

# The Human and Intellectual Capital Investments Necessary for a Sustainable Nuclear Energy Future

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It has been 25 years since I last attended a meeting of the American Nuclear Society, in this very hotel (although I believe it was then known as the Sheraton Park). Although the hotel name has changed, the faces in the audience have not. A bit more gray; and in fact a lot less hair—but after all these years, you are still energetic and attentive, and perhaps even a bit wiser for the wear. I've also seen lots of water over the dam since the 1970s—serving as a dean of engineering, a university president, a member and chair of the National Science Board, a council member of the National Academy of Engineering, and even as chair of the Big Ten Athletic Conference. This afternoon I wear still another hat, as chairman of the Nuclear Energy Research Advisory Committee (NERAC) of the Department of Energy.

#### The Nuclear Energy Research Advisory Committee

As you may be aware, NERAC was established in 1998 to provide independent advice to the U.S. Department of Energy (DOE) on complex science and technical issues that arise in the planning, managing, and implementation of DOE's nuclear energy program. The formation and activities of NERAC are directly related to the concern about the future of this nation's capability in nuclear energy technology expressed in a 1997 report of the Energy R&D Panel of the President's Council of Advisors on Science Technology (PCAST). The Council noted that the federal government's investment in research and development of nuclear technology declined substantially in the 1980's and 1990's and programs such as the Advanced Light Water Reactor program and Integral Fast Breeder Reactor were completed or phased out. In fact, by 1998, the funding for nuclear R&D had declined to zero, prompting the PCAST panel to note:

“Fission's future expandability is in doubt in the United States and many other regions of the world because of concerns about high costs, reactor-accident risks, radioactive-waste management, and potential links to the spread of nuclear weapons. We believe that the potential benefits of an expanded contribution from fission in helping address the carbon dioxide challenge warrant the modest research initiative proposed here (the Nuclear Energy Research Initiative), in order to find out whether and how improved technology could alleviate the concerns that cloud this energy option's future. *To write off fission now as some have suggested, instead*

*of trying to fix it where it is impaired, would be imprudent in energy terms and would risk losing much U.S. influence over the safety and proliferation resistance of nuclear energy in other countries. Fission belongs in the R&D portfolio.”*

Of related concern was the erosion in academic programs and facilities necessary to produce the human resources needed by the nation’s nuclear industry and nuclear defense programs. Over the past decade the number of nuclear engineering programs in this country have declined by half (from 80 to 40), the number of university research and training reactors by two-thirds (from 76 to 28), and enrollments have dropped by almost 60% (from 3,350 to 1,378). As noted in a recent planning study:

“Nuclear engineering programs in the United States are disappearing. Without concerted action by DOE, supported by OMB and the Congress, most of the existing nuclear engineering programs will soon evaporate or be absorbed and diffused in other engineering disciplines.”

PCAST expressed its concern that the decline in federal investment in the development of intellectual and human had eroded the nation’s capabilities in nuclear technology and threatened the availability of the nuclear option for meeting 21<sup>st</sup> Century energy needs. To this end, it strongly recommended a restoration of federal investment within the context of a long-range research and human resource development plan. The Department of Energy created the Nuclear Energy Research Advisory Committee to assist in this effort.

More specifically, NERAC assists DOE by reviewing the research and development (R&D) activities of the Office of Nuclear Energy, Science and Technology (NE) and providing advice and recommendations on long-range plans, priorities, and strategies to effectively address the scientific and engineering aspects of these efforts. In addition, the committee provides independent advice on national policy and scientific aspects on nuclear energy research issues as requested by the Secretary of Energy or the Director, NE. The committee operates in accordance with the Federal Advisory Committee Act (FACA) and has a diverse membership with a balance of disciplines, interests, experiences, points of view, and geography from academia, industry, and national

laboratory communities. A list of the current membership of the Committee is provided as an appendix to my testimony

Last year DOE requested that NERAC assist the Department in developing a long-term nuclear energy R&D plan, identifying priorities and possible programs along with an assessment of funding and infrastructure needs. Furthermore, the Committee was also tasked to evaluate DOE's physical infrastructure for nuclear energy research (e.g., research reactors, hot cells, and accelerators) in light of the needs suggested by the long range nuclear energy R&D plan. In addition, NERAC was asked to assess the current crisis in university nuclear engineering programs and campus-based research facilities in light of the growing human resources needs of the nation.

To conduct these long range planning activities and provide timely advice concerning ongoing or proposed DOE programs in nuclear energy research, NERAC works through a series of subcommittees:

- Long-Range Nuclear Technology Research and Development Plan
- Nuclear Science and Technology Infrastructure Roadmap Committee
- Long Term Isotope Research and Production Plan Subcommittee
- NERAC Blue Ribbon Panel on the Future of University Nuclear  
Engineering Programs and University Research Reactors
- Technology Opportunities for Increasing the Proliferation Resistance  
For Civilian Nuclear Power Systems (TOPS) Task Force
- Accelerator Transmutation of Waste Subcommittee
- Operating Nuclear Power Plant Research, Coordination, and Planning  
Subcommittee
- Generation IV Reactor R&D Planning Subcommittee

To address these concerns, NERAC, through its various subcommittees, has undertaken over the past two years a major planning effort to determine the investments in human resources, research and technology, and infrastructure necessary to restore the nation's capability in nuclear energy. In May we received the initial reports from our various planning subcommittees.

## Principal Conclusions of the Long-Range Planning Activities

Although these planning efforts are intended to be ongoing and evolutionary, they do provide a strong sense of priorities for DOE/NE in the years ahead. Put simply, the reports stress the importance of adequate investment in ideas (research), people (education), and tools (facilities). It is our believe that restoring an adequate investment in the development of intellectual and human capital is the first key step the nation must take to preserve its nuclear option.

Ideas: There is an urgent sense that the nation must rapidly restore an adequate investment in basic and applied research in nuclear energy if it is to sustain a viable United States capability in the 21<sup>st</sup> Century. The Long Range Planning Study has recommended a set of program and funding priorities ramping to a level of \$240 million by FY2005, including a growth in funding of the Nuclear Energy Research Initiative (NERI) to achieve the goals set by PCAST. We anticipate that this would scale up to levels more comparable to those characterizing the 1970s and 1980s as experimental facilities are developed and demonstration projects are launched. However NERAC believes it important that during the early years, the focus be on developing a broad-based research project rather than focusing prematurely on the development of specific technologies or projects. It is also recommended that at least a part of this program accommodate investigator-initiated basic research projects, selected on the basis of scientific merit rather than confined to DOE programmatic needs.

Here it should be noted that NERAC believes that such funding levels are not only necessary but realistic in view of the funding provided other DOE research programs such as fossil energy (\$293 M in FY 2001), renewable energy (\$410 M), nuclear physics (\$360 M), and high energy physics (\$708 M).

People: The report of the Long Range Planning Subcommittee reflects the views both of the other committees and NERAC membership when it states: "Perhaps the most important role for DOE/NE in the nuclear energy area at the present time is to insure that the education system and its facility infrastructure are in good shape." It is clear that United States nuclear engineering programs and university reactor facilities are at great risk and require immediate and concerted attention in DOE funding priorities. The

NERAC Blue Ribbon Panel has made a number of important recommendations concerning the nature of DOE programs and support necessary to preserve and strengthen these important national resources. In particular, the Panel recommends an increase of the Nuclear Engineering Educational Research (NEER) program to \$20 M/y, a new competitive research grant aimed at sustaining university research reactors at a level of \$15 M/y, and a graduate fellowship/traineeship program at \$5 M/y. The Panel believes that the plight of nuclear engineering education in this nation is sufficiently serious that the Department should take substantial steps in its FY2002 budget request to move toward these targets.

Tools: Finally, the Long Range Planning subcommittee, Infrastructure Roadmapping Subcommittee, and the Isotope Subcommittee stress the need for DOE facilities to sustain the nuclear energy research mission in the years ahead. Of particular need over the longer term are dependable sources of research isotopes and reactor facilities providing high volume flux irradiation for nuclear fuels and materials testing. NERAC recognizes the serious funding and policy issues associated with such facilities (including the use of existing facilities such as FFTF). However it is also important to state NERAC's view that without an adequate investment in basic and applied research programs and in human resource development, such expensive facilities will be useless. Again put most simply, the *tools* are useless without the *people* and *ideas* to make use of them. NERAC believes that these priorities should—indeed, must—guide the Department of Energy's and Administration's funding requests for DOE/NE. The most important needs of the nation at this critical juncture are the intellectual capital and human resources necessary to strengthen and sustain our capacity in nuclear technology

It is important to recognize that these reports represent the efforts, consideration, and wisdom not only of NERAC committee members but as well of the hundreds of members of the broader scientific and engineering community who participated in the various workshops and drafting sessions associated with these studies. As such we believe that the Department of Energy, the Administration, and the Congress should give careful consideration and significant weight to the recommendations in these reports as they frame the programmatic planning and funding requests for the nuclear energy research activities of the Department of Energy.

## Investing in the Future

Before closing, let me offer some more informal observations. I'm from Missouri, where we have a saying that to get a mule to move, sometimes you have to first whack it over the head with a 2x4 to get its attention. Well, I'm going to set aside my hat as chair of NERAC, and instead speak both as a former university president and former chair of the National Science Board to serve as a 2x4 to get the attention of the American Nuclear Society.

We've had several discussions this afternoon portraying an optimistic future for nuclear power in the century ahead, driven both by growing environmental concerns about the burning of fossil fuels and the growing energy needs of our planet, particularly driven by the needs of developing nations. Yet I fear that all of this optimism may be just so much wishful thinking.

The future of nuclear power today is symbolized by empty college classrooms and discontinued nuclear engineering programs, by decommissioned university reactors, and by students turning away from nuclear science and engineering to major in areas such as software engineering and biotechnology, where they see the real action. We simply must face reality. We in this room are a group of graying nuclear scientists, engineers, and executives that seem to have forgotten that the future of this technology will not be determined by us, but by the next generation of scientists, engineers, and leaders. And yet, as governments, industry, and universities, we simply have not made the necessary investments during the past two decades to create this new generation.

Let me give you two examples. First, consider the R&D budget of the Department of Energy. In FY 2001 the Department will spend:

- \$3.0 billion on research of its Office of Science
- \$3.7 billion on defense R&D
- \$1.3 billion on energy R&D (mostly renewables)
- \$1.1 billion on higher energy physics and nuclear physics

What will it spend on nuclear science and engineering and on nuclear engineering education? \$12 million! About 1% of what it is planning to spend on physicists chasing the Higgs boson!

Beyond that comparison, I would note that while most research budgets of the Department of Energy grew by 10% to 14% this year, for the third year in a row the nuclear science and engineering budget remained frozen at \$12 million. Its growth was zero.

Ironically, in the summer of 1999 and again in 2000, NERAC conveyed to the Department its highest priority recommendation that adequate funding be provided to these university programs. And what was the administration's response? Procrastination ... and a deaf ear.

We made the same recommendations to Congress. The same result: no action. As a consequence in 2001 we will have even fewer academic programs, fewer campus-based nuclear facilities, fewer students, and even more damage to this nation's nuclear technology capabilities.

Let me offer a second example: Education and research in nuclear science and engineering depend heavily on access to nuclear facilities, e.g., nuclear reactors, hot cells, accelerators, and the like. Over the decades, universities have made very substantial investments in developing and supporting campus-based nuclear reactors to sustain not only nuclear engineering programs but as well to provide support for many other areas of scientific research and training. Although these facilities were initially stimulated, encouraged, and supported by the Department of Energy (and its predecessor, the Atomic Energy Commission), federal support has dropped dramatically over the years, now consisting of roughly \$2.8 million per year for fuel subsidy and another \$1.5 million for limited support. Yet both the operating costs carried by universities and the projected costs of modernizing these facilities so that they are adequate for contemporary research and training are forcing universities, one by one, to decide that without Department of Energy support, it is simply not worth the expenditure in the face of other more urgent campus priorities. And one by one, these facilities are being closed down, dropping from 76 in number in the 1970s to 28 today. And we have



just learned that within the next several months, three of the leading nuclear engineering programs in the nation, MIT, Cornell, and Michigan will likely be forced to close their reactor facilities.

The irony is that for a small investment, amounting to \$10 million per year or less, the Department of Energy could keep a significant number of university reactor facilities open as national resources. But instead it chooses to spend \$44 million per year to keep sacred cows such as the Fast Flux Test Facility on life support (and perhaps even to resuscitate it at a considerably higher cost), while allowing university reactors, which are far more valuable for training and research purposes, to die, one by one.

Let me be very clear about the urgency of this matter. Unless the Department of Energy reprograms funding in FY 2001 and places a priority in its FY2002 budget to provide support for these university reactor facilities, a domino chain of closures will occur over the next several years eliminating most nuclear facilities on university campuses. Of course, one could argue that it might be better if all of the university reactors were closed, and one (or several) major national facilities were built for education and research. But, this should be a strategic decision rather than a consequence of benign neglect.

Let me conclude with the conclusion stated in an executive summary of a report by the Nuclear Energy Agency of the Organization for Economic Cooperation and Development:

“Today nuclear technology is widespread and multidisciplinary. Yet the advancement of this technology, with all its associated benefits, will be threatened, even curtailed, unless the declining number of university courses associated with it, and the declining interest among students in it, is arrested. In most countries there are now fewer comprehensive, high quality nuclear technology programs at universities than before. The ability of universities to attract top quality students to these programs, meet future staffing requirements of the nuclear industry, and conduct leading edge research in nuclear topics is becoming seriously compromised.

“Failure to take appropriate steps now will seriously jeopardize the provision of adequate expertise tomorrow. Governments should contribute to, if not take responsibility for, integrated planning to ensure that human resources are available to meet necessary obligations and address outstanding issues.”

Let me put my conclusion another way: It is time for us to stop talking about the future, and instead to start investing in it. By investing first in our people, our human capital, and then in new knowledge, our intellectual capital, we can take important steps toward a future of sustained capability in nuclear technology.