

State of nuclear science & engineering education in the U.S. and the need for greater international exchanges

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My Background

- 1986, PhD, University of Washington
- 1986-2001, Penn State (Professor)
- 2001-2009, Chair of Nuclear and Radiological Engineering Department at the University of Florida:
 - During my tenure, number of students increased by a factor 3 (80 grad students & 165 undergraduates), funding doubled, department ranking increased to 8th in the US
 - 2006-2007, NEDHO Chair
 - Contributed to the establishment of new DOE, NRC, and NNSA funding programs (i.e., NEUP & IUP)
- 2009-2010, University of Florida (Director of UFTR)
- 2011- present, Director of Nuclear Science and Engineering Lab (NSEL) at Arlington, Prof of Nuclear Engineering

Nuclear Science and Engineering Education

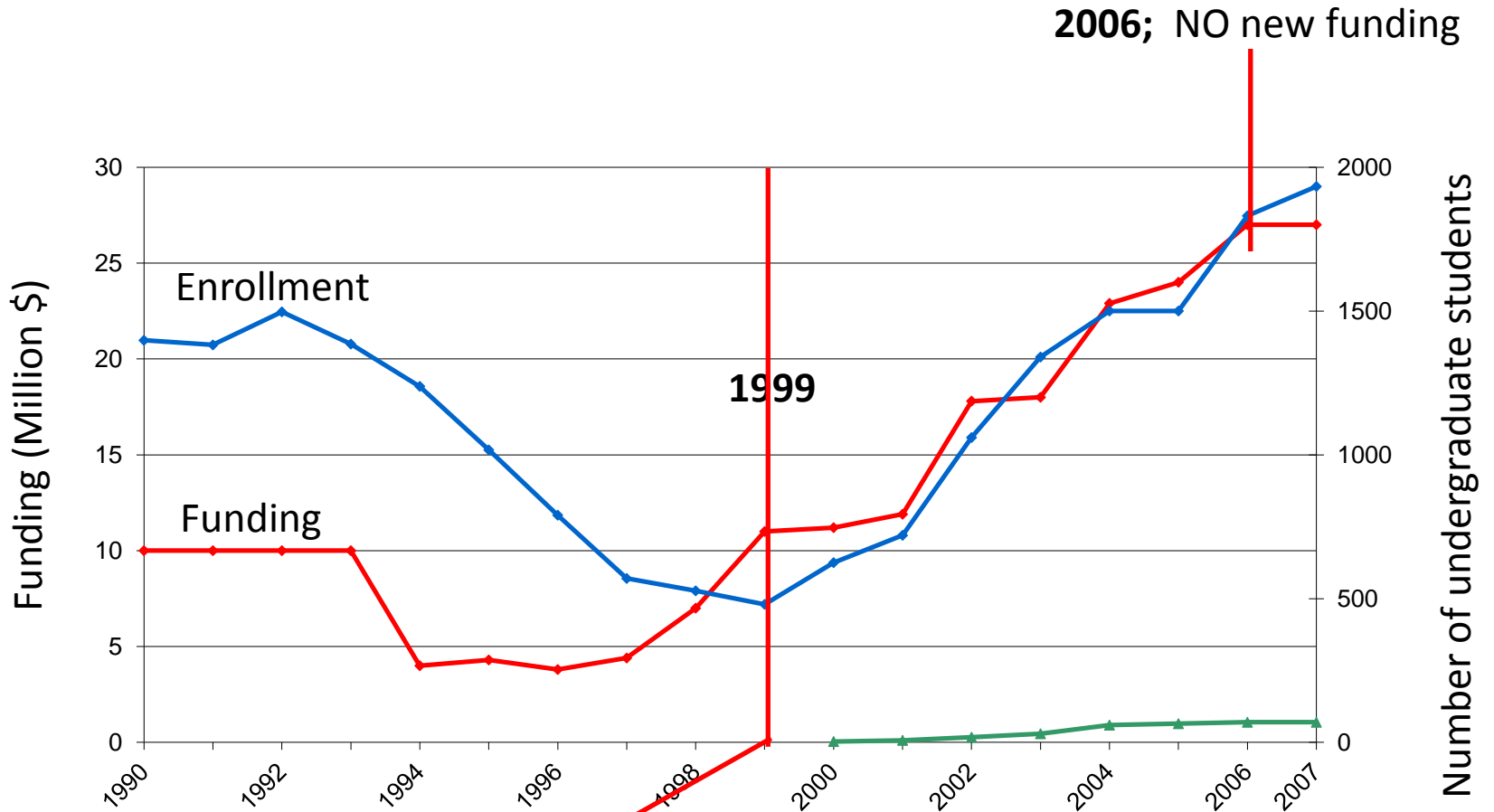
- Why do we need nuclear engineers and scientists?
Nuclear power, nuclear security and safeguards, radiation therapy and diagnostics, nuclear policy and international treaties
- Can other engineers/physicists replace nuclear engineers? **No**, because of:
 - Unique fundamentals and design of reactor cores and radiation systems, e.g.,

Nuclear science radiation
Reactor physics
Reactor kinetics
Reactor dynamics
Reactor thermal hydraulics*
Particle transport methods and their applications
Numerical transport theory
Reactor control systems
Reactor safety and accident analysis
Radiation protection and dosimetry
Radiation effects on matter
Nuclear materials*

Nuclear waste management
Nuclear security
Nuclear nonproliferation and safeguards
Radiation detection methods and experimentation
Reactor design and analysis
Radiation detection
Two-phase flow*
Reactor physics experiments
Radiation effects on matter
Monte Carlo methods for particle transport

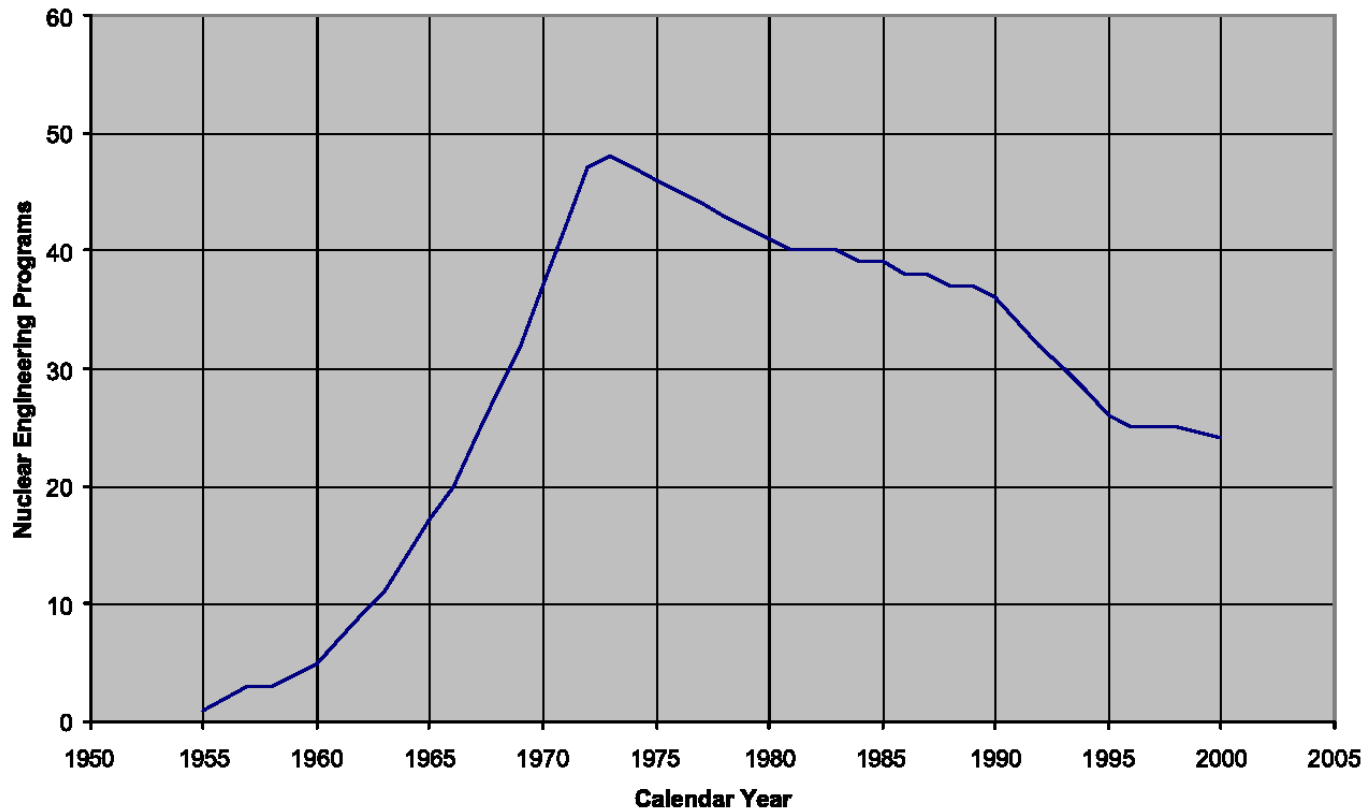
- Nuclear and reactor safety culture (e.g., $k = 1.00001$, why not simply 1.0 ?)
- Nuclear security, safeguards and nonproliferation
- Nuclear regulations
- Public concerns and international affairs

(Past) Enrollment & Funding



Number of graduates = 103

(Past) Number of NE Programs

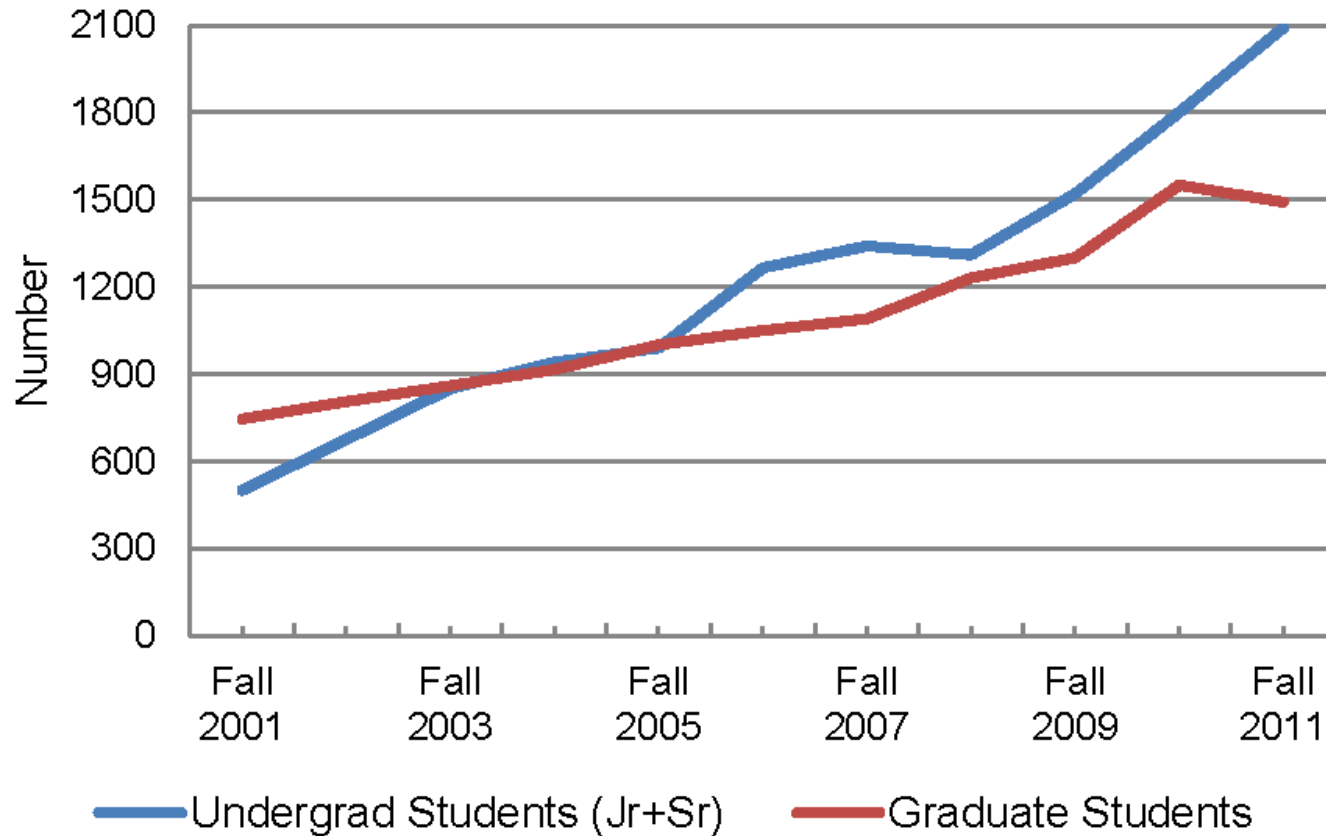


(Past)

DOE University Program (major activities)

- Reactor Sharing
- Matching Grants (with industry)
- Reactor Upgrades
- NEER (Nuclear Engineering Education Research)
- NERI (Nuclear Energy Research Initiative)
- INIE (Innovations in Nuclear Infrastructure and Education)
- Fellowships & Scholarships

Enrollment (after year 2000)



***Number of Nuclear engineering programs is ~30**

New programs: West Point, Colorado School of Mines, VT, and USNA

(present)

Government Investments (~100 M)

Nuclear Energy Education

- **Integrated University Program (IUP)**

- DOE-NE, NNSA and NRC provides
 - Scholarships & fellowships,
 - New faculty development
 - Course development
 - Mission-related Research
 - (~\$35 M)

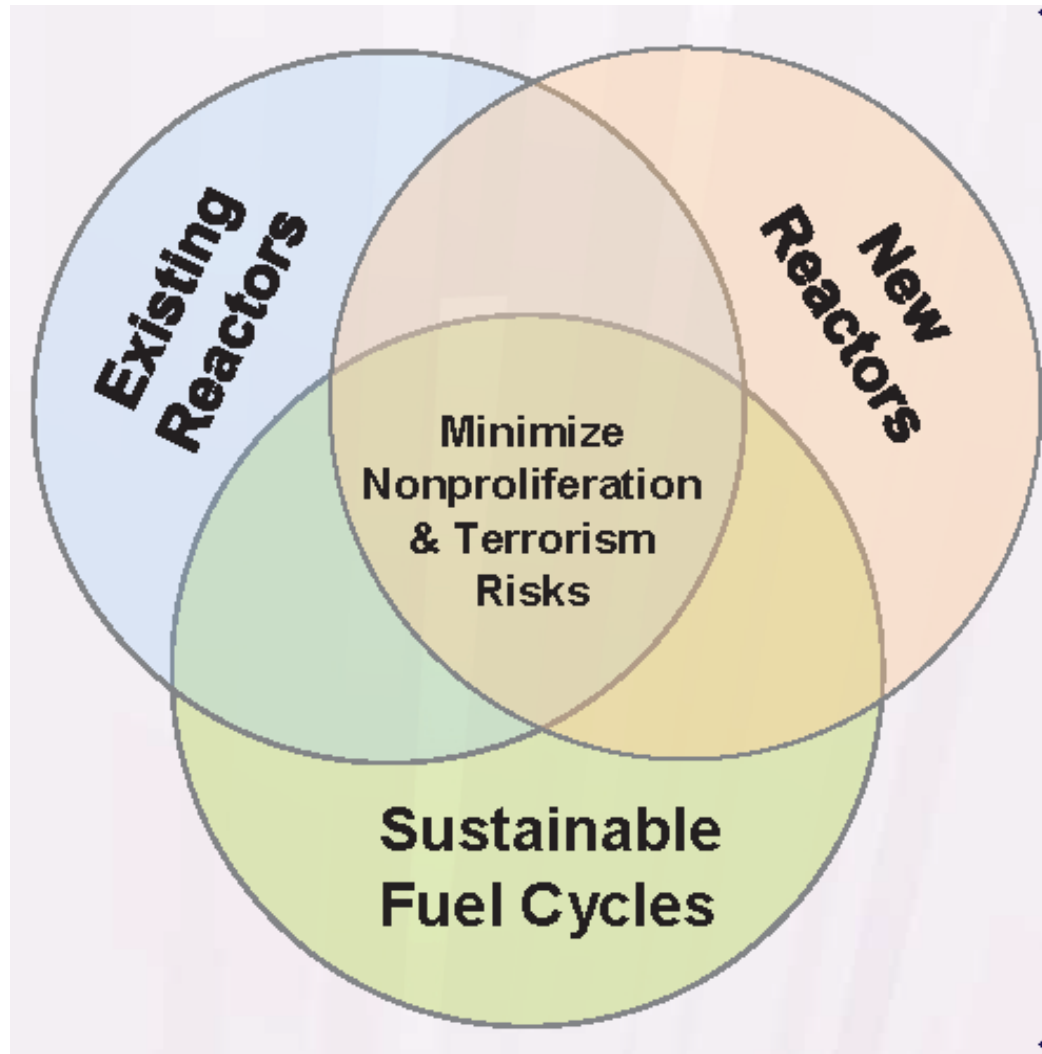
- **Nuclear Energy University Program (NEUP)**

- Integrated Research Projects; Infrastructure; R&D; mission supporting R&D; fellowships
- 20% of DOE-NE's R&D (~\$62 M)

- **Others**

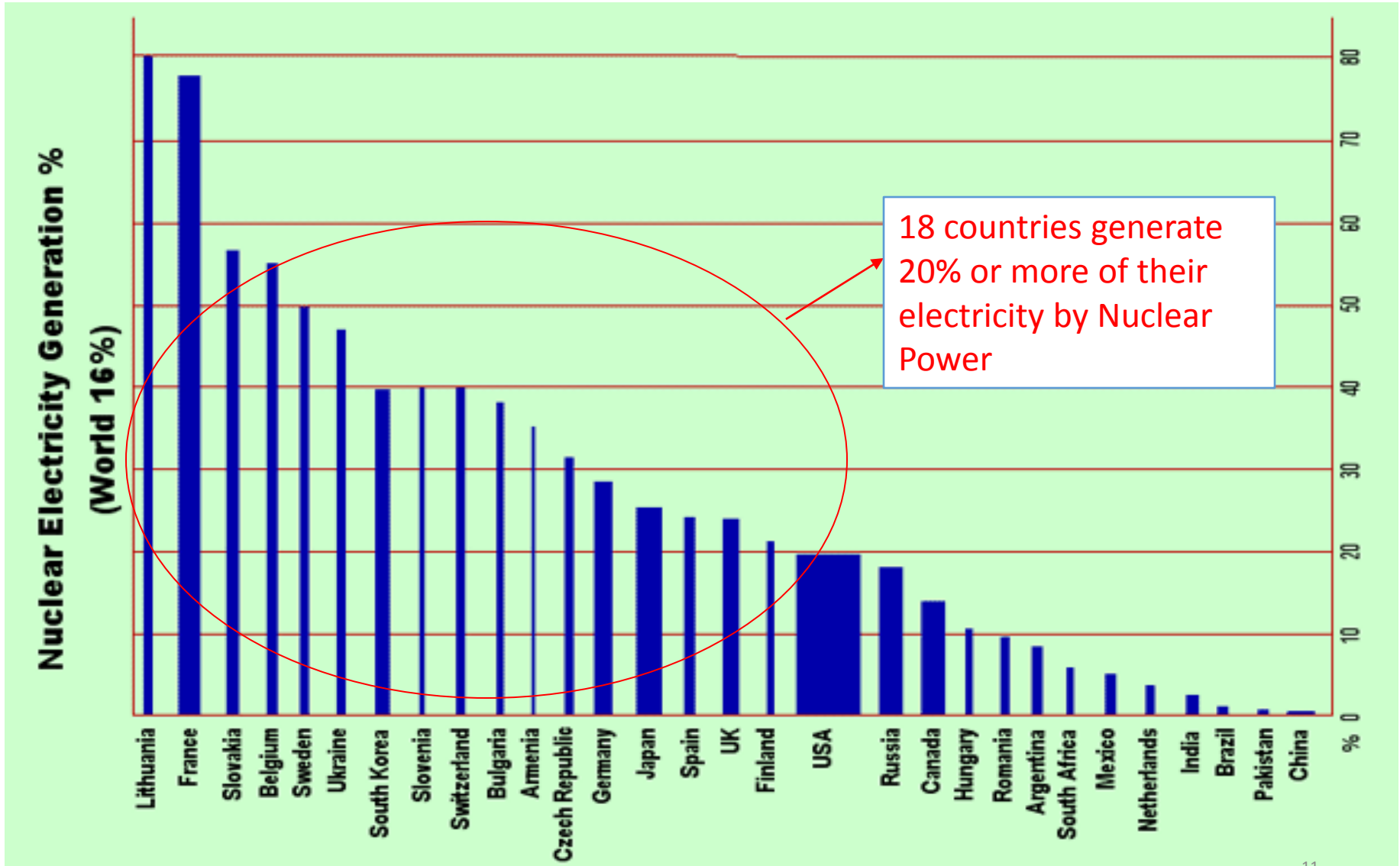
- Nuclear Forensics Education Award Program (DHS, DTRA, NNSA)

DOE Roadmap

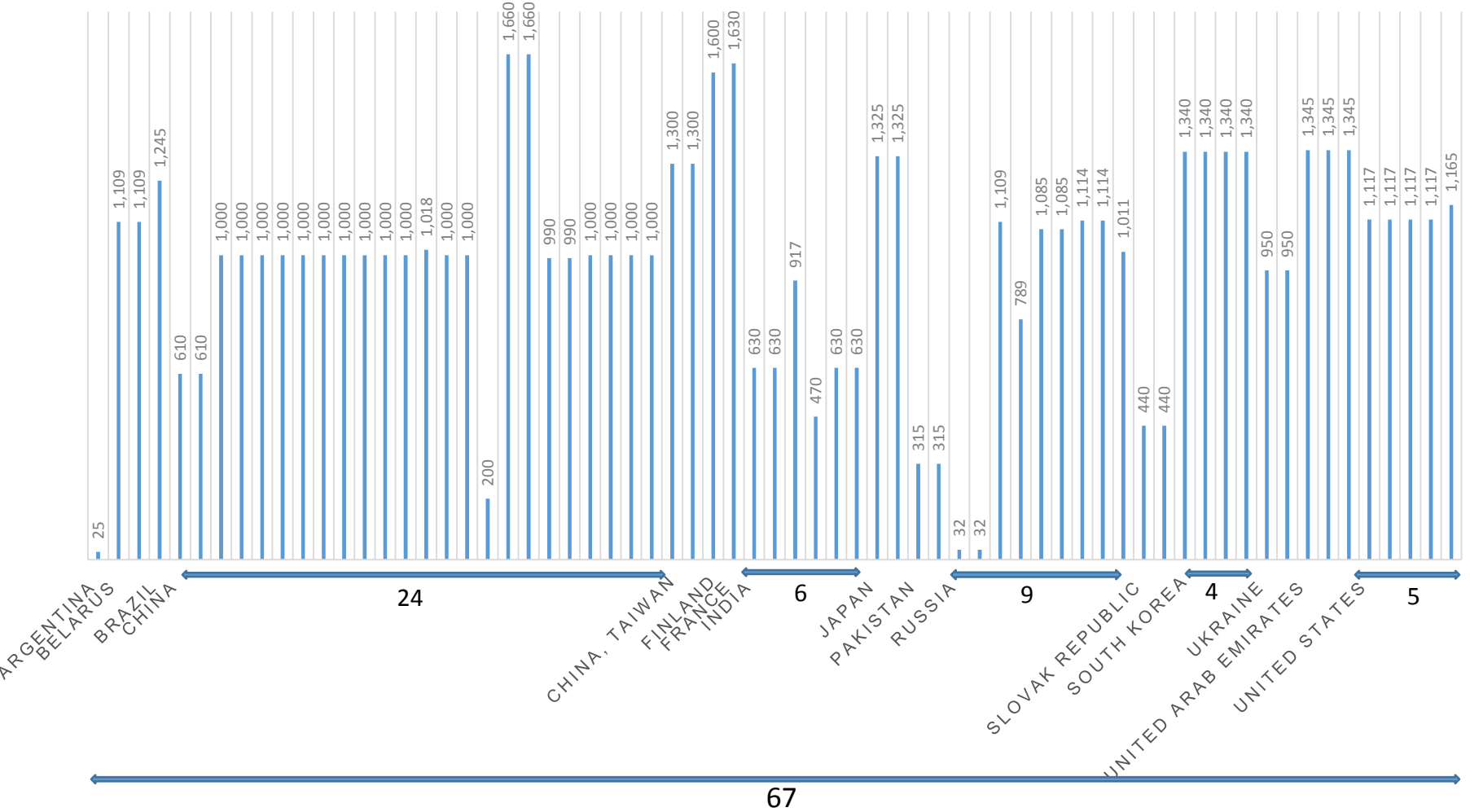


Nuclear Power - World

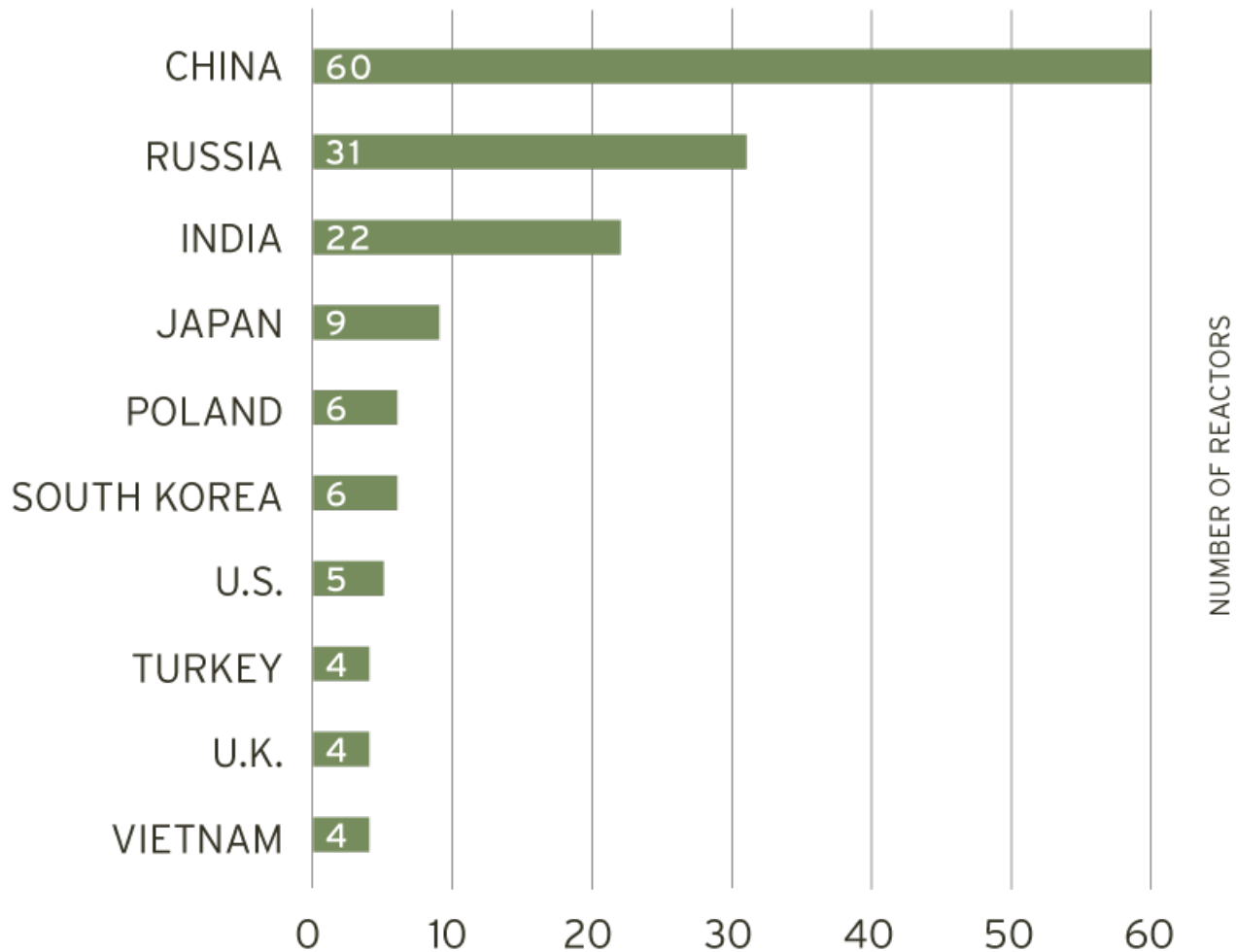
Nuclear Countries



NUCLEAR POWER PLANS UNDER CONSTRUCTION



Top 10 Planned Reactors by Country (151)



Planned represents nuclear reactors that are approved, funded or have major commitment in place, mostly expected in operation within 8-10 years;

Nuclear Education - World

Africa

Egypt*
Morocco*
South Africa

- Each country has one to two universities offering nuclear engineering degrees; they also have research institutes, research reactors, and their governments provide varying degrees of funding
- Egypt and Morocco have had very good educational programs
- For graduate studies, most of the training is done in western Europe and US
- They benefit from international organizations

American continent

Argentina
Brazil
Canada
Mexico
United States

- Each country has a few universities offering nuclear engineering degrees; they also have research institutes, research reactors, and their governments provide varying degrees of funding
- For graduate studies, most of the training is done in western Europe and US and Canada
- They benefit from international organizations
- US has largest number of institutions, reactors, military applications, radiation use, international involvements

Asia

China
India
Iran
Japan
Korea
Pakistan

- China has several universities are engaged in training nuclear engineers at different levels (BS, MS, and PhD); they are
- In India, until recently, the main nuclear engineering training occurred at Baba Atomic Lab
- US educational system has had significant influence on nuclear training in Korea and Pakistan
- Until mid early 90's, most of Korean scientists were trained in US, but now Korea has a robust educational and R&D programs and trained most of its engineers and scientists

Western Europe

Finland
France
Germany
Italy*
Netherlands
Spain
Sweden
Switzerland
United Kingdom

- European system is different than the American system.
- In addition to universities, nuclear institutes and national labs have active participation in education of nuclear engineers and scientists.
- There is a significant movement of scientists among European Countries;
- Italy has had a very good educational programs, but no nuclear power
- Europeans hold various summer institutes
- European Union (EU) makes investments on major collaborative projects

Eastern Europe

Armenia
Bulgaria
Czech Republic
Hungary
Lithuania
Romania
Russia
Slovakia
Slovenia
Ukraine

- Most of the nuclear engineering education happened in Russia
- So, all the countries have been trying to utilize their nuclear institutes and with help mostly from the West to train their engineers and scientists.
- Russia has various institutes, labs and universities for training nuclear scientists and engineers

International organizations

(supporting Nuclear Education and R&D)

International Atomic Energy Agency (IAEA)	It offers a wide spectrum of activities in support of education, training, human resource development and capacity building
Nuclear Energy Agency (NEA) - OECD	It assists its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.
World Nuclear University (WNU)	It is a worldwide network of educational and research institutions engaged in peaceful uses of nuclear energy.
International Institute of Nuclear Energy (I2EN)	It offers foreign partners of France the best solutions in education and training for the development of human resources in nuclear energy.
Latin American Network for Education in Nuclear Technology (LANENT)	It contributes to preserving, promoting and sharing nuclear knowledge as well as fostering nuclear knowledge transfer in the Latin American region.

My international activities (1)

Activities	Description
Conference and meetings	Technical papers in Europe, far east, America, Organizer of sessions, Technical Committees, keynote speeches Organized short courses and workshops
Reviewer	Served on international panels on research proposals
IAEA expert	IAEA Expert for Universidad Nacional Autónoma de México (UNAM) and Electric Research Institute (IIE) Hosted IAEA Fellows
Consultant	KEPCO (Korea Electric Power Corporation); simulation techniques TEPCO (Tokyo Electric Power Corporation); sale of software and training MRI (Mitsubishi Research Institute), sale of software and training Institute for Nuclear Energy, Taiwan
Memorandum of Agreement (MOU)	Established between National Tsing Hua University (Taiwan) and University of Florida
Organized Specialized workshops (in US)	International Workshop on Particle transport methodologies for Simulation of nuclear systems (13 times since 1995); participants from Belgium, Brazil, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Japan, Korea, Malaysia, Portugal, Switzerland

My international activities (2)

Activity	Description
(abroad)	Germany – Sponsored by NEA-OECD Belgium - Sponsored by SCK.CEN
Invited Instructor at Special Training courses	<ul style="list-style-type: none"> • A short course on “Neutron & Radiation Transport Simulation: Theory and Applications, KAIST, Taejon, Korea • Committee formed by JAERI (Japan Atomic Energy Research Institute) to discuss the future requirements on the system of the Information Technology Based Laboratory (ITBL), especially in the field of nuclear technology, Japan • International Joint Meeting Cancun 2004 LAS/ANS-SNM-SMSR XV SNM Annual Meeting and XXII SMSR Annual Meeting, Cancún, Q.R., Mexico • 2006 Frederic Joliot/Otto Hahn (FJOH) Summer School on Nuclear Reactors, addressing ‘Neutron Physics Issues and Fuel Cycle Optimization,’ Cadarache, France • 2009 CEA-EDF-INRIA Summer School on Particle Transport Numerical Methods and Applications, the Port Royal seminar centre, 78470 Saint-Lambert-des-Bois, France. • International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C 2011) Rio de Janeiro, RJ, Brazil, May 8-12, 2011, Latin American Section (LAS)/ANS

My international activities (3)

Activity	Description
Visiting Scientist	SCK.CEN, Belgian Nuclear Research Lab; lectured engineers on particle transport methods, and developed codes and methodologies for simulation the VENUS-3 critical facility
Served on advisory Board	International Advisory Council for the Nuclear and Quantum Engineering (NQe) Department, KAIST, Korea (2007-2010)
USSR-US & Russia-US (1991, 1992)	Numerical Particle Transport Methods (A delegation of US nuclear engineering professors and a delegation of Soviet/Russian professors met in US and then Russia)
ANS delegation to India	As Chair of NEDHO (Nuclear Engineering Department Heads Organization) represented US Nuclear Engineering Education

Summary

Training of nuclear engineers and scientists (nuclear countries)

- There is varying degrees of infrastructure and approaches for training of nuclear engineers and scientists
- Nuclear education is needed for non-power applications such as
 - Nuclear nonproliferation, safeguards and security
 - Medical physicist (radiation therapy, radiation diagnostics, and nuclear medicine)
 - Nuclear policy and international treaties
- Nuclear Engineering Programs in US have been diversified at different degrees to address above needs
- NNSA has allocated significant funds for establishment R&D consortia:
 - Currently, there are 3 consortia; one is finishing its 5-year term, soon a new one will be selected; VT is leading a team of 12 other universities and 5 national labs
 - There are other centers and institutes at different universities addressing nuclear security and safeguards issues
- There are various World-wide organizations addressing international issues
- There is significant collaborations among nuclear experts at all levels
- There is need for increase in funding for recruitment and training of highly qualified next generation nuclear scientists and engineers.
- Establishment of advanced facilities and research reactors and radiation devices

New Nuclear Countries¹

Activity	Country
Power reactors under construction	UAE, Belarus
Contracts signed, legal and regulatory infrastructure well-developed or developing	Lithuania, Turkey ² , Bangladesh, Vietnam
Committed plans, legal and regulatory infrastructure developing	Jordan ² , Poland, Egypt ² .
Well-developed plans but commitment pending	Thailand ² , Indonesia, Kazakhstan, Saudi Arabia, Chile; Italy ² (stalled commitment)
Developing plans	Israel ² , Nigeria, Kenya, Laos, Malaysia, Morocco ² .
Discussion as serious policy option	Namibia, Mongolia, Philippines, Singapore, Albania, Serbia, Croatia, Estonia & Latvia, Libya, Algeria, Kuwait, Azerbaijan, Sri Lanka, Tunisia, Syria, Qatar, Sudan, Venezuela, Bolivia, Peru.
Officially not a policy option at present	Australia, New Zealand, Portugal, Norway, Ireland, Kuwait, Cuba, Paraguay, Myanmar.

¹World Nuclear Association ; ²Established educational programs

Needs

Training of nuclear engineers and scientists (new nuclear countries)

- Funding
- Establishment of nuclear engineering programs
- Establishment of R&D facilities and institute
- Recruitment of students
- Public education
- Establishment of professional nuclear organizations
- Participation in international nuclear organizations
- Nuclear countries should provide assistance in various areas such as:
 - Establishment of R&D facilities
 - Establishment of new nuclear engineering programs and curricula
 - Exchange of engineers and scientists
 - Training of engineers and scientists
 - Organization of specialized workshops and short courses
 - Establishment of scholarships and fellowships
 - Training on nuclear safety culture
 - Establishment of nuclear regulations and policies

VT NSEL activities

- Training of next generation nuclear engineers and scientists, and offering specialized workshops, training courses, and short courses on nuclear subjects and policy matters in the DC metro regions
- To accomplish its goals, NSEL initiated collaborative activities with other educational, R&D organizations, and nonprofits
 - Signed a CRADA with US Naval Academy Nuclear Engineering Program to engaged in (Sept 2015)
 - Has cooperated with GWU professors (nuclear policy and nuclear physics)
 - Has collaborated with VT School of Public and International Affairs (SPIA) and Department of Science and Technology in Society (STS) on organization of workshops and forums on nuclear policy matters
 - Contributing to the GEM*STAR accelerator driven system project, led by the VT physics department
 - Contributing to the Integral Inherently Safe (I²S) reactor design, led by Georgia Tech
 - Contributing to the design of CHANDLER antineutrino detection system, led by VT physics department
 - Contributed to a FAS led study on LEU naval vessels; unintended consequences
 - Prof. Haghghat is Chairman of the Board of Virginia Nuclear Energy Consortium (VNEC) nonprofit organization; trying to establish new educational programs with support from State of Virginia and nuclear industry

NSEL –International activities

- Continue its collaborations with various institutions and participation in international activities
- Continue its recruitment of highly qualified graduate students, and collaborations with colleagues from international education and R&D institutions
- Planning to organize a forum entitled ‘A Dialogue with New Nuclear Countries,’ to address their needs and the role of nuclear countries (educational institutions and industry)
- Exploring establishment of a Global Nuclear Engineering Institute (GNEI) with primary focus on training of the workforce for the new nuclear countries

Thanks!
Questions?