have found programs throughout the laboratory systems that do this, programs that lead to genuine transformations in teachers' knowledge and enthusiasm for science. Moreover, our findings suggest that it will be during the adolescent years when students present the most significant needs as well as opportunities, and that is where we would focus the leveraging opportunity.

Leverage is not only essential in this context of the labs' mission, but also provides a useful metaphor. The leveraging force is that of our national laboratories. The fulcrum point at which this leverage is exerted is the professional development of teaching scientists through intensive transformative laboratory research experience, and in turn the effect is multiplied upon the millions of students in our Nation's middle schools, that critical stage during which students develop and sustain interest in science and mathematics and

when teaching scientists thus can have the greatest impact—precisely the same idea behind the "Gathering Storm" report, but adding to it the power of the national laboratories.

We also looked in some detail at the considerable variety of STEM education programs across most of the 13 Federal agencies that support science and engineering research, and we are pleased to note in your legislation that you have certainly recognized the important coordinating role that is necessary to be accomplished.

Finally, the leveraging opportunities associated with the national laboratories do extend beyond their ability to transform teachers. The labs also are home to some of our Nation's most advanced computational resources, which are capable of creating powerful simulation environments. Computational tools have become essential to research, made it easier to bring concepts to the marketplace quickly, and greatly increased productivity in both manufacturing and service industries throughout the economy. In short, these tools are key ingredients in American competitiveness.

But it is important to note that the emphasis of these tools also could be to increase the productivity of the process of education itself by making concepts in science and mathematics more compelling and more accessible for a wide range of students. These powerful simulation capabilities thus hold another leveraging opportunity for the Department of Energy, namely that of creating the sort of exciting and captivating interactive features that make possible the delivery of exploration and discovery-based learning tools.

Now STEM stimulation tools can be created at a price that becomes affordable to the large number of students and teachers who cannot otherwise participate directly in experiences of the laboratories and, moreover, engaging simulations can connect what would otherwise be abstract concepts in the physical sciences, engineering, and mathematics to simulations of real world applications.

Capturing this potential is the subject of another piece of legislation that I hope you will pay some attention to, S. 1023, the Digital Opportunity Investment Trust, and more is noted in my written testimony. But in short, it is the opportunity, Mr. Chairman and members of the committee, to support research to create innovation in the process of education itself and a careful assessment of what works and what does not work by leveraging the resources of the Department of Energy. Quite simply, we must enhance the effectiveness and productivity of our systems of education and training.

In summary, Mr. Chairman, the work of our task force undoubtedly supports the PACE legislation and we look forward to sharing a copy of our final report. Thank you for your attention and thank you for the able leadership that you are providing in this vitally important area. Thank you.

[The prepared statement of Mr. Proenza follows:]

PREPARED STATEMENT OF DR. LUIS M. PROENZA, PRESIDENT, UNIVERSITY OF AKRON

Mr. Chairman, Members of the Committee, thank you for your invitation to provide testimony in support of this vitally important legislation.

I am Luis Proenza, President of The University of Akron. I also am privileged to serve on the President's Council of Advisors on Science and Technology (PCAST) and on the executive committee of the Council on Competitiveness—bodies that have made recommendations that are directly relevant to the matters under your consideration. Many of you already are familiar with these recommendations, which are reflected in the President's American Competitiveness Initiative and incor-

porated in other pending legislation, such as the Ensign—Lieberman National Innovation Act of 2005.

I expect you have asked me here today because of my role as chairman of the Science and Mathematics Education Task Force (SMETF), which is a subcommittee of the Secretary of Energy Advisory Board (SEAB). However, in the spirit of full disclosure, I must tell you that, because the work of our task force is still in progress, the remarks I will make today must be treated strictly as my own. My comments will naturally reflect much of the work we have done to date and, of course, we will be pleased to share the final report with this committee as soon as it is completed. From my review of the PACE language, I might add that the work of SMETF appears to be most closely related to sections 3171, 3175, 3181 and 3195 of PACE-Energy and sections 161, 211 and 231 of PACE-Education.

Although the national laboratories conduct a substantial proportion of the nation's basic research in the physical sciences and engineering, as well as a healthy mix of other basic and applied sciences (e.g., biological and environmental sciences), the Department of Energy's role in the scientific leadership of the nation is generally underappreciated. To carry out its mission, DOE requires substantial manpower resources, which is one reason why the Department's involvement in the education pipeline must be understood better, supported adequately and leveraged. I am pleased that DOE's vital role in STEM education was given a clear legislative mandate in section 1102 of the recently passed Energy Policy Act of 2005 and that the Department's Office of Science, under Assistant Secretary Ray Orbach, was tasked to begin implementation of this section. I also note that former Secretary Abrams, who appointed SMETF, and Secretary Bodman, have expressed strong interest in ensuring the Department's participation in enhancing our nation's STEM education.

Much of what we have learned about competitiveness and innovation in recent years certainly speaks to the value of leveraging resources and to ensuring that the various components of our national innovation ecosystem are optimally linked, coordinated and enhanced. Thus, I am pleased that you have asked me to specifically focus on how we "would leverage Department of Energy resources, including personnel and equipment at the National Laboratories, to improve mathematics, science, and engineering education at all levels". That is precisely the task that SMETF has had under review during the last 14 months.

The National Laboratories represent exceptional scientific and engineering facilities and talent—17 geographically distributed laboratories of unparalleled strength and importance, particularly for the physical sciences and engineering, but also for a substantial mix of other basic and applied sciences (e.g., biological and environmental sciences). Such major resources are assets that can and should be accessed in support of strengthening STEM education. Leveraging is imperative because the labs must balance between their obvious and synergistic capacity to support STEM education and their need to maintain their mission focus. And this means we cannot leverage by simply increasing access. Rather, we must create leverage by multiplying the impact of those who come to the labs—by enhancing the capacity of STEM teachers to impact thousands upon thousands of students. By supporting the professional development of teachers, the labs can, as they have for many years, substantially enhance the educational competencies of teachers in science, mathematics, engineering, and technology. These professional development experiences enable teachers. to become conveyors of STEM expertise. And, having selected teachers as the means for exerting leverage, we also should determine where such teachers can have the most impact. Ample evidence suggests that the greatest impact that teachers can have is on middle school students, because that is the time when student performance and interest begins to drop and when students become especially vulnerable to the lack of strong educational experiences.

The DOE laboratories are a geographically distributed network of resources with great potential to provide teachers with authentic experiences in the scientific enterprise—thereby transforming science teachers into *teaching scientists.* The challenge is to leverage these unique resources—the national laboratories—as forcefully as possible through an intensive set of research experiences that yield teaching scientists capable of engaging students in STEM disciplines. We have found excellent STEM educational programs throughout the laboratory system, programs that lead to genuine transformations in teachers' knowledge and enthusiasm for science. Moreover, our findings suggest that it is during adolescence when students present the most significant needs as well as opportunities. *Thus, we will likely suggest the creation of a Teaching Scientist Professional Development Program that reaches cohorts of middle school teachers drawn from the geographical areas served by each laboratory—a hub-and-spoke strategy.* The basic design elements build on DOE's current Laboratory Science Teacher Professional Development Program (LSTPD) and entail intensive four- to eight-week summer internships spanning three years

for each cohort. The plan also would call for Department-wide coordination of essential program features already in use, while also making appropriate allowances for local adaptations suitable to each laboratory. Continuous formative assessments and formal evaluations, drawn from the LSTPD experience, would guide further refinement of the program and provide ongoing evidence of effectiveness.

Leverage is not only essential in the context of the labs' mission, but also provides a useful metaphor. The leveraging force is that of our national laboratories. The fulcrum point at which this leverage is exerted is the professional development of "teaching scientists" through intensive, transformative laboratory research experience. In turn, the effect is multiplied upon the millions of students in our nation's middle schools, the critical stage during which students develop and sustain interest in science and mathematics, and when "teaching scientists" thus can have the greatest impact.

Across many, if not all, of our federal agencies there are other important STEM education initiatives. During the work of the task force, we requested and received several presentations, which revealed considerable variety of STEM educational programs across agencies. Among them, we saw spectacular examples of curriculum development, but not every agency or organization is well placed to take on the task of curriculum development. Nor are many school systems or individual teachers prepared to optimally integrate these materials into the classroom. We also saw opportunities for new endeavors that would be useful in their own right, while also supporting coordination. For example, the National Science Education Resources Center at the Smithsonian is in the early stages of developing a Web site of resources for STEM education, which might be the basis for more substantive interagency efforts. Finally, while many STEM education resources are readily accessible through the Internet, it is less clear that these are having measurable impact on the condition of STEM education in America.

My colleagues and I have discussed the leadership role that is needed among federal agencies in leveraging major scientific and engineering resources, such as the national laboratories, for STEM education and we believe that DOE is well poised in this regard. *The Department of Energy can and should take on a leadership role in the development of educational efforts in cooperation with other agencies. In addition, DOE should encourage STEM education partnerships among agencies, businesses, universities, and national organizations.* Of course, DOE's ability to assume this role clearly depends on interagency discussions and the development of shared resources, both virtual and programmatic.

The leveraging opportunities associated with the national laboratories extend beyond their ability to bring teachers or students into contact with individual scientists or research programs at each of the 17 facilities. The laboratories, for example, also are home to some of our nation's most advanced computational resources, which are capable of creating powerful simulation environments. These tools are key ingredients in American competitiveness. Computational tools have become essential to research, made it easier to bring concepts to the marketplace quickly, and greatly increased productivity in both manufacturing and service industries throughout the economy. In work we have done through the Council on Competitiveness' High-Performance Computing Initiative, I personally have seen how some of these facilities, such as those at the Sandia National Laboratory, can assist industry in performing complex simulations to support improved manufacturing competitiveness.

These tools can also increase the productivity of the process of education and make concepts in science and mathematics more compelling and more accessible for a wide range of students. All of us are now familiar with how movie animation and video games have created compelling experiences built around simulated landscapes, cities and complex processes brought to life through high-performance computing. Modern personal computers and video game consoles now deliver computing power comparable to that of devices called supercomputers just a few years ago.

These powerful simulation capabilities, thus, hold another leveraging opportunity for DOE—namely, that of creating the sort of exciting and captivating interactive features that make possible the delivery of exploration and discovery-based learning tools long recommended by educational scientists. For example, agencies such as NASA and NOAA have taught students about space or deep ocean exploration through their Challenger and Jason programs. Now, STEM simulation tools can be created at a price that becomes affordable to the large number of students and teachers who cannot otherwise participate directly in experiences at the laboratories. Engaging simulations can connect what would otherwise be abstract concepts in the physical sciences, engineering and mathematics to simulations of real-world applications. DOE is in an excellent position to facilitate this by leveraging its subject matter expertise and strong record in computation. Even with comparatively

simple instructional simulation tools, it should be possible to demonstrate a 30% reduction in learning time.

Tools that can increase the productivity of our educational system and tailor learning to the unique interests and needs of a diverse student body are essential if America is to produce the talent needed to ensure American competitiveness. But capturing the potential of simulations and other information technologies will require significant and sustained investment in research, demonstration and evaluation of such tools. A strategy for achieving this is contained in another piece of pending legislation: S. 1023, the Digital Opportunity Investment Trust (DO IT). Although the PACE legislation you are considering proposes much-needed strategic advancements in STEM education and support for the physical sciences, those investments—in my judgment—would be greatly enhanced if we find a way to fill a large hole in our national research portfolio, namely in the support of research into innovation in the process of education itself and a careful assessment of what works and what doesn't work. That is the purpose of S. 1023, DO IT.

During the course of our work, SMETF heard of how little of what has been shown to work is actually in practice and how much of what is being done is lacking in assessment of its effectiveness. As a nation, we currently do not support much in the way of research into educational and training effectiveness, and yet we are now in a global labor market that puts a premium on information-technology-based jobs where our systems of education and training must be the bedrock, the very infrastructure, of our economic competitiveness. The fact that modern computers offer the potential to implement sophisticated approaches to instruction in STEM has both changed the rules and raised the penalty for inaction.

Quite simply, we must enhance the effectiveness and productivity of our systems of education and training and ensure that they can benefit from the same revolutionary broadband technologies that have transformed our communications, defense, commercial and entertainment sectors. To achieve this, I urge your serious consideration and support of the Digital Opportunity Investment Trust (DO IT) as an integral part of the PACE Act's strategy for strengthening American innovation.

As a member of the Digital Promise Coalition's Leadership Council, I have supported the DO IT legislation, S.1023 introduced by Senators Dodd, Snowe, Durbin and Burns. That legislation was based on a comprehensive research and development learning roadmap that was submitted to Congress two years ago. DO IT would be a form of venture capital fund to support the research necessary to create new teaching and learning tools using advanced technologies such as highly interactive virtual reality, simulation, embedded intelligence and one-on-one tutoring. It is time to harness the power of these tools for teaching and learning, especially in abstract areas of mathematics and science. We know that an integrated use of advanced technologies can make learning faster, more efficient, and allow a higher proportion of students to reach greater levels of competence. Our competitor nations are already far ahead of us in this area of research and in digitizing high-quality educational content for new educational technology applications. I feel strongly that no national strategy for reinvigorating our systems of research and innovation would be complete without something like the DO IT component.

In summary, Mr. Chairman, the work of SMETF will undoubtedly support the PACE legislation and we look forward to sharing a copy of our final report.

In closing, allow me to acknowledge my colleagues in SMETF. In particular, I want to thank Dr. Robert Calfee, vice chair of the task force, for his dedicated and insightful comments as well as for his many substantive contributions. We are most grateful for all the dedicated and talented staff in DOE and other agencies that took time to inform us of all the ongoing educational activities within the agencies and had the patience to answer our many questions and help us to understand the feasibility of the proposals we are considering. In particular, we wish to acknowledge the support of John Giordano and Peter Faletra.

Thank you for your attention; this concludes my testimony.

Senator CRAIG. Thank you very much. Your testimony is fascinating.

Let us turn now to—Senator Domenici is back. I was turning to Senator Bingaman. He has to leave at noon. So we will yield to you, Senator, for questions.

Senator BINGAMAN. Thank you very much.

Thank you both for being here and thank you for your good work, Dr. Vest. Thank you particularly for your work as a commissioner.

Let me ask you about this issue of ARPA-E. According to "Inside Energy," I think yesterday or the day before, they had an article where Secretary Bodman was quoted as saying that they would look at this issue, but he was inclined himself to build along the lines of Incutel rather than an ARPA-E model; Incutel being the private, as I understand it, the private fund that the CIA has established for promoting development of technologies useful for the intelligence community, ARPA-E, of course, being much more modeled after DARPA. There is a good quote in here, I thought, from Norm Augustine saying that "The DARPA model would be more closely matched to DOE's needs because in our view"—speaking I guess explaining the commission's position—"in our view the opportunity to gain new and create new technologies through contracts and through the current DOE structure, rather than venture investments, is greater."

Do you have a point of view you could express, either for yourself or for the commission, on this question?

Mr. VEST. Senator Bingaman, I would like to address at least parts of what you have raised. I will try to be clear as to my ideas and where it is the committee's. First of all, this is all about people and ideas and bringing new communities of scientists and engineers and innovators to the table of energy.

Incutel, as you have indicated, at least in shorthand notation is a venture capital operation for the intelligence community and a very effective one. Its primary role is to turn the venture capital and entrepreneurial small companies loose on developing new technologies that are generically of interest to the intelligence community, and it is very effective.

That is part of what needs to be happening in the Department of Energy today, in our committee's view. It certainly is not all of it and maybe is not even the core of it. We saw four reasons to recommend this ARPA structure. First—and again I refer back to Senator Craig—we think that the establishment and effective work of ARPA-E could bring a freshness and excitement and a sense of mission to certain areas of energy research that would go a long way to attracting many of the best and brightest minds, both mature scientists but, even more importantly, students and young researchers, and including those in the entrepreneurial world, to energy problems.

Second, that it would focus on creating out-of-the-box potentially transformational research that industry cannot or will not support.

Third, that the reason for utilizing an ARPA-like organization is that it is flat, it is nimble, it is sparse, yet it is capable of making decisions that allow it to sustain for long periods of time those projects whose promise is real, but also to phaseout programs that in their early stages prove not to be as productive or as promising as anticipated.

And fourth, to create a new tool within the Department of Energy for use by the Under Secretary for Science to help bridge some of the troubling gaps that develop between basic energy research, development, and industrial innovation. We think it can serve as a model for science and technology transfer.

So our committee actually discussed the idea of an Incutel-like model. We still feel there might be room for that. It might in fact

be a component within ARPA-E. But we did not believe it was appropriate for us, with our limited time, to specify the organization of ARPA-E in great detail. That really needs to be up to the Secretary and the Under Secretary for Science.

I know I am running on just a little long, but I went back over the last couple of days and read about—read further about the origin of ARPA in the Department of Defense in 1958, in response to Sputnik and all the things that were starting to be on the horizon, ICBMs and so forth. It has the following characteristics: a risk-taking culture, working in high-risk, high-payoff areas; independent from the military service R&D organizations; does not maintain its own laboratories—I want to be very clear about this. This is an administrative structure—idea-driven, outcome-oriented; funds researchers based on their quality, rather than in the defense industry, elsewhere in the private sector, or in universities; and is an honest broker among competing approaches.

It is not a single model. It has morphed and changed with time. So it is this nimble structure, something new, something exciting, bringing new talents into the energy problem, that we believe and I personally believe could be effectively done by an organization of this type. I would put the larger emphasis on that and bringing new people and ideas in and let the Secretary and others explore whether or not an Incutel-like structure should be part of it.

Senator BINGAMAN. Thank you very much.

The CHAIRMAN. Senator Bingaman, thank you for the question. Some of us will have to follow up on that issue and see if we can understand it better.

Mr. VEST. I should point out that our hero, Norm Augustine, was also the person who established ARPA—Incutel, excuse me, Incutel.

Senator CRAIG. Is that called truth in—full disclosure, I guess.

Mr. VEST. It is truth in expertise, if we may call it that.

The CHAIRMAN. I just want to put this one marker down on the entire discussion. The issue of moving science and scientific research from the public laboratories to the private sector is an enigma. Everybody loves it, everybody views it and says what a great thing. And then you look at it and with each decade you find that you made only a little incremental gain in actually being able to get it done. I think you understand that. It is because of all the rules of public property, disclosure, patents, exclusivity. Every time you have capital venture companies trying to fund breakout activities, they run into the same problem.

We are making headway, but I would think before we are finished you ought to tell us whether—what is the difference in application in these two in terms of maybe the ease with which you make the transition from the R&D to something that the private sector can use. Do you understand my question?

Mr. VEST. The difference between an ARPA model and Incutel?

The CHAIRMAN. Yes. I would think the latter is more like what we are doing today.

Mr. VEST. In the first order, the directions are different, Senator, because Incutel basically turns the venture capital community loose on technologies that they want to bring into the Department of Defense—into the intelligence community, and ARPA has more

the function of seeing that the right ideas are generated to begin with. So they are somewhat complementary.

The CHAIRMAN. Okay, we will take a look.

Let me move down to the Senators, if you would like. Who is next here, Senator Craig or Senator Alexander? Larry, go ahead.

Senator CRAIG. I will be very brief, gentlemen. Thank you again and I will spend time with your testimony. Both of you have challenged us and I will be anxious to see, doctor, your work, where it takes us as it relates to DOE and our capabilities there. We see these phenomenal resources and wonder how we energize them.

But Dr. Vest, you said something that is so profoundly true. I think of the phenomenal—I know of no other way of saying it because we have all benefited from it—the phenomenal wealth that the IT economy has brought to our country, that started way back when as we began to energize and focus and invest, and it morphed and morphed and morphed itself. It challenged bright young people and we became a world leader, and then it moved to the rest of the world and we took our technologies to them.

Two years ago this past December, I was sitting on a platform with the head of the environmental agency for mainland China at the national—or the World Climate Change Conference in Buenos Aeres, and he turned to me after his comments and said: We need to build 100 nuclear reactors. And oh, by the way, he kind of smiled, would you come and build them? What he was saying to me was that, because we were then at the edge of announcing to the world that we are going to get back into the nuclear game—we were almost there, the chairman was almost there, we were crafting the legislation, we felt that we had the wind to our back, that the world was coming with us, at least our immediate political world.

But it was fascinating to me because it registered on me once again how anxious the world is for us to lead because they know that when we do everything is transparent, largely speaking, and that it is transferable to them in many instances.

I think what you say is very true, that we ought not forget the marketplace, we ought not forget that what we do is the next wealth cycle, if you will, of our country, not just for us but potentially for the rest of the world.

I was visiting with Senator Domenici during some of the testimony, saying one of the great drains of our country today is that our wealth is moving abroad to acquire energy in just unbelievable amounts. Oh, if only half of it could stay and be invested in the types of things we are talking about.

Anyway, thank you both very, very much. That is certainly more of a comment than a question, but I do believe we oftentimes forget that what we do is the market, it is the economy, it is not just inside the laboratory. It challenges the great minds to produce something for a marketplace that is the engine of this great country.

The CHAIRMAN. Thank you, Senator.

Senator BINGAMAN. Thank you.

The CHAIRMAN. Senator, I should have gone to you a little sooner. I am sorry. Would you like to proceed?

## STATEMENT OF HON. ROBERT MENENDEZ, U.S. SENATOR FROM NEW JERSEY

Senator MENENDEZ. Thank you, Mr. Chairman. I appreciate your courtesy.

Let me say I am really impressed by the legislation that Senator Bingaman and Senator Alexander put together here, Mr. Chairman, and your calling it up so early. I am a strong supporter and co-sponsor of it. This is really in my mind about the future of our country, about innovation and technology in a world which has been transformed by technology. The boundaries of mankind have been transformed, where human capital can be located just about anywhere in the world and where a blueprint, a radiologist's report, an engineer's report, a tax return, can be accomplished just about anywhere in the world.

So having America be able to be at the very apex of that curve of intellect and the collective human capital and intellect that we have as a Nation is going to be our greatest opportunity and our greatest challenge as well. So I really appreciate what it is that we are doing through purposes of the legislation and I look forward to supporting it on the road ahead.

[The prepared statement of Senator Menendez follows:]

PREPARED STATEMENT OF HON. ROBERT MENENDEZ, U.S. SENATOR FROM NEW JERSEY

Thank you very much, Mr. Chairman, and thank you for moving so quickly in holding a hearing on this very important piece of legislation that I strongly support, and that I am proud to be an original cosponsor of. I would like to commend Senators Bingaman and Alexander of this committee, along with my former colleagues in the House, Representatives Boehlert and Gordon, for asking the National Academies to look at this issue of American competitiveness in science, technology, and innovation, and I hope that all three bills to come out of this report will get to the Floor of the Senate in short order.

As the subtitle of the National Academies report makes clear, investing in education and innovation is about our economic future. Today's young people will be facing a new world when they enter the workforce—a world that is globally integrated and where technology has transformed the boundaries of human capital. Our tax forms, blueprints, and x-rays can all be analyzed halfway around the world. The greatest asset we have in this country is our collective intellect, and the nation's competitive future will depend on us nurturing the intellect of the next generation of Americans.

This legislation is about more than our ability to compete in the global marketplace. It is also about the quality of our lives. It is about finding new cures for diseases such as cancer or alzheimers so that Americans can live longer, more fruitful lives. It is about discovering new technologies for generating energy that do less harm to our environment. And it is about the next technological breakthrough that makes us wonder how we ever lived our lives without it.

This bill, in conjunction with the two other bills that enact the recommendations of Rising Above the Gathering Storm, will help this country maintain its position as the world leader in research and development, high technology, and innovation. Already there are signs that our preeminence in this field may be slipping. As the National Science Foundation points out in Science and Engineering Indicators: 2004, the United States is losing ground to the rest of the world in the number of published articles in scientific journals, the number of patents, the share of global exports for high-technology products, and the percent of college graduates with natural science or engineering degrees. We need to turn this around, and we can do that by making sure our children have the proper tools, and the proper support, to succeed in science and technology.

I am concerned, however, that these bills will not properly equip the entire next generation of Americans. Currently, there is a distinct shortage of minorities in science and engineering jobs. According to the National Science Foundation, only 7% of our scientists and engineers are Hispanic, African-American, or Native-American, despite the fact that they make up 24% of the total population. A minority scientist

is also far less likely to achieve a post-graduate degree. By 2020, one-quarter of the nation's schoolchildren will be Hispanic, and another 14% will be African-American. That's 40% of our precious human capital, and we can not neglect that tremendous resource when we talk about improving our competitiveness for the future. No business could afford to leave 40% of its capital sitting idle, and neither can the United States. I look forward to working with my colleagues to make sure that we don't leave this enormous cohort behind as we strive to ensure America's scientific and technological future.

As for the bill before this committee, I am particularly excited about the way it would forge closer links between the Energy Department's National Laboratories and local students and teachers. We have one of these labs in New Jersey, the Princeton Plasma Physics Laboratory, and the world-class research that it performs is already a tremendous asset for New Jersey, the United States, and the world as a whole. But if we can leverage the strengths of that laboratory into better learning experiences for our students and training opportunities for our teachers, both the local community and the PPPL itself benefit.

One of the overriding themes through this bill, and the other two PACE bills, is that we need to make a major national commitment to research and development, and I hope we can follow through on that. The President has also talked a lot recently about making a serious commitment to innovation through the American Competitiveness Initiative (ACI), and I think he should be commended for making such a strong statement of support. However, I am disappointed that his budget proposes to eliminate, again, the Advanced Technology Program (ATP). New Jersey is the 5th largest recipient of ATP funds in the nation, obtaining 36 grants worth $110 million over the life of the program. The ATP makes competitive matching grants to businesses that do high-risk, high-reward research and development, which is exactly what this Administration has been trumpeting as its priority. The ATP has provided $18 billion in economic growth on $2.1 billion in investments and has more than paid for itself since its inception. I believe this program does a tremendous job in stimulating research by the private sector that otherwise might never be performed, and I hope we will once again be able to reverse this ill conceived plan to kill the ATP.

Senator MENENDEZ. I do have one line of questions. Dr. Proenza, you said in your comments about building mathematics and science in the elementary and secondary level as we create building blocks of learning and enthusiasm for math and sciences as we move on to higher education. I just wonder when I see that over the next decade and a half 25 percent of all the Nation's school children will be Americans of Hispanic descent, added to between 15 and 20 percent of African Americans, that is anywhere between 40 and 45 percent of human capital in this country, in terms of the educational future, which I consider the economic future of the country. How do we, within this broad context that we are trying to pursue, significantly try to engage that part of the student population to be enthused and engaged when considering some of the challenges they face in science and mathematics?

There is no corporation in America could afford to have 40 or 45 percent of its capital sitting idle or not fully productive, and I am concerned when we are talking about this, our legitimate pursuits in math and science to continue to be the leader of the world and to be at that apex of human intellect in some of the most significant aspects of our lives, that we are going to leave a lot of that human capital behind. I wonder if you have any thoughts about that, or Dr. Vest as well?

Mr. PROENZA. Senator, that's a very important point that of course faces the Nation as a whole. As a person of Hispanic background that came to this country at a very early age, I did notice that we tend to expect less of our children in America than the educational systems of other countries. That is an element. Certainly we have to build into our society the kind of anticipation and

expectation of success that some societies have been able to do quite widely and start early. Jim Hechtman's work at Chicago certainly indicates that the greatest return on investment will be seen by looking at the early childhood years. The work that we have done in our task force indicates that our young people in America tend to stay even with those in other parts of the world up into the middle school years. That is where we begin to lose them, and that is why we emphasized that that is where we have an opportunity to leverage our resources optimally early on.

Obviously, we want to see this continue and we would certainly be looking to recommendations along those lines. Expecting more, starting early, and ensuring that we do not lose them in those vital years would be three suggestions that I would make, Senator. Thank you for your question.

Mr. VEST. Let me add to that, and let me begin by saying this is purely a personal statement, not the statement representing the committee.

Former Governor Jim Hunt runs an institute that studies higher education policy. One of the recent reports had the following fact: if you are an adult, white American like myself, you have two times the probability of having a bachelor's degree as your African American colleague and fellow citizen and almost three times the probability of a Hispanic citizen.

This cannot go on. One of the points he makes is that if you then add to that the correlation between earning power and income and having a bachelor's degree and look at the demographic projections, you will come to the conclusion that the average income in America is going to go down if we do not resolve this problem.

Now, I am an engineer, not a politician, so I will be pretty straightforward. When you see a problem you are supposed to analyze it and fix it. I think the only way we are going to make the kind of rapid progress in drawing on all our citizens in this country the way we have to is to be explicit about it. If I had my way, these summer institutes and the outreach programs of American colleges and universities and so forth would have a very explicit component of their mission to address the specific needs of our minority citizens.

I think we have to roll up our sleeves and work hard at this, but, having said that, at the end of the day having inspirational activities, learning opportunities, and jobs is the same for everybody no matter what your background is, and that is the starting point.

Senator MENENDEZ. I appreciate that. I find it interesting that as we look at part of the legislation, which I support, it takes away the numerical limitation on aliens to come to be part of our research efforts here, that domestically we have a very large population that hopefully we can enhance in the math and sciences, that we can produce from our own citizenry the human capital to meet some of these challenges.

Mr. VEST. Behind our requests and our recommendations in this report on undergraduate scholarships and graduate fellowships for U.S. citizens is a model that looks roughly like this. We believe we need to increase the fraction of our American citizens who are educated in these fields, both undergraduate and advanced levels. We believe that that should be done by raising ultimately on the order

of another couple of percent or so the number of U.S. citizens going into these fields, while not diminishing that extraordinarily important talent, the world's best and brightest, that also come here. That is really our goal.

Senator MENENDEZ. Thank you, Mr. Chairman.

The CHAIRMAN. I am very glad you explained that, because I think, Senator, we need Senators like you, who have the concern that you have expressed, to understand that the recommendations are not intended to be penal and say, let us say we are not going to get that for the minorities in the United States, but let us bring the counterpart, that is a minority who was educated overseas. We are trying to do both, as he indicated, knowing that in the mean time we are very, very short. We cannot get there in the right way unless we do both.

So I hope before we are finished that you will see your way clear to think that is a positive. I have the same concerns as you and I support the thrust. Thank you.

Let us see. Senator Talent, did you want to inquire or not?

[No response.]

The CHAIRMAN. Senator Alexander.

Senator ALEXANDER. Thank you, Mr. Chairman.

Thanks to the witnesses for your presence and your work in helping us understand these issues. Dr. Vest, I want to say especially to you I appreciate your leadership as I have worked with you more on the two commissions that you have been a part of. Without that consensus document, we would not really be anywhere in this effort.

I want to endorse your point about the shortage of engineers in America. That is the wrong way of thinking about what we are doing. We are educating more talented engineers and scientists, not to take jobs, but to create jobs. We are and have been for years losing millions of jobs every year. What distinguishes the United States from the other countries in the world is that we create more good new jobs than we lose, and we need to help people understand that we are not doing this to graduate people to take jobs. Most of our new jobs come from little startups, one or two people, this idea, that skill. That is true in every part of this country and that is a very important point.

I want to ask you if you would be willing to ask your staff to write a letter to the chairman describing in a page the process that you went through reviewing, coming to the conclusion about the 20 recommendations of the Augustine Report, because I think many Senators are not aware that you sifted through many models and many ideas and you narrowed them down and you subjected them to peer review. You did something that we are really not able to do, and that is one reason it is getting such wide acceptance here.

But I would like to be able to cite that from time to time when somebody says, well, why did you pick the You Teach Program in Austin, Texas? Here is another good program over here in Salt Lake City. Well, you probably considered 20 programs and you came with this model. So just a page on that would be helpful.

A second thing would be, could you comment for a minute on why you believe, as I have heard you say, that all 20 of these recommendations need to be adopted, not 18 of them or 15 of them

or 14 of them, that they are as a whole, that they are not individual recommendations? Would you want to make a brief comment about that?

Mr. VEST. Yes, Senator Alexander. You and Senator Bingaman asked us a very straightforward, if complex, question, in a single sentence: What are the things that the Nation needs to do in science and technology to ensure our prosperity and security in the globalized economy of the 21st century, or some words very close to that?

That is the question that under Norm Augustine's remarkable leadership we have attempted to answer. We came up with something that I have characterized here as being bold, comprehensive, and strategic. Frankly, that represents a lot of business thinking. Businesses do not go forward—and you know we had many CEOs or former CEOs on our committee. Businesses do not move forward without both a strategy, a long-term vision, figuring out what all the pieces are of the puzzle, recognizing that they each have a role to play in coming up with a comprehensive thrust forward.

So it is sort of a business kind of analysis and thought that led us to believe that we had to produce something very comprehensive, that recognized the fact this is a long-term problem, it is not all going to be solved overnight, that we have to look at the educational pipeline all the way from kindergarten forward, and that many of these things would bear fruit at different points in time. But it is a comprehensive package and we believe that each of its parts will be more effective if somehow the entire program moves forward.

Senator ALEXANDER. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Senator. Thanks for all your hard work.

Senator Talent, we are glad to have you here.

**STATEMENT OF HON. JAMES TALENT, U.S. SENATOR FROM MISSOURI**

Senator TALENT. Thank you, Mr. Chairman. Thanks for letting me get in here at the end.

Two areas I wanted to bring up with you, just your general opinions on them, and this is based on what I have seen and observed over the years on the ground about how we can encourage the interest in the sciences. The first is, what do you see as—what would you like to say that you see the role of the community colleges in general being? When I think of institutions that sort of connect up, that are the connectors between the needs of the corporate community, the business community, the trade for highly skilled people, and then the kids or the younger people, it is the community colleges that are on the ground sort of pulling all that together.

So if you have a view on that, and it does not necessarily have to be all that specific, but what do you think?

Then the second thing is, how as a practical matter do you think we can get more scientists, people who have maybe had a career or half a career in research or in private life, into the classroom? Because I think what inspires young people are being around people who themselves have a passion for the subject. If you get a his-

torian in teaching history, those kids are going to see the passion that that person has and they are going to be attracted to that.

How would you go about—how important do you think that is and how would you go about doing it?

Mr. PROENZA. Senator, to your first question, community colleges are playing an increasingly vital role in the fundamental workforce training of the United States, particularly entry-level jobs and those that utilize technology, but from the perspective of knowing how to use it in the workplace. Our universities are advancing the knowledge frontiers, if you will, and thereby adding to that dimension the kinds of people that need to come in and transform the workplace to become more efficient, more productive, and ultimately to bring on line the new tools that will create competitiveness and indeed increased wealth creation opportunity for our Nation.

But there is no question that community colleges have done an outstanding job in linking to the fundamental needs at the workplace.

Your second question requires that we do continue to transform the way in which teachers are certified and we get away from the need to simply put them through pedagogical courses, if you will, and look to bridging the gap between teachers who are studying pedagogy and those that need fundamental content. You are absolutely right, there are many people in the economy, coming out of the military, in various businesses, particularly those that are high technology and utilizing science and engineering in what they do, that can bring to the classroom that vitality that I spoke about, which the laboratories are able to engender in those teachers that they bring in, and why we feel that that is such a vital component for leveraging the national laboratories.

In Ohio, for example, at my university we have brokered a partnership with the National Inventors Hall of Fame to bring exciting things in the National Inventors Hall of Fame that have so dominated the recognition of those inventors by that organization into a middle school that is focused on science and mathematics. That is a partnership between our university, the National Inventors Hall of Fame, and the Akron Public Schools.

It is possible there are, as Dr. Vest indicated, many exceptional models out there of similar enterprises and we should do as much of that as we can.

Senator TALENT. I was visited earlier today by an engineering professor from Missouri and we were talking about the subject. He said he had two daughters and, talking to them about going into engineering, they say, no, it is just not very cool, dad. I think there is too much of that sense among young people, but if they were exposed to somebody who had created some product for some company and could give them these real life stories and just sort of show that, I think the kids would see: Wow, you know, you can really make these things or design on the computer or whatever.

I do not know how much this is a big money item, really. This is just—because I bet these resources are out there and there are people who are willing to do this.

Doctor, do you have a comment?

Mr. VEST. Senator Talent, we could have an entire hearing on this last point you have made.

Senator TALENT. Well, do not tempt the chairman. It is a subject that he might call you all back.

[Laughter.]

Mr. VEST. But I want to say this. I was horrified recently looking at a survey that had been done in a small area, but a survey of why young kids were not going into engineering. The No. 1 reason given in the sort of open form part of the survey was: We want to go into something where we can make the world better. This is our failure. It is not somebody else's failure. I spent my whole life in engineering education. This is our failure.

They need to understand that their scientific and engineering backgrounds can in fact be the things that can solve these great global problems. That is the message we all have to get out.

Community colleges are extremely important because I try to consistently use the phrase, we have to create, we have to have a workforce and leadership that can both create and perform the jobs of the future. But it all begins with K-12. If you do not fix K-12, colleges cannot do their job, universities cannot do their job.

Finally, I will just tell you, sir, that industry is full of people ready to go out and play this role as Luis, as Dr. Proenza has said. IBM, Intel, all these companies already are launching these programs. The national labs do it. We just need to build that momentum, get whatever barriers are there out of the way, because inspiration is the major deal here.

Senator TALENT. Thank you, Mr. Chairman.

Mr. PROENZA. If I might just say, Dr. Vest just reminded me we have a mutual colleague on the President's Council on Science and Technology, Floyd Kwame, who made I think a very telling point. He said you do not go to college to study French to become a Frenchman. So when you go to school and study engineering, it is not just to become an engineer; it is actually to learn how to solve problems.

It is that linkage that I think Dr. Vest is looking to find a way to solve, to convince our young people that these tools of science, engineering, mathematics, and technology are problem-solving tools. To Senator Craig's earlier comment, it is that connection that we have been so vitally interested in and which the PACE legislation I think underscores.

Senator TALENT. And the easiest way to do that is if you can expose them at the right age to people who believe that passionately and will just naturally communicate that to them because they have lived it, that is better than public service announcements or other things talking at them. It is the teacher that they are around or some class that they are in. That is kind of my feeling about it.

Thank you, Mr. Chairman.

The CHAIRMAN. Well, we are going to close now. But I just wanted to say, while it might not—I am not sure yet whether it is within this piece of legislation or the one that goes to the Education Committee, but, you know, Dr. Proenza, we are going to run into a problem in terms of certification of teachers. We have extreme self-righteousness on the part of States, that you are going to be certified the way we say and you are going to go to our universities

and take 2 years of learning how to educate kids. Even if you already have a Ph.D. and you have taught this, that, and the other, you have got to go back to college and get—we have got to find some way in this legislation that if we are going to go through all this resource-building that we are not going to end up with doing all this training and getting people ready to teach, only to find that the State has a different thought about it. They have got to find out up front. If they want to participate, they have got to join up. They have got to accept what we are doing as something good for them. They cannot be out in left field.

I know you already know that, both of you, very well and I am a little—I am permitted to be a little tougher on it than you because you are part of that system. But I have been very open that about 6 States decided about 15 years ago that we did not even need colleges of education within their universities. I think you know that, Dr. Vest. I praised them because I did not think their colleges of education were doing much good.

What we needed to do is get teachers who knew how to teach and that knew the subject matter, not only what you teach in a college of education. The statistics are terrific, terrible, how many kids are being taught in the fourth through twelfth grade by people that do not know nothing about math and they are being taught math, being taught science by a person that is not a scientist.

We cannot do that and get where you want to go, can we, doctor? They have to know something about it.

Mr. VEST. No, sir. That is why that recommendation in our report is numbered A-1: get kids to go into these fields and disciplines, get the additional work they need in pedagogy, and get out into the field.

The CHAIRMAN. Well, I thought the hearing went well. Since our piece of this major legislation is pretty well defined, we are going to take a look with our staff and see if we need any further things to fill in. But I want to state for the record, if we think we have got enough we are going to proceed to mark up this bill one of these days not too far off and see if we can get the first piece of this legislation at least down to the Senate floor.

I am fully aware and the leadership in the Senate knows this is not the legislation, this is a piece of it, and our goal is to find a way to do what you recommended and that is to get all of it forwarded and in some way to put it together. So if it goes down by itself and you talk about it as commissioners who put it together—we do not intend to run it on its own. We are going to wait for the other committees and then see how they package it. Then the House is starting its version.

So all we are trying to do is set the pace. It is interesting, set the pace for PACE.

Thank you for being here and it is a pleasure getting to meet you, doctor. I look forward to meeting and talking with you more. Thank you.

[Whereupon, at 12:30 p.m., the hearing was adjourned.]

# APPENDIXES

## APPENDIX I

## Responses to Additional Questions

### RESPONSES OF LUIS PROENZA TO QUESTIONS FROM SENATOR DOMENICI

*Question 1.* In your written testimony, you propose a "hub and spokes" model for math and science education programs, centered on the National Laboratories. You also mention the need for flexibility to make each program meet the local school district's needs.

How can the national laboratories best ensure that they are targeting their programs to the needs of local school districts?

Answer. The hub-and-spoke notion is one in which each of the laboratories is assigned a geographical service area. In fact, DOE has identified such geographical areas, as shown in the attached diagram.* The "flexibility" idea relates to the needed local adaptations that are appropriate to each of the laboratories areas of expertise, as well as to possible local needs of the school districts served by each laboratory. Such needs could include, for example, some districts having greater need for mathematics teachers as compared to science and vice versa. Guidance on this matter could follow the approach identified by the California Council on Science and Technology or utilize established networks within each state's educational systems.

*Question 2.* In your written testimony, you discuss the importance of incorporating digital technologies, such as virtual reality simulations, into math and science instruction. These technologies, as you point out, rely on broadband communication.

How many of our public schools are equipped for broadband today? Is funding the only limiting factor to increasing broadband access at our nation's schools?

Answer. Broadband is rapidly expanding and is now increasingly available even through wireless communications providers. What is more, we are rapidly seeing the deployment of additional technologies, such as Pod casting and self contained portable technologies (e.g., PDA's, pentop computers, tablet computers, etc.) that enable simulations to be brought to the classroom independent of broadband. In Ohio, the Third Frontier Network and initiatives such as One Cleveland/One NEO are rapidly expanding broadband access to the classroom. Also, The University of Akron, for example, has had an exemplary tradition of enabling broadband access to university resources for a wide array of public schools throughout the Northeast Ohio region. In short, the current state of the broadband access issue, given the Administration's efforts to advance broadband access, the initiatives of local communities and the continued evolution of technology, should make this matter a moot issue.

### RESPONSES OF LUIS PROENZA TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* Sections 171 and 181 of the PACE bill in the HELP committee direct the Secretary of Energy to establish large undergraduate and graduate programs at the Department in the areas of math, science and engineering education. Can you please comment on how you think the Department can handle such large scholarship programs?

Answer. The DOE is experienced in the handling of numerous undergraduate, graduate and postdoctoral support mechanisms. I am not aware of any apparent limitations for DOE in this regard.

*Question 2.* The PACE—Energy bill authorizes the development of a summer internship program for middle and secondary school students to actually work with

*Attachments have been retained in committee files.

scientists for hands on experience. Can you please comment on the best way to implement such a program—should a technical staff member be physically assigned a student much like a graduate student or are there other interactive methods that can be employed?

Answer. DOE already has many programs that involve middle and secondary school students in summer internships and other programs. Our review of these programs suggested that they are positive and should be continued wherever possible. However, we did not see the opportunity of such programs to have anything like the leveraging impact of working through teachers. In other words, the 17 National Laboratories can and should have programs that provide access opportunities for students, but such programs can never equal the impact that can be gained through the transformative effects of laboratory experience for teachers. It is a simple matter of the "10,000 teachers for 10 million minds" leveraging opportunity.

*Question 3.* Based upon your experience with the SEAB study on math and science education and our PACE—Energy bill concerning summer institutes—how should the Department best implement the program to affect the greatest number of students in the most beneficial way?

Answer. See my response to 2, above. Once again, it is a question of leveraging vs. direct exposure. The Science Bowls and other outreach efforts should be continued, particularly in the local service areas of the National Laboratories, but the greatest leveraging impact, we believe, can be gained through the professional development of teachers.

*Question 4.* This legislation proposes to strengthen the math and science competencies of K-12 teachers in a number of ways, which of course we hope will lead to better prepared and educated students. PACE also creates opportunities for students to participate in internships at the labs, which we hope will give them an exciting, hands-on experience leading to greater interest and success in math and science. What more can we do to excite, interest, or encourage young people to pursue postsecondary education and careers in math or science?

Answer. As far as creating opportunities for exciting, interesting and encouraging students to pursue STEM careers, we believe that DOE's most direct opportunity lies through the professional development of teachers. Beyond that, we see untapped potential in the domains of (1) making Web-based materials available that provide interactive opportunities for students and teachers alike and which enable powerful simulation or visualization experiences of complex physical and engineering problems and (2) that enable students and teachers to remotely access laboratory facilities in an interactive mode.

### Responses of Luis Proenza to Questions From Senator Akaka

*Question 1.* Dr. Proenza, I would like to ask you for your ideas on this as well. Are there ways that you could see extending the reach of National Labs' expertise to states that are geographically remote from Los Alamos, Brookhaven, or Lawrence Livermore?

Answer. Once again, the role of teachers cannot be underestimated as a leveraging force. In addition, the National Laboratories can develop computer-based exercises as well as remote-access opportunities that utilize the Internet to extend the reach of the laboratories beyond their immediate locales and the boundaries of their assigned geographical areas. In addition, we are of the opinion that other Federal agencies, as well as university and corporate resources, can and should be considered as adjuncts to the National Laboratories. That means that a significant interagency coordinating role must be mounted, perhaps through the National Science and Technology Council and the Office of Science and Technology Policy.

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### Responses of Charles M. Vest to Questions From Senator Domenici

*Question 1.* In the Gathering Storm report, your committee recommended an increase in long-term basic research of 10 percent a year over the next seven years.

Does the President's American Competitiveness Initiative go far enough towards meeting this recommendation?

Should research agencies beyond the three highlighted by the President be considered for similar funding increases? If so, which ones?

Answer. The President's American Competitiveness Initiative is a very positive first step toward the comprehensive actions recommended by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine report *Rising Above the Gathering Storm.*

As indicated the committee recommended that funding for basic research be increased by 10% per year over the next 7 years. The President's American competi-

tiveness initiative doubles "the Federal commitment to the most critical basic research programs in the physical sciences over the next 10 years."

The committee did not specify the agencies that should receive the increase—other than indicating that the Department of Defense 6.1 budget and the fields of the physical sciences, mathematics, engineering, and computer sciences throughout federal agencies were of particular concern. Based on past history as analyzed by the National Science Foundation, the four agencies providing the highest percentage of funding for the fields identified by the committee as being of special concern are the National Science Foundation, the Department of Energy, the National Aeronautics and Space Administration, and the Department of Defense as shown in the table below:

PRELIMINARY FEDERAL OBLIGATIONS FOR BASIC RESEARCH IN THE PHYSICAL SCIENCES, MATHEMATICS, COMPUTER SCIENCES, AND ENGINEERING, BY AGENCY, FY 2004[1]

| | Funding (billions $) | % of total |
|---|---|---|
| All agencies | 7.4 | |
| Department of Energy | 2.1 | 28 |
| National Science Foundation | 1.9 | 26 |
| National Aeronautics and Space Administration | 1.5 | 21 |
| Department of Defense | 1.1 | 15 |

[1] Other agencies which fund these areas are Commerce, HHS, USDA, DHS, Interior, VA, and EPA. HHS is largest at 6%; remainder at 1% or less for a total of 10%. Source: NSF, 2005. *Federal Funds for Research and Development: Fiscal Years 2002, 2003, and 2004* (Publication No: NSF 05-307)

The President's budget increase focuses on the National Science Foundation, the National Institute of Standards and Technology, and the Department of Energy Office of Science.

Maintaining or increasing funding for all federal research agencies, of course, is important. If additional agencies were to be added, the committee would suggest focusing the increases on the *basic research* activities of the Department of Defense (6.1) and the National Aeronautics and Space Administration in the physical sciences, engineering, computer sciences, and mathematics.

Although not an exact match, the committee believes that the actions provided in the President's American Competitiveness Initiative are consistent with the recommendations in the report.

RESPONSES OF CHARLES M. VEST TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* What were the academies thinking that led to the proposal for an ARPA-E entity with the Department and what other models did your panel consider?

Answer. The committee believes that ARPA-E would be an important and productive component of the research and development infrastructure needed to respond to the nation's urgent need for clean, affordable, reliable energy. ARPA-E would provide the following benefits for the nation:

- Bring a freshness, excitement, and sense of mission to energy research that will attract many of our best and brightest minds—those of experienced scientists and engineers, and, especially, those of students and young researchers, including those in the entrepreneurial world.
- Focus on creative, out-of-the-box, potentially transformational research that industry cannot or will not support.
- Utilize an ARPA-like organization that is flat, nimble, and sparse, yet capable of setting goals and making decisions that will allow it to sustain for long periods of time those projects whose promise is real, and to phase out programs that do not prove to be productive or as promising as anticipated.
- Create a new tool to bridge the troubling gaps between basic energy research, development, and industrial innovation.

The committee considered several models before deciding to focus on energy and to use ARPA as a template. Among these were In-Q-Tel (which engages the entrepreneurial community with technologies of potential interest to the intelligence community), HSARPA (the Department of Homeland Security Version of ARPA), SEMATECH (a jointly funded research venture of the federal government and the

semiconductor industry), Advanced Technology Program (ATP), Small Business Innovation Research program (SBIR), Civilian Technology Corporation (recommended in a previous 1992 National Academies report chaired by Harold Brown), and Discovery Innovation Institutes (recommended by a 2005 National Academies report chaired by James Duderstadt).

*Question 2.* It is my understanding that legislation for the Department of Homeland Security includes the formation of a Homeland Security ARPA. Did you panel look at how this ARPA has performed?

Answer. The committee did consider HSARPA and found its focus was more on short-term research than what the committee intends to be the case with ARPA-E.

*Question 3.* One of the recommendations of your panel was to set aside 8 percent of programmatic funding for out of the box R&D proposals which would not normally or otherwise fare well in the tradition peer review process. Is this similar to the Laboratory Directed Research and Development funding or set aside for the National Laboratories? Can you please explain say how this would be implemented in the Office of Science?

Answer. This proposal is somewhat different from the National Laboratory set aside which is focused on the top of the organization. Our discussions with National Laboratory directors indicate that although they have discretionary funds, the same is not true for those in the middle of the organization. We have also heard concerns that the earmarking of funds limits the ability of the national labs to make the best use of their funds.

The committee also believes that this investment should be managed in the DOE's Office of Science by appropriately expert technical program managers in the middle of the organization, who we believe are already well organized to do so.

*Question 4.* In a companion bill which now resides in the HELP committee, the Office of Science and Technology Policy was given the added responsibility for coordinating Math and Science education across various agencies, like DOE, NASA and NSF. Can you please comment on this?

Answer. The committee believes this action is consistent with the goals of its report. This coordination role is familiar to OSTP and was effectively executed more than a decade ago under a now-defunct coordinating council. The placement of the deputy assistant director under the assistant director for science in OSTP is also consistent with the organization of the office over the last several years.

The major issue with coordinating across federal agencies in general is in finding the right balance between ensuring coordination and effectiveness across agencies while not diluting or trespassing upon individual agency missions.

The case of coordinating STEM education is particularly challenging because there are no national goals—thus the bill's language about establishing the goals and opening them up for public comment. It is important that this process not become overly political. To avoid politicization, there might be some kind of public input to the appointment process.

*Quesion 5.* This legislation proposes to strengthen the math and science competencies of K-12 teachers in a number of ways, which of course we hope will lead to better prepared and educated students. PACE also creates opportunities for students to participate in internships at the labs, which we hope will give them an exciting, hands-on experience leading to greater interest and success in math and science. What more can we do to excite, interest, or encourage young people to pursue post-secondary education and careers in math or science?

Answer. The greater the degree to which middle and high school students have the opportunity to engage in research activities whether at national labs, universities, industry, community colleges, or within their own schools, the greater the degree they will be excited, interested, and encouraged in pursuing careers in science, math, and engineering. Funding for these activities would be very useful.

### Response of Charles M. Vest to Question From Senator Akaka

*Question 1.* Professor Vest, thank you for your testimony. I am pleased with the provisions in S. 2197 for education, teacher enhancement, and for supporting young researchers and advancing innovating technology. As many of my colleagues on this Committee know, I began my professional career as an educator, so educational initiatives are very important to me.

I endorse the programs in the PACE-E bill, but I am concerned about the "Labeffect," in that some of the programs are to be established in the geographic regions of the National Labs. I am interested in your suggestions of how we can ensure that states like Hawaii which do not have a Department of Energy National Laboratory can enjoy the fruits of the program for assistance for specialty schools and Centers

of Excellence in Math and Science in specialty or magnet schools? These two initiatives can be very important for reaching middle and high school students, and I am sure our schools would like to participate in the expertise of the National labs.

Answer. Although the legislation focuses on Department of Energy National Labs, there are 700 federal labs supported by many other agencies located in every state that could be used for a similar purpose. (See *http://www.federallabs.org/* )

According to the information on this website, each year approximately $25 billion of federally funded research and development takes place at more than 700 federal laboratories and centers which address virtually every area of science and technology and employ more than 100,000 scientists and engineer.

Examples in Hawaii include the Pacific Basin Agricultural Research Center in Hilo, the Institute of Pacific Islands Forestry in Honolulu, and the National Oceanic & Atmospheric Administration's (NOAA) Honolulu laboratory.

I would make two additional points. First, I think that there should be modest coordination among these educational outreach efforts by the labs. There should be sharing of best practices and some degree of coherence brought to the programs in order to do the best possible job and to gain efficiencies. Second, our Gathering Storm report recommended the establishment of summer institutes for teachers, with a goal of reaching 50,000 practicing teachers each summer. We envision that these could be conducted in industry and at universities, as well as at the national labs.

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RESPONSES OF RAYMOND L. ORBACH TO QUESTIONS FROM SENATOR DOMENICI

*Question 1.* What are some of the strengths of current education programs at the National Labs? Which of those programs should we be emulating at other facilities?

Answer. The key differentiating factor in all the education programs our national laboratories offer is mentor-intensive research experiences that expose the participants to the real world of science. This is done through internships and fellowships that peak in the summer but occur year-round. There are three types of programs, each based on a specific target population, which could be emulated at all national laboratories. Each of these types of programs has operated in some form or another at many of the national laboratories. The most common program type, which has the greatest number of participants, is the internship program for college-level students. Two of the most important best practices that define internship programs are to set clearly defined goals for the students and to provide proper guidance to the mentors. Other critical components of this model are providing stipend support for the students and having each national laboratory education office administer its own programs to ensure the proper guidance and assessment of the programs. The second program type is targeted at teachers and provides them with professional development research experiences that their respective school systems cannot provide. Although research indicates the most successful programs involve teachers for many weeks over multiple years, only about half of our labs have the resources to carry out such extensive programs. The third type of program targets faculty from colleges and universities who have typically not been at a national laboratory. This is a developmental program that has led the participating faculty to compete successfully for federal grant support, often for the first time in their careers.

*Question 2.* Are there particular areas of science and engineering the Department of Energy has an interest in assuring that students are still "entering the pipeline?"

In other words, are there energy fields that, given current trends, we expect will have future shortages of qualified employees?

Answer. The Department is working to improve its understanding of market and employment trends. There are professions related to certain sectors of energy-related fields that will probably see an increase in employment demand because of retirement and/or renewed growth. For instance, with renewed interest in nuclear power, student enrollments in nuclear-related disciplines have swelled. In such cases where the Department does not foresee future shortages, it has and will continue to direct its funding to more pressing priorities. There are, however, small niches within certain sectors such as radio-chemists which are and may continue to see some shortages. The difficulty in projecting is that, rather than a few large sectors seeing shortfalls, numerous small sectors are more likely to see shortages.

RESPONSES OF RAYMOND L. ORBACH TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* The Energy Policy Act of 2005 established a stand-alone fund in section 1102 that required the Secretary of Energy to set aside 0.3 percent of the monies made available for research, development and demonstration or roughly $40 million for this fiscal year. How has the Department implemented this provision?

Answer. The Department is still in the process of reviewing section 1102 of the Energy Policy Act. If you include all sources of funding for education, including direct funding by DOE as well as education programs funded by the national laboratories you will find that DOE funding exceeds the amount called for in the Energy Policy Act.

*Question 2.* The PACE Energy legislation proposes to amend the DOE Science Education Act to create a coordinator for Math, Science and Engineering Education programs which reports to the Undersecretary for Science and is responsible for the various education programs Department-wide. Does such a position help the Department?

Answer. The director of my Workforce Development for Teachers and Scientists program effectively serves that need already. Over the past three years, the director has convened all the education offices in the National Labs to plan a concerted effort in education. The director typically represents the Department in interagency and governmental meetings that involve science and engineering education.

*Question 3.* The PACE Energy legislation proposes to have each national laboratory establish a program whereby the laboratory supports a Center of Excellence in Math and Science at a public school in the region of the laboratory which will involve laboratory staff teaching at the school. Do you think the laboratories will embrace such a program when they so programmatically oriented?

Answer. I do not think many of the labs would embrace such a program. A problem with such a program is that the scientists are not trained as teachers. Companies such as IBM and organizations like Teach for America have often struggled with placing non-teachers with science content knowledge in school settings without the help of experienced teachers. Another issue in implementing such a program, especially for national laboratories near metropolitan areas with very large numbers of schools, is determining who should be provided with this intensive support and deciding what schools should be served.

On the other hand, providing schools access to the scientific community on a long-term basis can be very constructive. By far, the most efficient and effective impact that national laboratory scientists could have is by working directly with teachers. That is why bringing teachers to the national laboratories to learn how science is actually done and training these teachers to be leaders and agents of change is so well received at all our national laboratories.

*ARPA-E and Potential Alternatives*

*Question 4.* Secretary Bodman has been quoted in the trade press as preferring an In-Q-Tel like entity. To me the overall question is how the Department can accelerate high risk basic energy research into something which is acceptable to the marketplace. Can you discuss the pros and cons of the ARPA proposed in the legislation versus say the In-Q-Tel that the Secretary is quoted as favoring?

Answer. The Administration is in the process of evaluating the provisions of S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006 (also known as the PACE-Energy Act)—including the Advanced Research Projects Authority-Energy (ARPA-E) provisions.

The Secretary has stated that In-Q-Tel, the Central Intelligence Agency's "venture capital fund," is a possible alternative model to ARPA-E. As the Department proceeds with its consideration of the legislation, we look forward to substantive discussion with the Committee and others on the merits of ARPA-E or possible alternatives.

*Question 5.* PACE takes some important steps to leverage the resources and expertise available to the Department of Energy, and the Office of Science in particular, to strengthen math and science education at both the K-12 and postsecondary levels, such as summer institutes for teachers, internship opportunities for middle and high school students, and statewide specialty schools. Are there additional ways to maximize the resources and expertise available to the Department to strengthen math and science education at both the K-12 and postsecondary levels?

Answer. This occurs through collaborations with other federal agencies, the entire education community, and the private sector. For example, the Office of Science supports a Faculty and Student Team program that last year brought nearly 40 teams to our national laboratories. This was done in partnership with the National Science Foundation. This year the National Institutes of Health are also starting to use the national laboratories to help provide advanced research experiences to some of its students, through a similar partnership.

RESPONSES OF RAYMOND L. ORBACH TO QUESTIONS FROM SENATOR AKAKA

*Funding DOE Math, Science, and Engineering Education*

*Question 1.* Dr. Orbach, it is nice to see you again, and I appreciate all the work that the Office of Science does to promote hydrogen, fusion, and other cutting-edge initiatives. I agree with our distinguished witnesses that science education is critical for America's competitiveness, and I support the goals of the PACE bills.

I want to ask you about financing for these proposed education initiatives since I noted concerns in your testimony. If I understand correctly, .3 percent of the total Department of Energy appropriation would be set aside for a Math, Science, and Engineering Education Fund. Secondly, there would be a revolving fund established in the Treasury Department that would help fund the "Advanced Research Projects Authority" for the Department of Energy.

I am interested in any comments you might have on these two provisions in particular, and any additional thoughts you might have about financing promising energy technologies and encouraging scientific education and teaching.

Answer. The Energy Policy Act of 2005 already amended the Science Education Enhancement Act to include a provision for a "Science Education Enhancement Fund", composed of "not less than 0.3 percent of the amount made available to the Department for research, development, demonstration, and commercial application". The PACE-Energy Act would further amend the same section of the Science Education Enhancement Act to change the title of the fund to the "Mathematics, Science, and Engineering Fund", in the same amount as the Energy Policy Act provision.

The 0.3 percent set aside for the "Math, Science, and Engineering Education Fund" would amount to roughly $40 million dollars a year when applied against all research, development, demonstration, and commercial application funding within the Department. If you include all sources of funding for education, including direct funding by DOE as well as education programs funded by the national laboratories you will find that DOE funding exceeds the figure called for in the PACE-Energy and Energy Policy Acts.

*ARPA-E and Potential Alternatives*

*Question 2.* I have previously spoken about the need to rely less on oil and natural resources and look more toward the use of advanced technology to facilitate renewable energy sources.

The PACE-Energy bill includes a provision to establish the Advanced Research Projects Authority—Energy (ARPA-E). This organization will be headed by a newly appointed Director [and] will have authority to award competitive, merit-based grants, cooperative agreements, and contracts to public or private entities.

Given that this office will be charged with rapidly developing critical energy technologies, do you anticipate that the Director would have any special acquisition authorities to expedite the research and development, and, if so, how will you ensure that the efforts of this ARPA-E office will not result in loosely-managed research projects that do not yield the desired results?

Answer. The Administration is in the process of evaluating the provisions of S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006—including the ARPA-E provisions. As this assessment proceeds, we would be happy to discuss our views on ARPA-E or possible alternatives with you or your staff.

RESPONSES OF RAYMOND L. ORBACH TO QUESTIONS FROM SENATOR WYDEN

*Legislation to Commercialize Promising Technologies*

*Question 1.* All the research in the world won't improve U.S. competitiveness if it doesn't lead to new products and services that the U.S. can sell to global markets. What is the timetable for this legislation to commercialize promising technologies?

Answer. The Administration is currently evaluating the provisions of the PACE-Energy Act. DOE would be happy to discuss proposals to accelerate the commercialization of promising technologies with you or your staff

We cannot address the question of a timetable for this legislation as the legislative schedule is set by the Congress.

*PACE and U.S. Competitiveness*

*Question 2.* According to the World Economic Forum, the U.S. is no. 2 behind Finland on their competitive index. We must be doing something right. How does the PACE legislation build on and further the things that our nation is already doing successfully.

Answer. There are a number of reasons why the U.S. has been so successful. Two of our biggest advantages are our very substantial pnvate and public sector invest-

ments in research and development for new technologies and our sustained support for the next generation of scientists via our world-leading college and university system.

Although economists are loath to identify a precise number, it is widely accepted that, as Nobel Laureate Robert Solow put it, "[T]echnology remains the dominant engine of growth, with human capital investment [that is to say education] in second place." From his December 8, 1987 Nobel Prize lecture: ". . . Technological progress, very broadly defined to include improvements in the human factor, was necessary to allow long-run growth in real wages and the standard of living . . . . Gross output per hour of work in the U.S. economy doubled between 1909 and 1949; and some seven-eighths of that increase could be attributed to 'technological change in the broadest sense' and only the remaining eighth could be attributed to conventional increase in capital intensity . . . . The broad conclusion has held up surprisingly well in the thirty years since then . . . [E]ducation per worker accounts for 30 percent of the increase in output per worker and the advance of knowledge accounts for 64 percent . . . ."

Or, in other words, Science is good for the Nation. Support of science, the basis of technological growth, is a necessary investment for fully two-thirds of economic growth, according to Solow.

The President's American Competitiveness Initiative (ACI), unveiled in his State of the Union message, demonstrates the President's strong commitment to continued U.S. competitiveness through a renewed national effort in basic scientific research science and math education, and private-sector investment. The State of the Union message, and the subsequent release of the President's FY 2007 budget that contains substantial increases for basic research in the physical sciences, are all part of the strategy to maintain and sharpen America's competitiveness.

With respect specifically to the PACE-Energy legislation, the Department has just begun to consider this legislation. As our assessment proceeds, we would be happy to talk with you or your staff.

*Science and Technology Training for Women and Girls*

*Question 3.* Could the PACE legislation achieve the same or better results at lower cost, if the Energy Department was enforcing Title IX and not writing off the potential contribution of 51% of the U.S. population—women and girls—who want to become leaders in the STEM (science, technology, engineering and math) fields?

Answer. The Department certainly does not write off the contributions or potential contributions of any part of U.S. society. Participants in all of DOE's education programs as well as all recipients of our research funding are selected competitively, based on merit.

*Ensuring DOE R&D Funding goes to the "Best and the Brightest"*

*Question 4.* Do you have any objections to adding language to the PACE bill to help ensure that Energy Department R&D funding goes to the best and the brightest, regardless of gender?

Answer. As stated in the previous response, Office of Science funding is awarded on a competitive merit basis, ensuring that only the "best and the brightest" receive funding. While we strongly support funding the best proposals, without regard to gender, we do not feel that legislative language mandating what we already do will offer any additional benefit.

RESPONSES OF RAYMOND L. ORBACH TO QUESTIONS FROM SENATOR FEINSTEIN

*ARPA-E and the Development of Low-or Non-Carbon Emitting Technologies*

*Question 1.* The "Protecting America's Competitive Edge Through Energy Act of 2006" includes a provision that would create an Advanced Research Projects Authority-Energy (ARPA-E). On the surface, ARPA-E should promote the development of new technologies. However, these grants do not target the development of low-carbon or carbon-free technologies. Given the real threat of climate change, would you support targeting climate-friendly technologies?

Answer. The Administration is currently evaluating the provisions of S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006—including the ARPA-E provisions. As our assessment proceeds, however we would be happy to discuss the details of the legislation, including ARPA-E or possible alternatives with you or your staff.

The President's Advanced Energy Initiative aims to reduce America's dependence on imported energy sources, encourage the use of alternative fuel technologies that reduce emissions, and generate cleaner electricity. The FY 2007 DOE budget requests $2.1 billion to meet these goals, an increase of $381 million over FY 2006.

The FY 2007 budget request emphasizes investment in alternative fuel technologies, among other areas. Numerous DOE offices will participate in the Advanced Energy Initiative. The Office of Science's share ($539 million) of this Initiative will fund the ITER project, an experimental reactor expected to further the potential of nuclear fusion as a source of environmentally safe energy, as well as solar, biomass, and hydrogen research programs.

The Office of Energy Efficiency and Renewable Energy's share ($771 million) of the Initiative includes funding increases for hydrogen, fuel cell, biomass, solar, and wind research programs. The Office of Fossil Energy's share ($444 million) supports its Coal Research Initiative and other power generation/stationary fuel cell research programs. The Office of Nuclear Energy, Science and Technology's share ($392 million) includes $250 million for the Global Nuclear Energy Partnership (GNEP) and also supports Generation IV, Nuclear Power 2010, and the Nuclear Hydrogen Initiative. GNEP is a comprehensive strategy to enable an expansion of nuclear power in the U.S. and around the world, to promote nuclear nonproliferation goals; and to help resolve nuclear waste disposal issues.

*ARPA-E and the Commercialization of Promising Energy Technologies*

*Question 2.* Additionally, ARPA-E does not include a clear regulatory pathway to commercialization. Do you believe that the DARPA model is a good model for energy technologies given the lack of a customer in the energy markets compared to the military? Can you provide thoughts on how these technologies can be commercially developed?

Answer. As stated above, the Administration is in the process of evaluating the provisions of S. 2197, the Protecting America's Competitive Edge through Energy Act of 2006—including the ARPA-E provisions, and so we are not in a position to comment at this time. As our assessment proceeds, however, we would be happy to discuss our views and gain input from the Committee and its staff.

# APPENDIX II

## Additional Material Submitted for the Record

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### PREPARED STATEMENT OF DR. PATRICK KOCIOLEK, EXECUTIVE DIRECTOR OF THE CALIFORNIA ACADEMY OF SCIENCES

I would like to thank the Committee for the opportunity to present this testimony for the record on the important issue of improving science education to ensure America's long term competitiveness. The PACE-Energy Act (S. 2197) currently being considered by the Committee provides an excellent foundation for improving the scientific understanding of future scientists and non-scientists alike. I applaud the effort.

America's competitiveness in the 21st century is inextricably linked to science and, therefore, science education. The areas of science that have been important to our country, and continue and will be important in the foreseeable future include space sciences, technology, medicine, agriculture, chemistry, energy and biology. 1 would, however, like to add additional perspective on the important role played in science education by "informal" institutions such as the California Academy of Sciences as well as other zoos, aquaria, planetariums, science centers and museums.

As the Committee prepares to markup S. 2197 I recommend that the Committee consider opportunities for informal science education within the scope of the new programs authorized in the bill. The remainder of my statement discusses the significant contributions of informal science education to the objectives of this legislation.

#### INFORMAL SCIENCE INSTITUTIONS ARE INSTRUMENTAL IN DEVELOPING EARLY INTEREST AND EXCITEMENT KEY TO LONG-TERM INTEREST IN SCIENCE AND SCIENCE CAREERS

Through a wide ranging set of exhibitions and programs, museums, aquaria and planetariums play important roles in helping people better understand science, appreciate the role of science in their daily lives, have them participate in the scientific process and experience and consider careers in the scientific enterprise. This familiarity with science is critical for our stature in the world and the functioning of our democracy. The pipeline for future scientists must be developed early, to not address immediate needs, but to ensure a reliable source of scientists for future generations.

A study by the National Science Foundation indicated that over 90% who currently have careers in science remember being stimulated about the sciences through visits to natural history museums, aquariums and planetariums. This staggering figure demonstrates the impact informal learning opportunities can have on our children's interests and their career decisions.

Our institution, and others like it, take this a step further and provide real world training to young people. The California Academy of Sciences runs a program called "Careers in Science" in which we offer paid internships to young people (concentrating on underrepresented and economically disadvantaged populations) starting at age 15. Once accepted into this program, students continue as employees of the Academy, working in laboratories, libraries, and on the public floor of the museum, through their first year in college. Over 90 percent of the students who participate in this program do go on to college, many representing the first in their families to do so. Last year we had 135 applications for the 8 openings in this program.

#### INFORMAL SCIENCE INSTITUTIONS AND FORMAL EDUCATION ARE INEXTRICABLY LINKED

Museums are excellent adjuncts to the formal education process. In San Francisco, the California Academy of Sciences hosts classes and teachers from every school-public and private, elementary, middle and high school, to its museum every year. In addition, 40% of the schools from Monterey to the Oregon border send at least one class to the Academy every year. The importance of augmenting what is

happening in the classroom cannot be underestimated. Early assessment tools are showing students who have had an experience at a museum do better on classroom assignments and test scores than those not attending the museum. It has been estimated that museums spend more than $1 billion helping to provide over 18 million instructional hours for educational programming. These programs are built around national and state science standards to ensure a direct link between classroom topics and expectations and the museum programs.

Museums also provide teachers with access to scientists, experiences, information and objects that can augment their classroom activities and learning environment. In this day and age where resources of many kinds are in short supply in our nation's schools, museums have important education tools and objects support inquiry-based learning. In some instances informal science education institutions provide access to resources that it does not make sense for each school system to possess—for example, few school systems would consider duplicating the live animal collection of the National Zoo. In other instances, school systems do not have access to even rudimentary science tools such as microscopes. In these cases, access to a museum or science center provides students with their only hands on experience with the scientific process.

In addition, these "informal" institutions can and do provide career enhancement opportunities for teachers, allowing them to engage and discuss with scientists on the cutting edge of their fields, providing teachers with the latest knowledge to take into their classrooms. Teacher trainings and a wide range of professional development opportunities afforded by museums help with the "domino effect" of leveraging impact from teachers to students.

INFORMAL SCIENCE INSTITUTIONS INCREASE THE GENERAL SCIENCE LITERACY SO IMPORTANT IN AN INCREASINGLY COMPLEX TECHNICAL ENVIRONMENT

Museums are great equalizers in our society: They bring real objects and ideas to a large and diverse audience that would otherwise not have direct access to incredible resources: resources from the community as well as from around the world. Natural history museums, aquaria, planetariums and science centers host hundreds of millions of visitors, local, regional and national.

Museums are trusted sources of information. 90% of Americans, across large segments of our society trust what they learn from museums. This incredible responsibility of museums can be translated into access and the ability to convey important concepts and information that are relevant, useful and make impacts on the daily lives of our citizens.

To meet the current and emerging demands in the sciences, we need to create a workforce well versed in the sciences, and invest in research and development to stay ahead and apace of the world. However, it is also essential that all Americans better understand the scientific process and the importance science has on their lives, as well as the lives of their children, grandchildren and future generations of Americans.

So many decisions that we make each day, from the foods we eat, medical procedures we choose, transportation alternatives we consider, to how we heat and cool our homes and businesses, and the environmental conditions in which we live, require some understanding of scientific principles and processes. And—as much of the legislation brought before our local, state and national legislatures have scientific bases (homeland security, agriculture, and transportation to name a few)—the integrity and effectiveness of the democratic process is impacted by the level of understanding of science by the general public. To maintain and forward our competitive advantage on a worldwide scale, America needs to help make a more scientifically literate citizenry.

INFORMAL SCIENCE INSTITUTIONS CONDUCT IMPORTANT SCIENTIFIC RESEARCH

In many museums, original scientific research is conducted that is critical for America's future. Identities and distribution of organisms that share the planet with us helps us understand climate change, environmental degradation, conservation biology all with impacts on the food we eat, water we drink, air we breathe, energy we use. Confirming the identity of potential organisms from bioterrorism to alien and invasive species in our lands and waters, is accomplished by research expertise in America's museums. This research is supported by tools such as geographic information systems, high throughput DNA analysis, bioinformatics, electron microscopy, as well as environmental data capture and imaging. A wide range of collaborators with museum-based research include federal agencies, institutions of higher learning, national laboratories and museums, agencies and NGO's all around the world. This research in museums also forms the foundation of exhibitions, and engages

high school, undergraduate, and graduate students as well as professionals. Participation in museum sponsored or conducted research provides real world experiences in the scientific process for high school, undergraduate and graduate students.

INFORMAL SCIENCE INSTITUTIONS FOSTER LIFELONG LEARNING

An increasingly important aspect of our society is providing for meaningful learning opportunities for our aging population. Lifelong learning for retirees, seniors and others are critical to ensure quality of life for this growing segment of our society. Docents and volunteers at museums allow people the ability to continue their learning experiences until late in life, to stay up-to-date and young in ideas and experiences. And they help to teach and serve as role models for children. Many docents have retired from careers in science, and these programs continue to utilize important resources in our communities. Adult education programming offers traditional school settings, while museum travel programs and nature tours, hikes and forays provide alternative settings and learning opportunities. All of these provide our citizens with scientific knowledge and ways of thinking that benefit them in choices related to quality of life issues and support for scientific and education initiatives.

OUR IMPACT ON EDUCATION EXTENDS WELL BEYOND OUR WALLS

The impact of museums goes far beyond the physical buildings themselves. Literally tens of millions of Americans access information developed by museums via the world wide web on topics as diverse as biology, astrobiology, mathematics, physics, geology, foods and energy-related topics, gaining access to authentic and reliable information images, sounds, research results and curricula as well as other information resources.

MUSEUMS ARE IMPORTANT PARTNERS IN REALIZING AMERICA'S COMPETITIVENESS

So, as we discuss the important roles of education, research and incentives for America to stay on the front edge of scientific innovations to remain competitive, it is important to consider and realize the importance America's museums, science centers, aquaria and planetariums play in advancing the knowledge of the general public, in all of its diversity, for better lives today and in the future.

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