U.S. Workforce and Educational Facilities' Readiness to Meet Future Nuclear Challenges:

Progress Report on an APS POPA Study

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APS Spring Meeting 2008

Charge

To study the adequacy of the U.S. nuclear workforce and educational facilities to meet future nuclear challenges.

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National Needs for Nuclear Expertise

- Nuclear power
- Safeguarding the weapons complex
- Defense against nuclear and other forms of terrorism
- Healthcare
- Occupational health and safety

Workforce

- Variety of engineers: nuclear, mechanical, computer…..
- Nuclear chemists and radiochemists
- Physicists, including health, nuclear, materials
- Study focused on nuclear engineers, nuclear & radiochemists, and health physicists with at least a Bachelor's degree.

Facilities

- **University reactors**
  - ***Research reactors (> 1MW)*** perform state-of-the-art experiments in a variety of disciplines, including nuclear engineering, materials science, physics, and medicine.
  - ***Training reactors (<1 MW)*** provide hands-on experiences for students, including both nuclear engineering and health physics students, as well as reactor technicians.
- **Other research infrastructure in universities**

Status of Nuclear Power

- Currently, 104 civilian nuclear reactors
- Number held steady for over 2 decades
- How private industry has survived
  - Hiring those with nuclear degrees
  - Retraining others to perform nuclear tasks
    - Mainly mechanical engineers
    - Civil engineers
    - Chemical engineers, etc.
  - Hiring Ex-Nuclear Navy personnel

APS Statement on Global Warming and Climate Change

"The evidence is incontrovertible: Global warming is occurring. If no mitigating actions are taken, significant disruptions in the earth's physical and ecological systems, social systems, security and human health are likely to occur. We must reduce emissions of greenhouse gases beginning now."

Reference: National Policy, 07.1, *Climate Change*,

http://www.aps.org/policy/statements/07_1.cfm

MIT Study

The Future of Nuclear Power: An Interdisciplinary MIT Study
ISBN 0-615-12420-8, 2003, http://web.mit.edu/nuclearpower/.

There are few options in near future to reduce greenhouse gas emissions from the production of energy:

- Increased plant efficiency
- Expansion of renewables:wind, solar, etc.
- Capture and sequestering of carbon dioxide emissions
- Increasing the contribution from nuclear reactors.

Contribution of Nuclear Power in U.S. Energy Mix

- 104 reactors provide ~20% of electricity
- Currently accounts for ~70% of non-carbon emitting electricity
- American Physical Society has argued that a balanced U.S. energy policy should maintain the nuclear energy option through the development and availability of nuclear plants and supporting infrastructure that can be built, operated, and eventually decommissioned in a safe, secure, environmentally sound and cost-effective manner.

  APS Panel on Public Affairs, *Securing Benefits, Limiting Risk*, May 2005.

http://www.aps.org/policy/reports/popareports/index.cfm.

Future U.S. Nuclear Scenarios

Due to resurgence of interest in nuclear power, various scenarios through the year 2050 are being discussed.

- Maintaining the current number of reactors without reprocessing (once-through fuel cycle)
- Significantly increasing – some call for doubling or even tripling – the number of reactors without reprocessing
- Significantly increasing the number of reactors while closing the fuel cycle by reprocessing and recycling spent fuel.

Energy Policy Act of 2005

- First comprehensive U.S. energy legislation in over a decade
- Among its many provisions, EPACT authorized the Nuclear Power 2010 program
  - Joint government/industry endeavor to identify new nuclear reactor sites, bring to market advanced standardized nuclear reactor designs, and demonstrate improved regulatory licensing
  - Authorized the implementation of Federal loan guarantees and other financial incentives.
- Private industry has announced plans to develop combined construction and operating license applications for ~30 new nuclear power plants and several of these applications already have been submitted to the NRC.

Global Nuclear Energy Partnership

- Spur the global growth of nuclear power, even in developing countries, while simultaneously reducing the threat of nuclear weapons proliferation.
- On domestic front, according to Clay Sell, Former Deputy Secretary of Energy:

"…The first element [of GNEP] is to expand dramatically the use of nuclear power here in the United States……. from a public policy standpoint we're shooting for 300 reactors in 2050; that's a significant increase. That's what we think would be appropriate to meet our energy needs as well as to manage our greenhouse gas emissions and that's going to require significant advances in technology."

Foreign Press Center Briefing, Washington, DC, February 16, 2006, http://fpc.state.gov/fpc/61808.htm.

Working Group Logistics

- Held two Workshops
- Conducted Site Visits to university reactors
  - North Carolina State
  - MIT
  - University of CA-Davis/McClellan Nuclear Research Center
- Visited new nuclear engineering program at South Carolina State University (an HBCU) established with University of Wisc-Madison and distance reactor training with NC State.

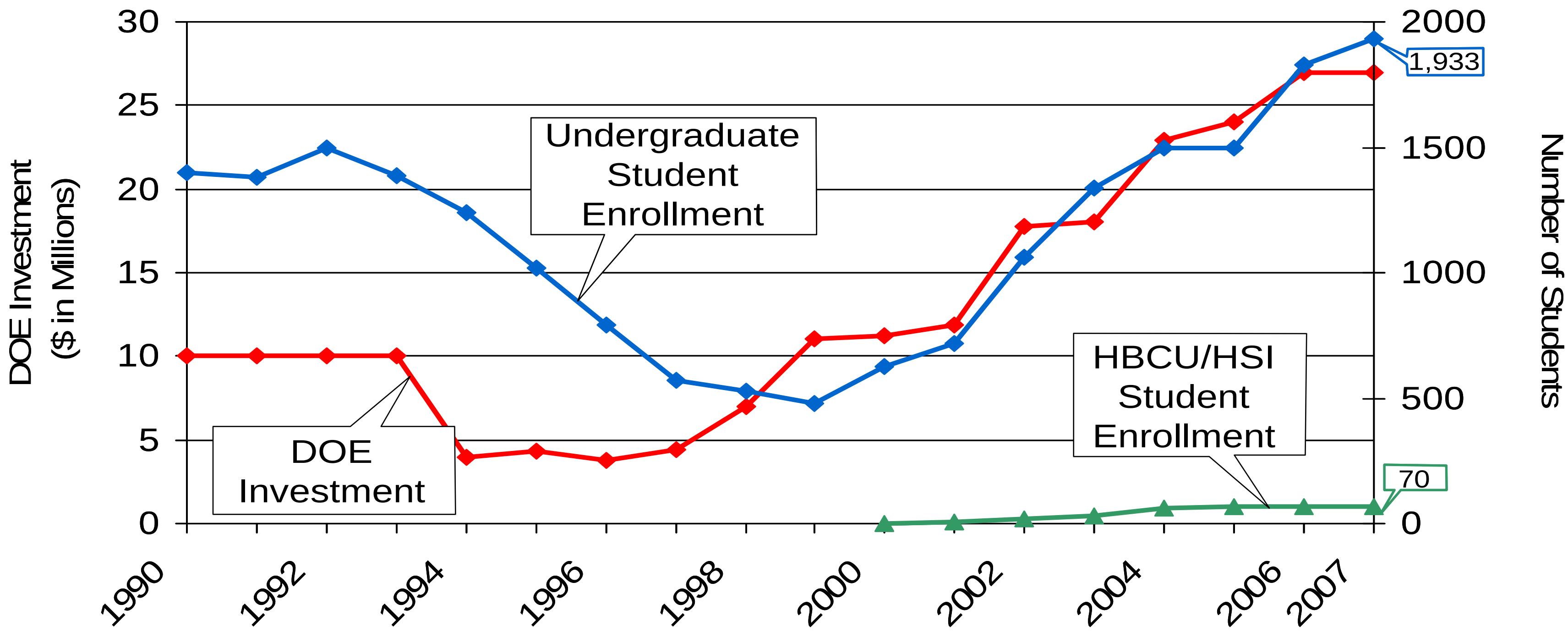
Audience for Report on Study

- Executive Branch of the Federal government
- Congress and staffers
- Governors and State Legislators, who provide much of the base funding to university departments and reactors at public universities
- University faculty and administrators, who have a primary stake in the health of their academic departments and reactors
- APS members

Organization of Report

- Overview of Federal support for nuclear science and engineering research and education
- Summaries past reports on nuclear science and engineering education, the closely aligned fields of nuclear chemistry and radiochemistry, and health physics
- Assessment of DOE's *Innovations in Nuclear Infrastructure and Education (INIE)* program, what it has meant to the university research and training reactors, and describes the results of a survey of the needs of those facilities
- Status of facilities for measuring actinide cross sections that are crucial for designing and implementing advanced nuclear reactor fuel cycles
- Findings relative to the workforce and educational facilities and their adequacy to meet both public and private future nuclear challenges
- Recommendations are currently under discussion among POPA members and the Working Group

DOE Investments in Univ. Nuclear Science and Engineering Research & Education/Undergraduate Student Enrollments in Nuclear Engineering



Data source: DOE

Other Factors for Increasing Enrollments

- Growing public concern about global warming
- Positive governmental statements in support of nuclear energy
- More aggressive student recruitment by nuclear engineering departments
- Broadening the names and academic emphases of many departments

Nuclear Energy Research Advisory Committee (NERAC)

- In 1996, the President's Council of Advisors on Science and Technology (PCAST) urged President Clinton to reinvest in nuclear science and engineering research and education.
- PCAST urged him to establish the Nuclear Energy Research Advisory Committee to provide advice to DOE on this reinvestment.
- In 1998, the Clinton administration constituted NERAC to advise DOE as it began reinvesting both funds and management attention to rebuilding the educational infrastructure for nuclear engineering, health physics, and to a more limited degree, nuclear chemistry and radiochemistry.

Funded Programs

- ***Reactor Fuel Assistance***, which comprised essentially all DOE's support to universities before 1997 and provides fresh fuel to, and takes back spent fuel from, the operating university research and training reactors in the United States
- ***Nuclear Engineering/Health Physics Fellowships and Scholarships***, a competitive program which provides direct support to students studying in these fields
- ***Radiochemistry***, under which DOE awards three-year grants to support education activities in the field of radiochemistry
- ***Nuclear Engineering and Science Education Recruitment Program***, which is designed to increase the number of students entering nuclear engineering by providing a core curriculum to instruct high school science teachers in nuclear science and engineering topics
- ***International Student Exchange Program,*** which sponsors U.S. students studying nuclear engineering to spend 3-4 months abroad doing research at nuclear facilities in Germany, France, and Japan

Funded Programs (cont'd)

- ***DOE/Industry Matching Grants***, through which DOE and participating companies provide matching funds, up to $60,000 from each side, to universities for use in funding scholarships, improving nuclear engineering and science curricula, and modernizing experimental and instructional facilities
- ***Nuclear Energy Research Initiative (NERI)***, which uses peer-review selection of proposals to support fundamental research in nuclear science and engineering at universities, national laboratories, and in private industry
- ***Nuclear Engineering Education Research (NEER) Grants***, a highly competitive, independently peer-reviewed research grants program aimed at university nuclear engineering programs
- ***Reactor Use Sharing***, through which DOE enables universities with reactors to provide students and faculty from other institutions with access to their research facilities
- ***Reactor Upgrades***, through which DOE provides assistance to universities to improve the operational and experimental capabilities of university research and training reactors
- ***Innovations in Nuclear Infrastructure and Education (INIE)***, a program which encourages strategic partnerships among the universities, the DOE national laboratories, and industry, and leverages resources made available by the partners.

Reversal of Policy

- In FY 2007 budget request, DOE announced that it had completed its mission in the area of nuclear science and engineering education and planned to terminate the university program.
- Proposed zero funding for nuclear education for both FY 2007 and FY 2008, and proposed to provide only basic fuel services for university research reactors under a new infrastructure program.
- Actions of Congress
  - For FY 2007, rejected DOE’s proposal to terminate the program and provided $16.5 million, which was far less than the $27 million the program received in FY 2006.
  - In the FY 2008 Consolidated Appropriations Act, provided $15 million and **transferred the program to the NRC**!!!

SUMMARY OF PAST REPORTS ON U.S. NUCLEAR READINESS

Nuclear Science and Engineering Education

- **There will be a continuing, long-term, significant need for nuclear educated scientists and engineers, and this need is all-sector encompassing, including industry, government, and academia.**

- Quoting a recent report from the American Nuclear Society, "*It is clear that the growing problems associated with the interface between nuclear weapons and nuclear power will increasingly require innovative technical and policy solutions and people who are literate, trained, and educated in nuclear processes.*"

Reference: U.S. University-Based Nuclear Science and Engineering Education System for the 21st Century, Special Committee on Federal Investment in Nuclear Education, American Nuclear Society, December 2006.

NS&E Education (cont'd)

- **Some agency of the Federal government must be in the stewardship position with respect to nuclear science and engineering education**, and the designated agency must have the resources necessary to support the widespread needs for the development and maintenance of human resources, facilities, and basic and applied research.
- Federal support for the nuclear science and engineering disciplines has been extremely effective in improving the quantity and quality of human nuclear technology expertise and expanding the university infrastructure for nuclear research and training.

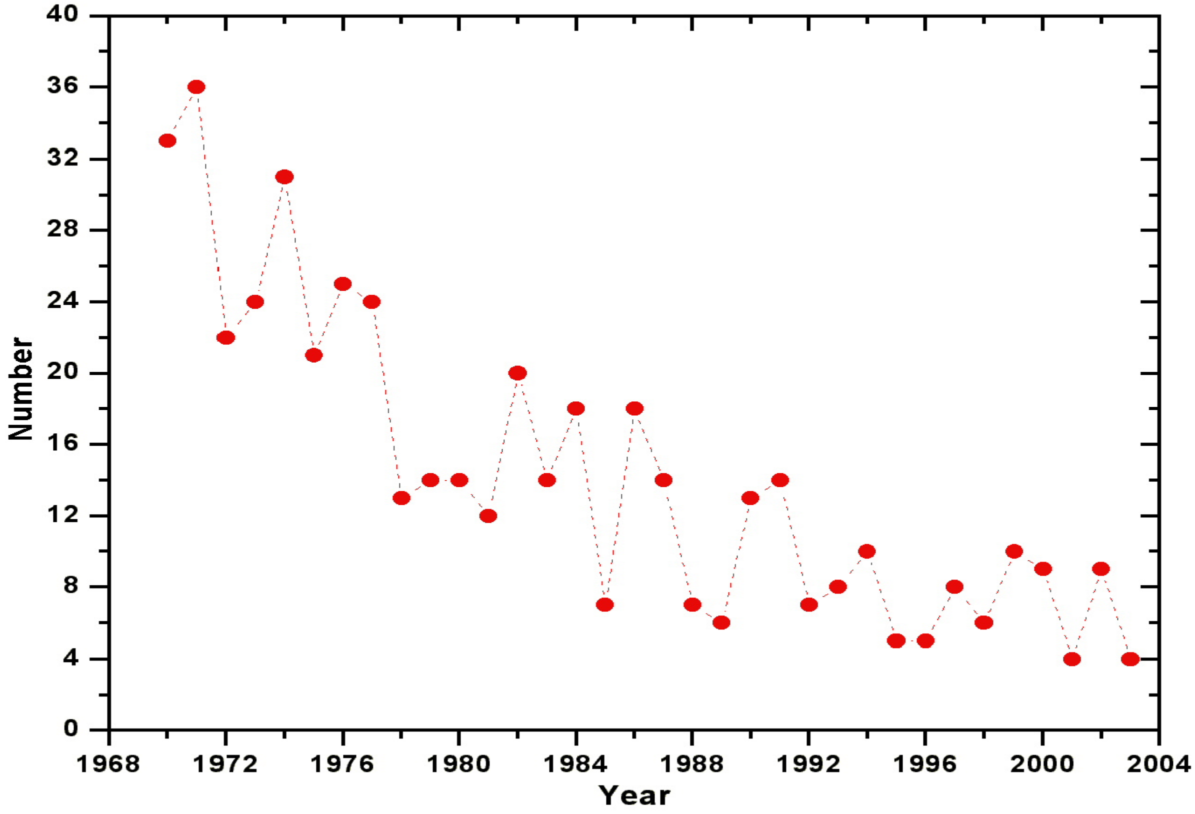
Nuclear Chemistry and Radiochemistry

- Nuclear chemistry and radiochemistry overlap in many ways and many scientists consider themselves to be both.
- Radiochemistry is the study of radioactive elements using chemical techniques, focusing on their radioactive characteristics.
- Nuclear chemistry is the study of the fundamental properties of nuclei, both radioactive and non-radioactive, using chemical techniques. It is quite close to the field of nuclear physics.
- Experts often group Ph.D. nuclear chemists and radiochemists into six categories according to the following research interests:
  - Fundamental nuclear chemistry
  - Chemistry of radioactive elements
  - Analytical applications
  - Nuclear probes for chemical studies
  - Tracer techniques and labeled compounds
  - Nuclear medicine and radiopharmaceuticals.

Nuclear & Radiochemistry (cont'd)

- More than just for nuclear power's processing of both fresh and spent reactor fuel, nuclear chemistry and radiochemistry are extremely important to the Nation's energy, health, and security in the following cross-cutting roles:
  - Nuclear weapons stockpile stewardship and validation
  - Nuclear forensics and surveillance of clandestine nuclear activities
  - Monitoring of radioactive elements in the environment
  - Production of radioisotopes
  - Preparation of radiopharmaceuticals for therapeutic and diagnostic medical applications.

Numbers of Nuclear Chemistry Ph.D.s Earned at U.S. Universtities: 1970-2003



References: ORISE (1970-72); ACS-DNCT 1979 Ad Hoc Comm. (1973-79); NSF 1980-2003

Nuclear & Radiochemistry (cont'd)

- **Nuclear chemistry is all but extinct in the United States!!!**
- The Federal government must take an active role in reinvigorating the fields of nuclear chemistry and radiochemistry, including
  - Increasing the numbers of tenure-track faculty
  - Increasing the allocation of funding to support students and research
  - Devising effective means of outreach to the general public

Nuclear & Radiochemistry (cont'd)

- Caution should be exercised in comparisons with the exact numbers from the very early years as those may have included some category 2 and 3 radiochemists.
- Beginning in 1980, the National Science Foundation (NSF) reported only numbers for fundamental nuclear chemistry.
- In 2004, NSF dropped nuclear chemistry as a category in its database.

Nuclear & Radiochemistry (cont'd)

- If nuclear chemistry and radiochemistry are not quickly reinvigorated, reprocessing in the U.S. will have to be removed from the suite of future nuclear options unless a decision is made to import expertise from abroad.
- Nuclear energy needs for nuclear chemists and radiochemists with Ph.D.s
  - Train large cadre of radiochemical technicians.
  - Perform the research that leads to breakthrough radiochemical technologies for spent nuclear fuel storage, separations and reprocessing.

Health Physics

- *"Even if it is assumed that an equal percentage of individuals retire over a forty-year working lifetime, the number of existing health physics program graduates, i.e., ~122 per year, does not meet or exceed the demand based on a retirement rate of 167 per year."*

  Reference: Human Capital Crisis Task Force Report, Health Physics Society, July 2004, http://hps.org/documents/ManpowerTaskForceReport.pdf.

- In the very near term, it will become increasing challenging to find an adequate number of technical level radiation protection professionals.

University Research and Training Reactors

- The number of university reactors has dwindled from 63 in the late 1970s to 27 today.
- Recently, a number of university reactors have been decommissioned, including the research reactors at Cornell and Michigan.
- During FY 2006, DOE’s INIE Program provided $9.41 Million to six consortia consisting of both research and training.

INIE Consortia

Western

- Oregon State University (Lead)
- University of California-Davis
- Washington State
- University of California-Berkeley
- Idaho State University
- Reed College
- University of California-Irvine
- University of Utah
- University of Nevada-Las Vegas
- 2006 Funding: $1.25 Million

Big-10

- Pennsylvania State University (Lead)
- Ohio State University
- University of Wisconsin-Madison
- Univ. of Illinois at Urbana-Champaign
- Purdue University
- University of Michigan
- University of Cincinnati
- 2006 Funding: $1.9 Million

New England

- Mass Institute of Technology (Lead)
- Rhode Island Nuclear Science Center
- University of Massachusetts – Lowell
- Rensselaer Polytechnic Institute
- 2006 Funding: $1.0 Million

Midwest

- University of Missouri-Columbia (Lead)
- University of Missouri-Rolla
- University of Missouri-Kansas City
- Linn State Technical College
- Polytechnic University of Puerto Rico
- Kansas State University
- 2006 Funding: $1.34 Million

Southeast

- North Carolina State University (Lead)
- University of Maryland
- Georgia Institute of Technology
- University of Tennessee
- University of Florida
- University of South Carolina
- South Carolina State University
- 2006 Funding: $2.65 Million

Southwest

- Texas A&M University (Lead)
- University of Texas
- University of New Mexico
- 2006 Funding: $1.27Million

Reactor Power and Threat of Decommissioning

REACTOR	POWER	UNDER THREAT FOR DECOMMISSIONING?
MUSIC		
NC State	1 MW	NO
U of Florida	100 kW	NO
U of MD	250 kW	YES
NEW ENGLAND		
MIT	5 MW	NO
UMASS-LOWELL	1 MW	NO
RINSC	2 MW	NO
SOUTHWEST		
TEXAS A&M	1 MW	NO
UTEXAS	1.1 MW	NO
U NEW MEXICO	5 W	NO
BIG 10		
PENN ST	1 MW	NO
WISCONSIN	1 MW	NO
PURDUE	1 kW	NO
MIDWEST		
MURR (UM-C)	10 MW	NO
UM-ROLLA	200 kW	NO
KANSAS STATE	250 kW, Upgrade to 1.25 MW pending	NO
WESTERN		
OREGON ST	1.1 MW	NO
WASHINGTON ST	1 MW	NO
UC-DAVIS	2 MW	NO
UC-IRVINE	250 kW	YES
REED	250 kW	NO
IDAHO STATE	0.005 kW	NO

Most Important Reactor Needs

REACTOR		MOST IMPORTANT NEEDS
MUSIC		Sustainable long-term funding
		to hire operations and technical staff
		and periodically to upgrade equipment
NEW ENGLAND		
MIT		Base support of operations
UMASS-LOWELL		e+ beam, neutron scattering, etc.,in support of nanotechnology
RINSC		Upgrade console, electronics
SOUTHWEST		Long-term funding for the following:
		(i) Sustained support for undergraduate and graduate students
		(ii) Additional reactor research staff to mentor students
		(iii) Instrumentation upgrades and development
BIG 10		Reactors are in good shape. Researchers are needed.
PURDUE		Upgrades to reactor instrumentation
MIDWEST		
MURR (UM-C)		Operational: continued fuel support, including support for the
		successful conversion from HEU to LEU.
		R&D: support for developing U.S. source of Moly-99 and
		support to further enhance research and education.
UM-ROLLA		Upgrade to digital instrumentation
		Computerization of procedures
KANSAS STATE		Support staff and effluent monitoring
WESTERN		
OREGON ST		Replace secondary water system, neutron diffractometer,
		replace reflector assemby, sustainable long-term funding
WASHINGTON ST		Reactor console and control upgrades
UC-DAVIS		Reactor fuel, retaining staff, maintaining equipment
UC-IRVINE		Base operations support for staffing
REED		Funding for sharing, operating, and instrumentation
IDAHO STATE		Funding for operations and instrumentation

Minimum Modernization Funded Needed

REACTOR	INITIAL FUNDING NEEDED	ITEMS FOR INITIAL FUNDING	ANNUAL FUNDING NEEDED
MUSIC	Achieved by previous pgms.		$700-900K*
NEW ENGLAND			
MIT	$3M		$100-200K
UMASS-LOWELL	$200K		$20K
RINSC	$150K-$200K	Upgrade reactor console, electronics	$100K
SOUTHWEST			
TEXAS A&M	Currently OK		$75K
UTEXAS	$750K	Rehire research staff and students	$250K
		released due to INIE closeout and	
		fund instrumentation projects	
U NEW MEXICO	$150K	Upgrade reactor console	$15K
BIG 10	Already upgraded w/INIE Funds		$500K
Purdue	$120K	New console	$15K
MIDWEST			
MURR (UM-C)	$4.3M	Operational Items **	$250K (Operational)
UM-ROLLA	$800K		$100K
KANSAS STATE	$200K	Support staff and effluent monitoring	$50K
WESTERN			
OREGON ST	$1M	Replace secondary water system &	$50-100K
		reflector assembly, neutron diffractometer	
WASHINGTON ST	$750K		$50K
UC-DAVIS	$6M		$2M
UC-IRVINE	Systems in good shape		$10K
REED			$20-30K
IDAHO STATE	$100K	Neutron detectors/cables,	$40K
		health physics instrumentation	

* $20-50K is needed annually for reactor instrumentation maintenance.
$700-900K is needed to support personnel and R&D activities in all southeast univ. reactors.
Also, if NCSU implements a power upgrade, it would need approximately $1.5 M.
** Cooling tower modification ($2.0M), New Be reflector ($0.8M), new Type B shipping cask
for fuel and radioisotopes ($1.5M)

Average Annual Funding Received Since 2000

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INIE Successes

(Innovations in Nuclear Infrastructure and Education)

- Provided seed money for a number of major infrastructure and instrumentation purchases and upgrades.
- Demonstrated to university administrators that university reactors are a national asset, valued by the Federal government, and thus a worthwhile long-term university investment.
- Fostered important collaborations among members of each consortium, and even national laboratories and institutions outside the consortia.
- Launched major new research thrusts that led to the leveraging of Federal funds with other agencies, such as the National Science Foundation.

INIE Successes (cont'd)

- Contributed to the significant increase in the number of undergraduates studying nuclear science and engineering.
- Stimulated the hiring of new tenure-track faculty.
- Played an important role in freeing university reactors from threats of decommissioning.
- Contributed to the 2000 establishment of a new undergraduate nuclear engineering program at SC State, an HBCU.

  First to be created in over a quarter-century at any U.S. university and the only undergrad nuclear engineering program at an HBCU.

  Due to the elimination of the INIE Program, the future of university reactors is uncertain???!!

Actinide Cross Sections

- A wealth of high precision nuclear data is needed to support the design of the next generation nuclear reactors.
- To predict reactor system performance, various fission and neutron capture cross sections are needed.
- The quest to calculate cross sections from fundamental theory alone should be an important long-term goal (Nuclear Physicists!!).
- Better nuclear theory should leverage the physics understanding as one performs studies from one isotope to another.

Cross Sections Needed for Next Generation Nuclear Reactor Systems

Fission Cross Section Measurements

- Np237, Pu238, Pu239, Pu240, Pu241, Pu242, Am241, Am242m, Am243, Cm244, Cm245

Capture Cross Section Measurements

- Si28, Np237, U238, Pu239, Pu240, Pu242

Inelastic Cross Section Measurements

- Na23, U238, Fe56

Average number of fission neutrons

- Pu238, Pu240

Source: Tony Hill, GNEP Team Leader for the Neutron and Nuclear Science Group

Actinide Cross Section Measurements

- Measured many fission and neutron capture cross sections at the Los Alamos Neutron Science Center (LANSCE).
- U.S. has the neutron source facilities needed for many of the cross section measurements.
- Capabilities not present in the U.S. usually can be found at international facilities:
  - Neutron Time of Flight facility at CERN in Geneva, Switzerland
  - Institute for Reference Materials and Measurements in Geel, Belgium
  - Joint Institute for Nuclear Research in Dubna, Russia.
- Many of the fission and neutron capture cross section measurements are extremely challenging and entirely new techniques need to be developed.
- This is fertile ground for Ph.D. theses, and should be eligible for funding support from both the National Science Foundation and DOE’s Office of Science.
-

NUCLEAR ENGINEERING DEGREES

Nuclear Engineering Degrees by Year

	Degrees		
Year	B.S.	M.S.	Ph.D.
2006	346	214	70
2005	268	171	74
2004	219	154	75
2003	166	132	78
2002	195*	130	67
2001	120	145	80
2000	159	133	74
1999	199	142	86
1998	222	160	98

*Three programs were discontinued/out-of-scope after 2002 and not included in the 2003 survey. These three programs reported a total of 17 B.S. degrees in 2002.

Data obtained from *Nuclear Engineering Enrollments and Degrees Survey,* Oak Ridge Institute for Science and Education, http://orise.orau.gov/sep/files/NE_E_D_Brief60_03-07.pdf.

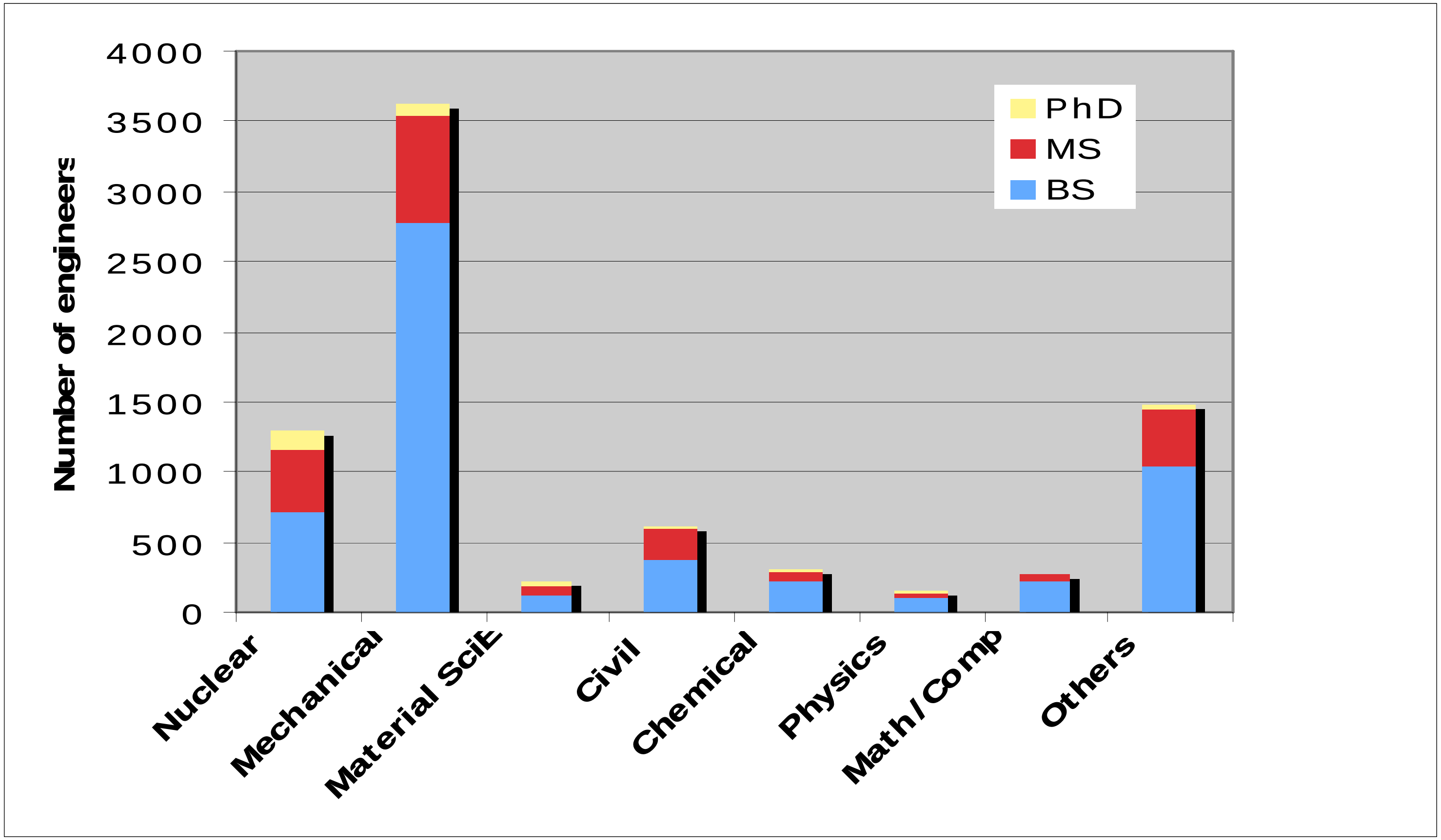
Nuclear Engineering Degrees by Academic Institution, 2006

		Degrees, Sept. 1, 2005 – Aug. 31, 2006		
State	Name of Institution	B.S.	M.S.	Ph.D.
CA	University of California, Berkeley	8	8	8
FL	University of Florida	10	5	0
GA	Georgia Institute of Technology	22	18	1
ID	Idaho State University	2	2	1
IL	University of Illinois at Urbana-Champaign	13	12	4
IN	Purdue University	21	15	5
KS	Kansas State University	13	2	0
MA	Massachusetts Institute of Technology	16	20	20
MA	University of Massachusetts, Lowell	2	1	0
MD	University of Maryland	5	2	0
ME	University of Maine	1	0	0
MI	University of Michigan	25	13	4
MO	University of Missouri - Columbia	0	2	2
MO	University of Missouri - Rolla	14	0	0
NC	North Carolina State University	21	5	6
NM	University of New Mexico	10	10	2
NV	University of Nevada, Las Vegas	3	2	1
NY	Rensselaer Polytechnic Institute	27	4	0
NY	United States Military Academy	14	0	0
OH	Air Force Institute of Technology	0	8	1
OH	Ohio State University	0	4	1
OH	University of Cincinnati	0	4	2
OR	Oregon State University	22	5	2
PA	Pennsylvania State University	31	11	3
SC	South Carolina State University	2	0	0
SC	University of South Carolina	0	8	0
TN	University of Tennessee	15	20	0
TX	Texas A&M University	31	9	1
TX	University of Texas	2	6	1
UT	University of Utah	0	3	0
WI	University of Wisconsin	16	15	5
	TOTALS:	**346**	**214**	**70**

Data obtained idge Institute for Science and Education, http://orise.orau.gov/sep/files/NE_E_D_Brief60_03-07.pdf.

NUCLEAR EMPLOYMENT DATA

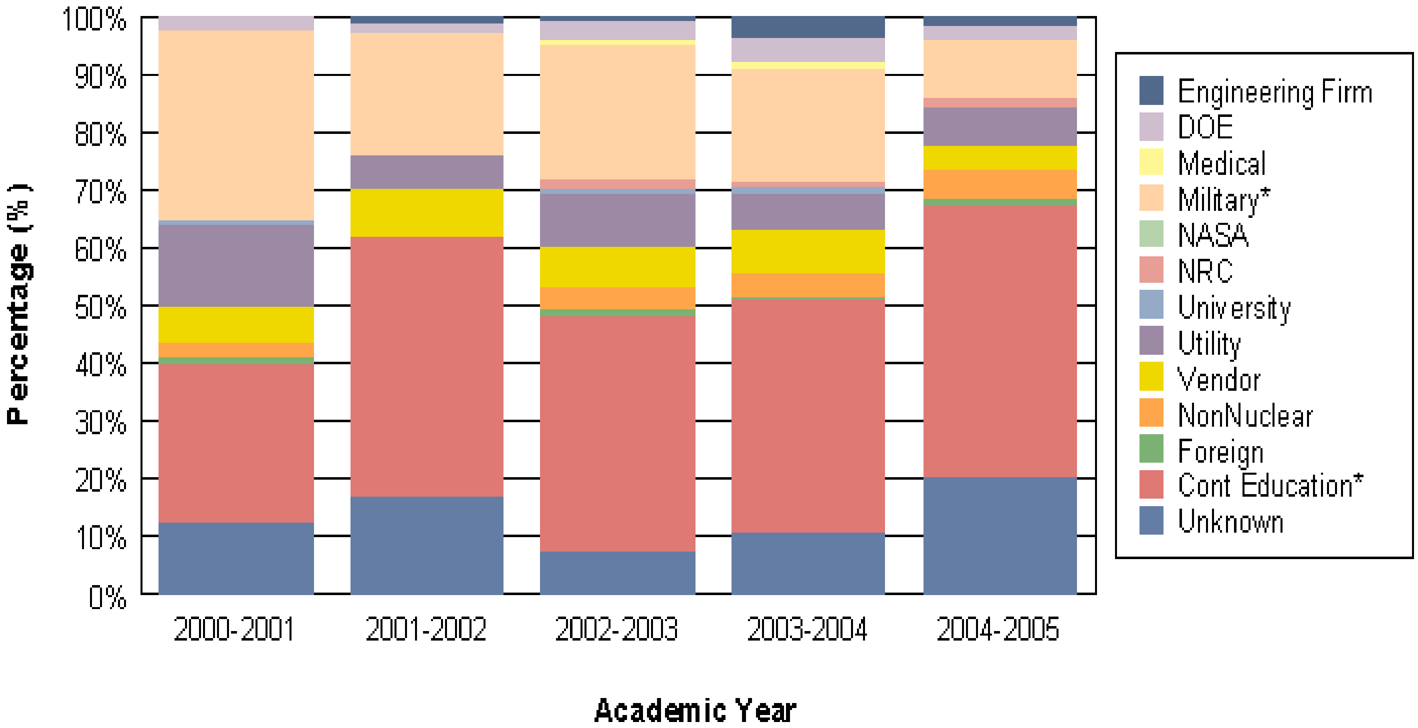
Engineers Currently Employed at Reactor Vendors



Total number of engineers = 7967; 5569 BS, 2058 MS, 340 PhD

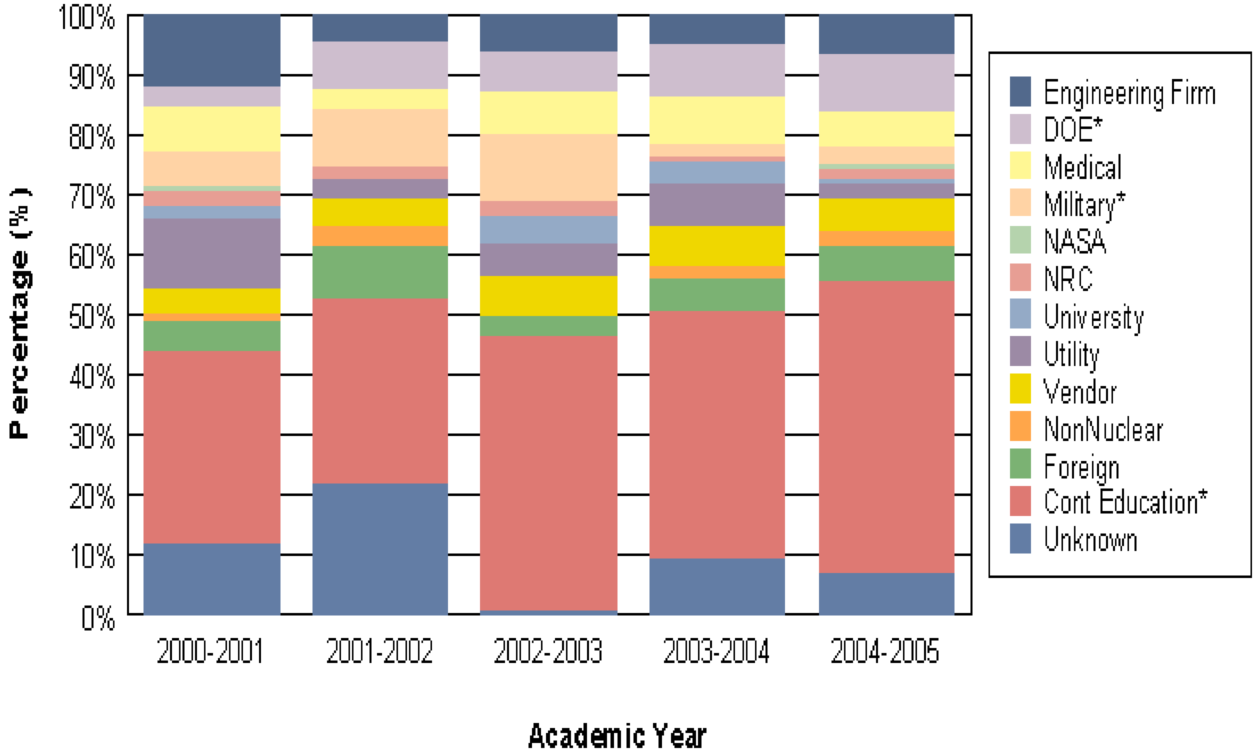
Reactor Engineers and Staffing Nuclear Plants, Workshop Presentation to the Working Group by Professor John Lee, Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Workshop held in Washington, D.C., July 2007.

Initial Outcomes of Nuclear Engineering Bachelor's Degree Recipients



Asterisks highlight popular post-graduate activities.
Data obtained from DOE-NE.

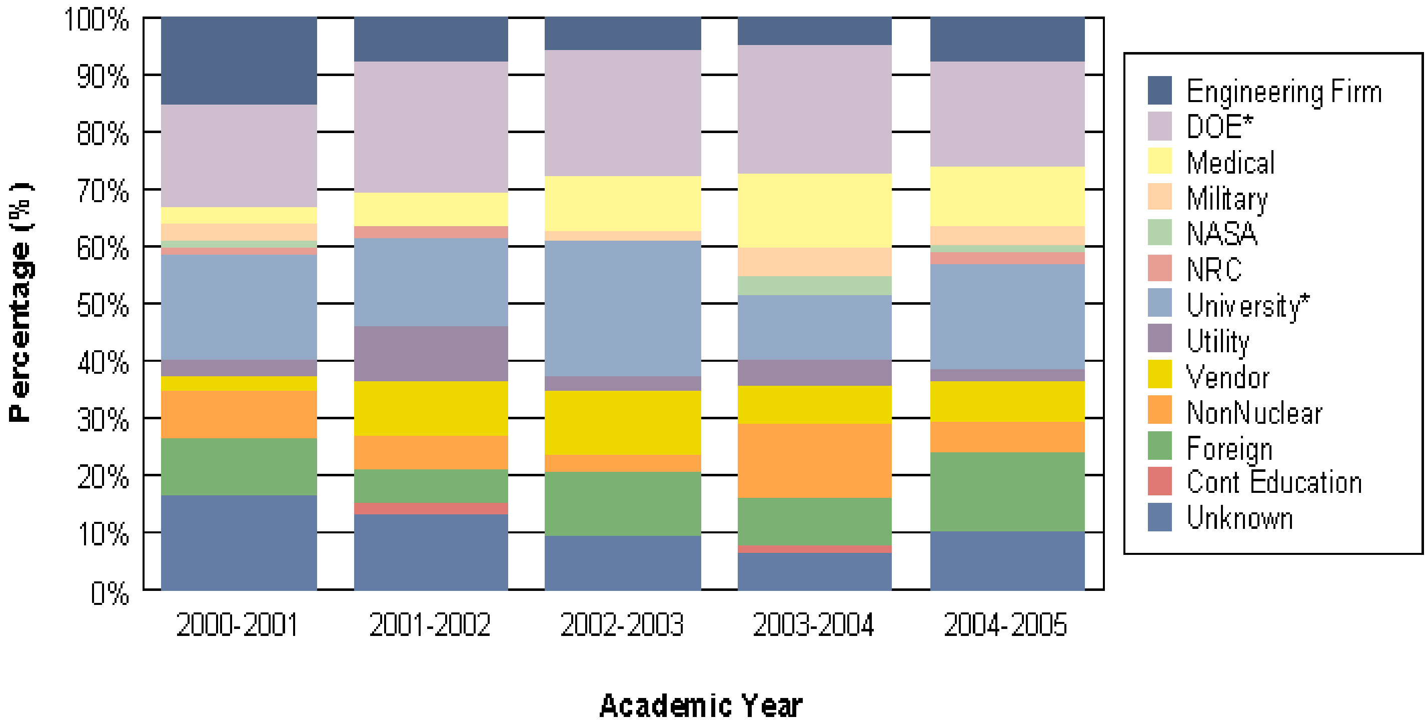
Initial Outcomes of Nuclear Engineering Master's Degree Recipients



Asterisks highlight popular post-graduate activities.

Data obtained from DOE-NE.

Initial Outcomes of Nuclear Engineering Ph.D. Degree Recipients



Asterisks highlight popular post-graduate activities.

Data obtained from DOE-NE.

Initial Employment or Other Post-Graduation Plans for Nuclear Engineering Degree Recipients, Class of 2006

	B.S. degree	M.S. degree	Ph.D. degree
Continued Study	135	77	12
Academic Employment	2	2	9
Federal Government Employment	10	21	5
DOE Contractor Employment	9	9	3
State and Local Government Employment	2	1	0
Nuclear Utility Employment	29	23	2
Other Nuclear-Related Employment	11	14	9
Other Business Employment	8	7	10
Foreign (non-U.S.) Employment	0	9	10
U.S. Military, Active Duty	47	4	2
Other Employment	3	1	1
Still Seeking Employment	8	5	0
Not Reported	82	41	7
Totals	346	214	70

Data obtained from *Nuclear Engineering Enrollments and Degrees Survey,* Oak Ridge Institute for Science and Education, http://orise.orau.gov/sep/files/NE_E_D_Brief60_03-07.pdf.

Findings

- With approximately 35% of nuclear workers reaching retirement eligibility in the next five years (*NEI 2007 Workforce Survey)*, there will likely be an increase in the hiring of engineering across the board and subsequently increase demands for nuclear engineering education.
- The status quo nuclear energy scenario of keeping the number of nuclear reactors fixed out to 2050 probably will not hurt for nuclear engineers, as long as it remains profitable for the nuclear industry to train non-nuclear engineers to perform nuclear tasks.

Findings (cont'd)

- Under Scenarios 2 and 3 (doubling the number of reactors), vendors, utilities, and the NRC will need to increase their ranks by about 300 engineers with some nuclear training per year. *(Dallas Frey, Director of Staffing & Organizational Development,Westinghouse International Headquarters, Monroeville, PA.).*
- According to the data presented, the number of new graduates at all degree levels entering nuclear employment in these sectors is only about 160, about half of what is needed.

Findings (cont'd)

- It is doubtful that the massive reactor building campaigns necessary for doubling or tripling the number of reactors out to the year 2050 could thrive under the culture of on-the-job training.
- On the other hand, private industry's nuclear workforce will be highly dependent on market-driven forces and it is impossible at the present time to predict future outcomes.

Findings (cont'd)

- The public sector cannot depend upon market-driven forces to ensure that the Nation has an adequate supply of nuclear scientists and engineers.
  - The weapons complex must be safeguarded
  - Experts must be ready at all times to respond to nuclear accidents and acts of terrorism.
- Thus, to meet the public needs for nuclear technologies in coming years, the Nation must ensure that a safety net is in place and cannot allow the number of nuclear engineering departments and programs to collapse as occurred in past years, when the number of nuclear engineering departments decreased from 65 in 1980 to the current 30.

Findings (cont'd)

- The almost extinct field of nuclear chemistry will be indispensable in the future.
- In the U.S., if the facilities and infrastructure for nuclear and radiochemistry are not reestablished, the U.S. in the long haul will lose ground in its R&D on many fronts, including devising more efficient and safer methods of handling and processing both fresh and spent fuels in all future nuclear energy scenarios.
- Fulfilling nuclear chemistry and radiochemistry's many other cross-cutting roles in such areas as homeland security and public health will not be possible unless expertise is imported from abroad.
- Market-driven forces will not be able to produce more domestically trained nuclear chemists and radiochemists if the educational infrastructure continues disappearing.

Findings (continued)

- Having adequate personnel for nuclear power, public health, and various other forms of radiation protection will become an increasingly difficult problem.
- An area of concern for university faculty who train health physicists is the lack of nuclear power-related experience. Many faculty who possessed that background have retired or will be retiring in the near future.
- Concerning the university research and training nuclear reactors, due to the elimination of the INIE program, their futures are uncertain.

Findings (continued)

- A better understanding of the fundamental physics of nuclear isotopes would greatly strengthen advanced reactor systems R&D.
- There is likely to be a severe shortage of nuclear scientists and engineers in several sectors of government responsible for providing a safety net both for the nuclear power industry and for national security.
  - National laboratories
  - Areas of DOE not contained in the national laboratories
  - Nuclear Regulatory Commission
  - Department of Homeland Security
  - Department of Defense
  - Nuclear Emergency Support Team (NEST), which travels to the site of a suspected nuclear or radiological threat.