Human Capacity Building for the Nuclear Enterprise

Professor Lisa Marshall
ANS President

LAS-ANS Symposium
July 15, 2024

Roadmap

- A little about my work @ NC State University (2001 -) & ANS (2005 -)
- Nuclear energy in an energy transition era
- STEM educational needs
- Opportunity for an educational ecosystem to engage, recruit & retain
- ANS outreach program, example of work on the ground
- Discussion

NC State Nuclear Engineering

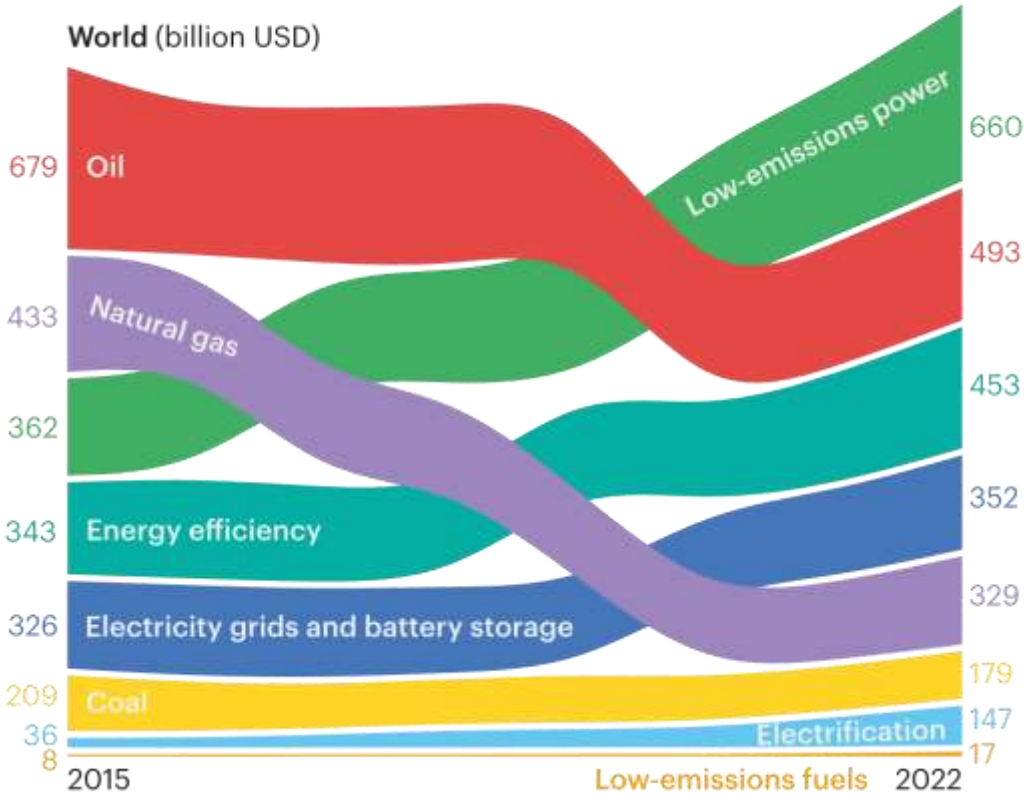
- Started in 2001 in newly formed position, Director of Outreach
- Outreach → Recruitment → Retention → Engagement
  - New student orientation → first-year NE adviser → first-year engineering program
  - Co-curricular programming
  - Educator programming
- As of January 2023, assistant extension professor
  - On research teams for nonproliferation enabling capabilities (CNEC), consent-based siting (NC Consoritum)
- ANS involvement (2005-ongoing) … NEA (WG 1, 3, 6) & IAEA (LMP1)
- My guiding questions:
  - What is needed for students to thrive?
  - How do we attract & retain talent for the nuclear enterprise?

ANS

NC STATE UNIVERSITY
Department of Nuclear Engineering

Global Energy Landscape

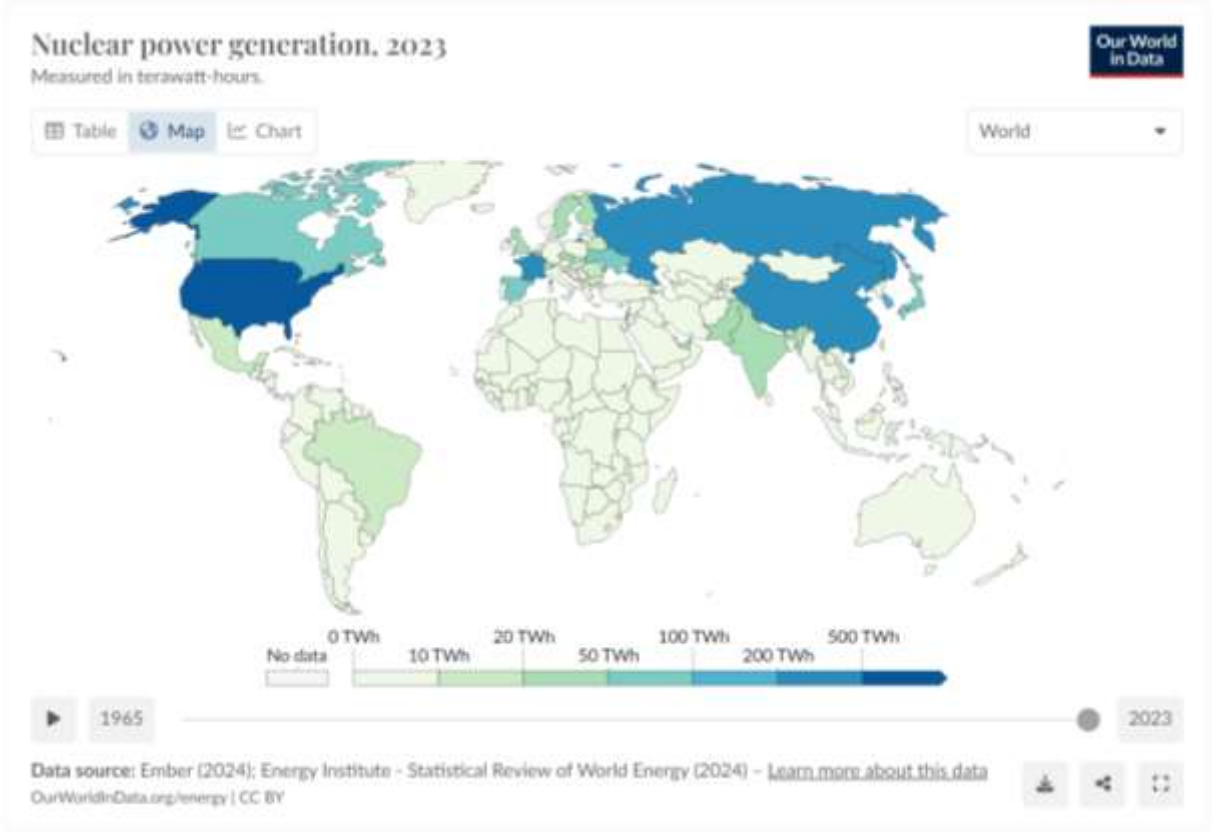
- Global energy system is being reshaped
- According to the IEA (2023), by the end of this decade
  - Nearly 10 times as many EVs will be on the road
  - Heat pumps & other electric heating systems will outsell boilers
  - Low carbon emission technologies will make up a growing portion of our global electricity mix
- Global renewable capacity must triple, fossil fuel use must decline, energy efficiency must increase, energy sector methane emissions need to fall, industrializing economies must have access to large-scale financing for 'clean energy' investments
- The shift affords new industrial opportunities, greater energy security, better environmental stewardship, and nation/allied nation stability
- Challenges: cost inflation, supply chain bottlenecks, higher borrowing costs
- Opportunities can/have gained through public policy, market stimuli & technologies
  - In USA: Jobs Act, Inflation Reduction Act, ADVANCE Act, reactor designs

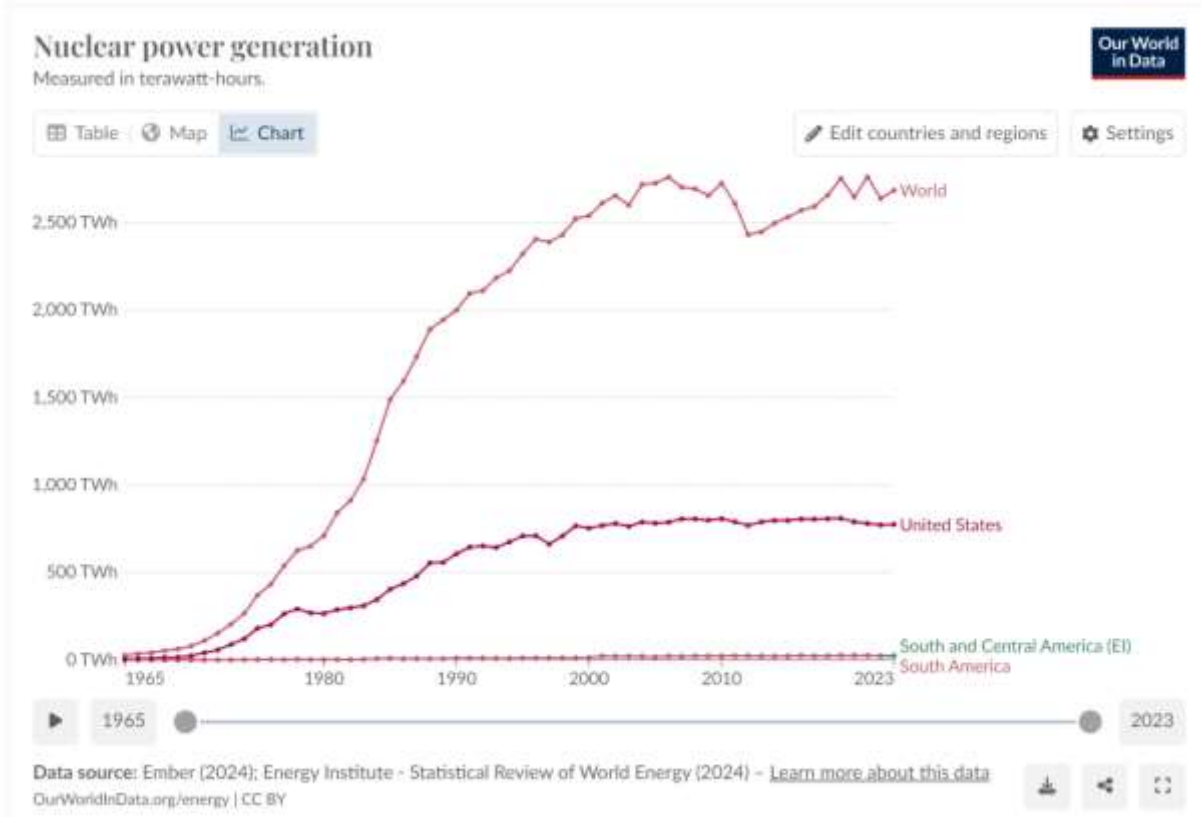


https://www.iea.org/reports/world-energy-outlook-2023/context-and-scenario-design

Nuclear Energy Landscape

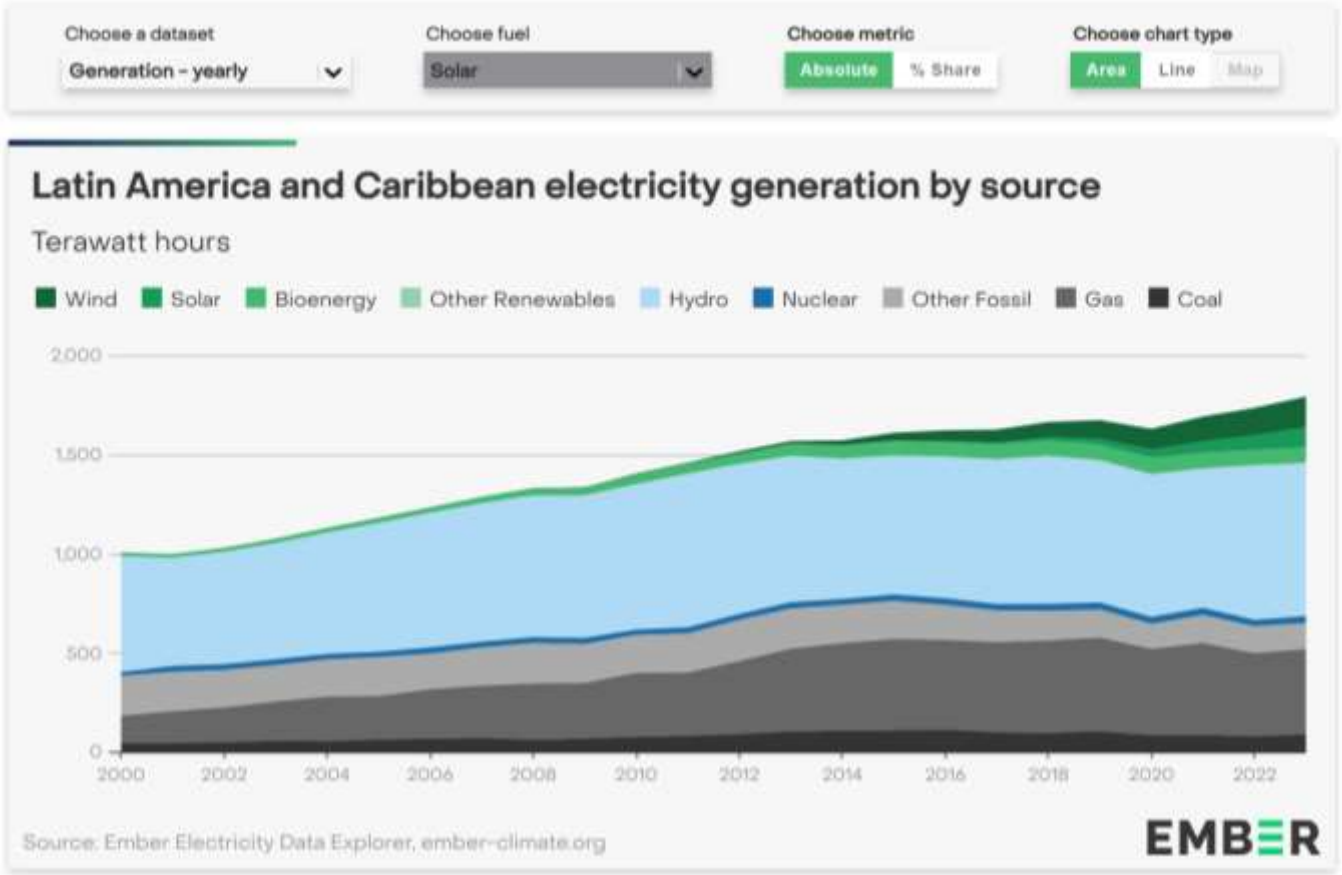
World: 2,685.74 TWh
LAC: 38.8
USA: 775.35





https://ourworldindata.org/nuclear-energy

LAC Landscape



Argentina: 3 reactors, with a combined net capacity of 1.6 GWe. In 2022, nuclear generated 5.4% of its electricity from nuclear.

Brazil: 2 reactors, with a combined net capacity of 1.9 GWe. In 2022, nuclear generated 2.5% of the country's electricity.

Mexico has two operable nuclear reactors, with a combined net capacity of 1.6 GWe. In 2022, nuclear generated 4.5% of the country's electricity.

Colombia? Who else?

https://world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today

What do we need to thrive?

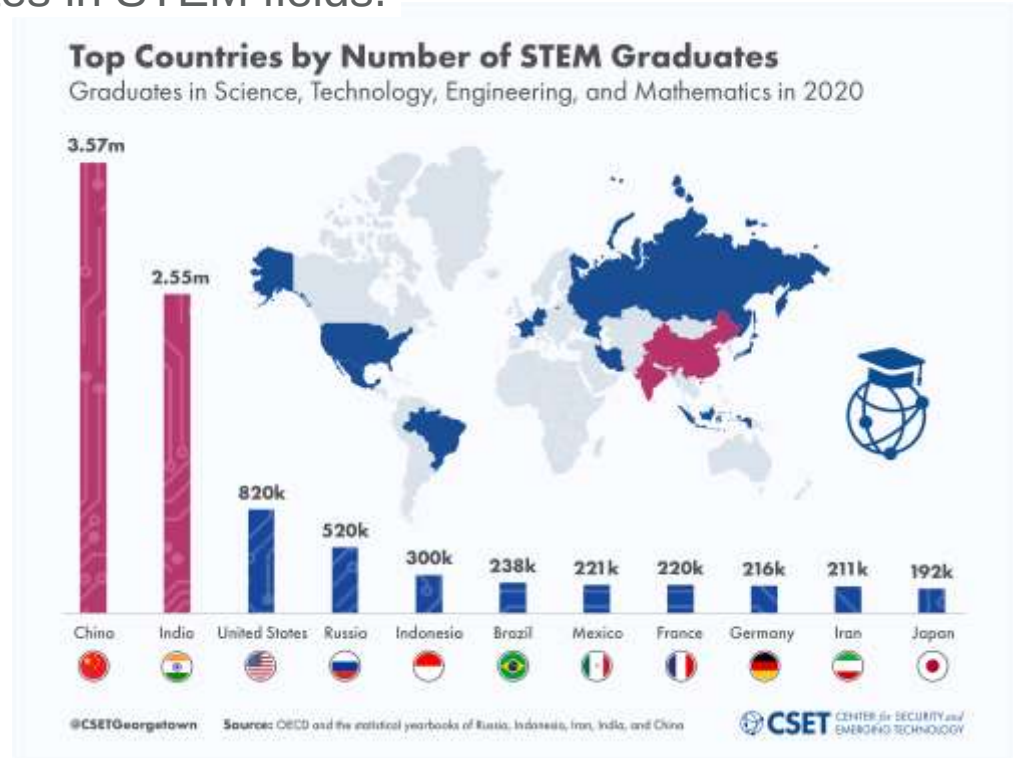
Both for the current & future nuclear fleet

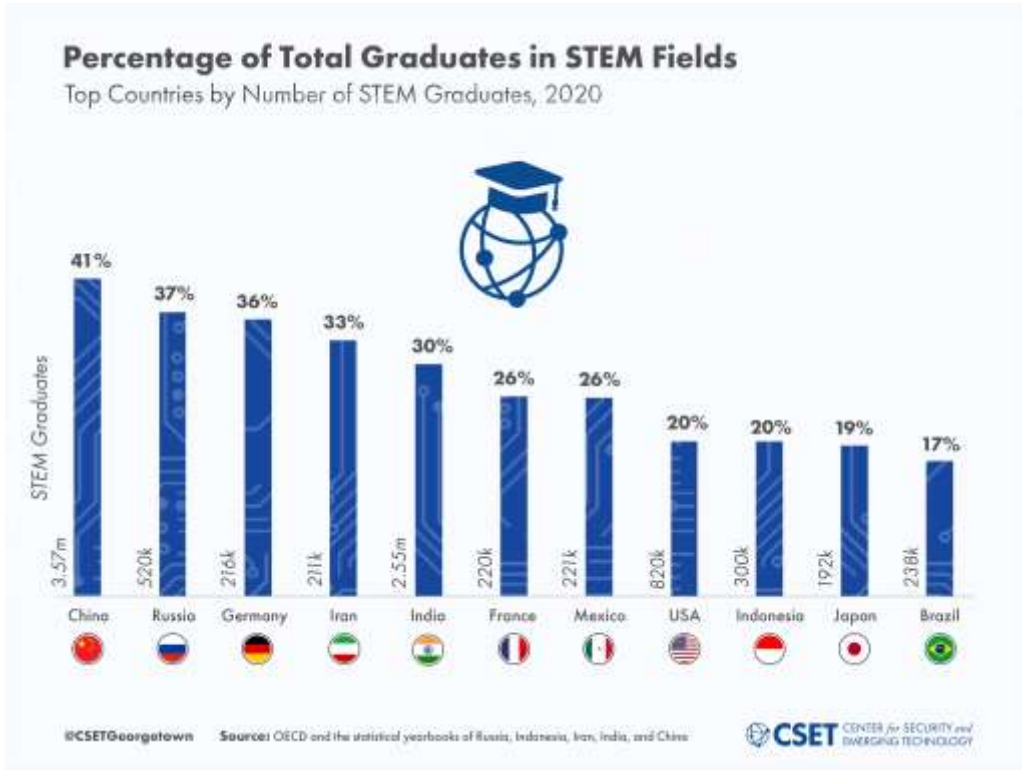
- People, policies & products
- I'll focus on "people" since discussing innovations & technologies at this symposium
  - People: global & regional

Global Workforce Landscape

Throughout most of the 20th century, the USA and Europe — particularly Russia, Germany, the UK, and France — were considered the **global centers of scientific and technological education**.

In the last few decades, **new players** have emerged. In Asia, e.g. China, India, South Korea, and Japan rapidly expanded their STEM education programs and today produce significant numbers of graduates in STEM fields.





LAC STEM Landscape

Globally, countries require science & technology education as well as investment for societal development and economic growth.

Latin American countries have around 20 million students in higher education systems, most of them studying in the 3 biggest countries of the region: Argentina, Brazil, Mexico. **However, less than 17% of graduates in the region attained STEM degrees.**

- According to a 2015 report from the OECD, Mexico is the exception in the region with 24% of graduates attaining STEM degrees. By 2020, it's 26%.
- Other countries in the region have fewer than 10% of their graduates focusing on STEM areas.
- STEM/engineering remains gendered globally

https://axial.acs.org/cross-disciplinary-concepts/latin-america-challenge

US STEM Education Landscape

The need is known.

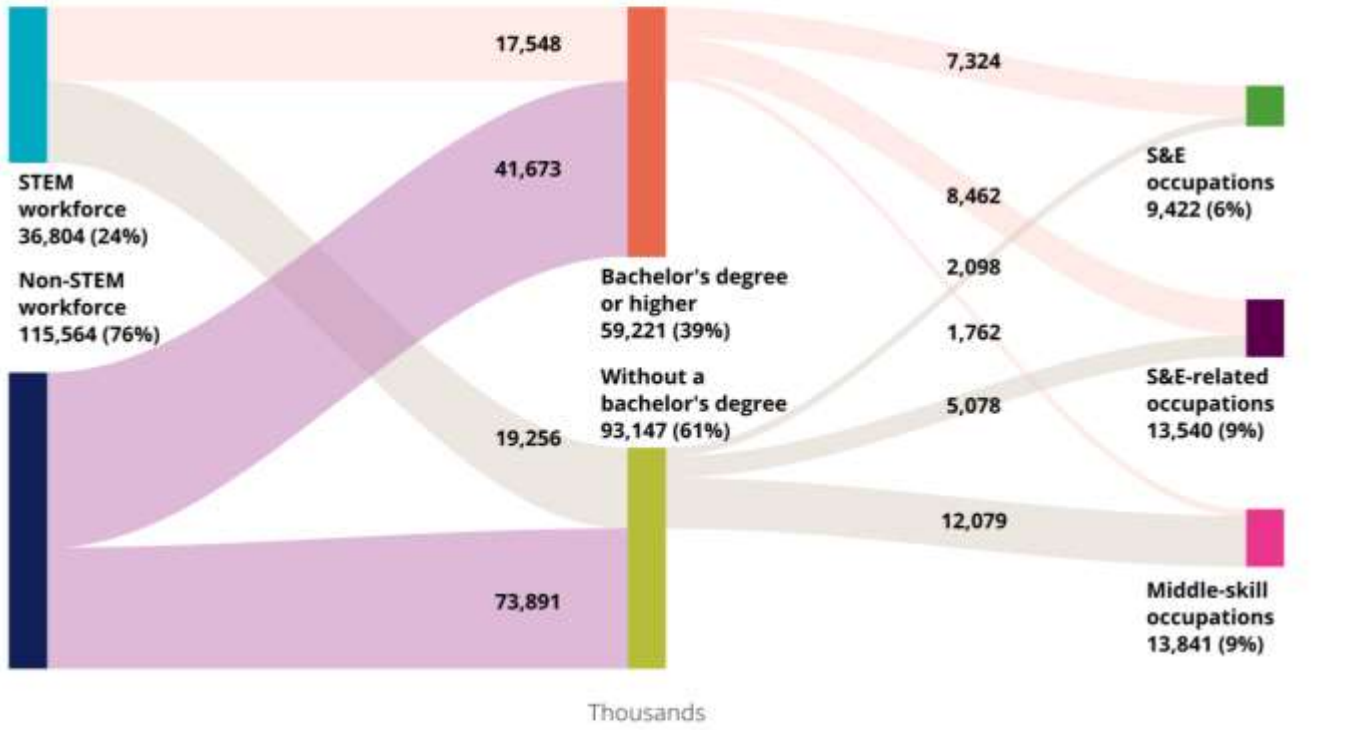
- Liftoff Report (DOE)
- SE Nuclear (E4 Carolinas+)
- EPRI, NEI ... Workforce development strategic plans
- Partnership for nuclear energy
- NSF-Clean Energy Technology (fusion)

How do we engage for STEM? How do we have fuller participation?

National Center for Science and Engineering Statistics | NSB-2024-3

Figure 7

U.S. workforce, by STEM occupation group and education level: 2021

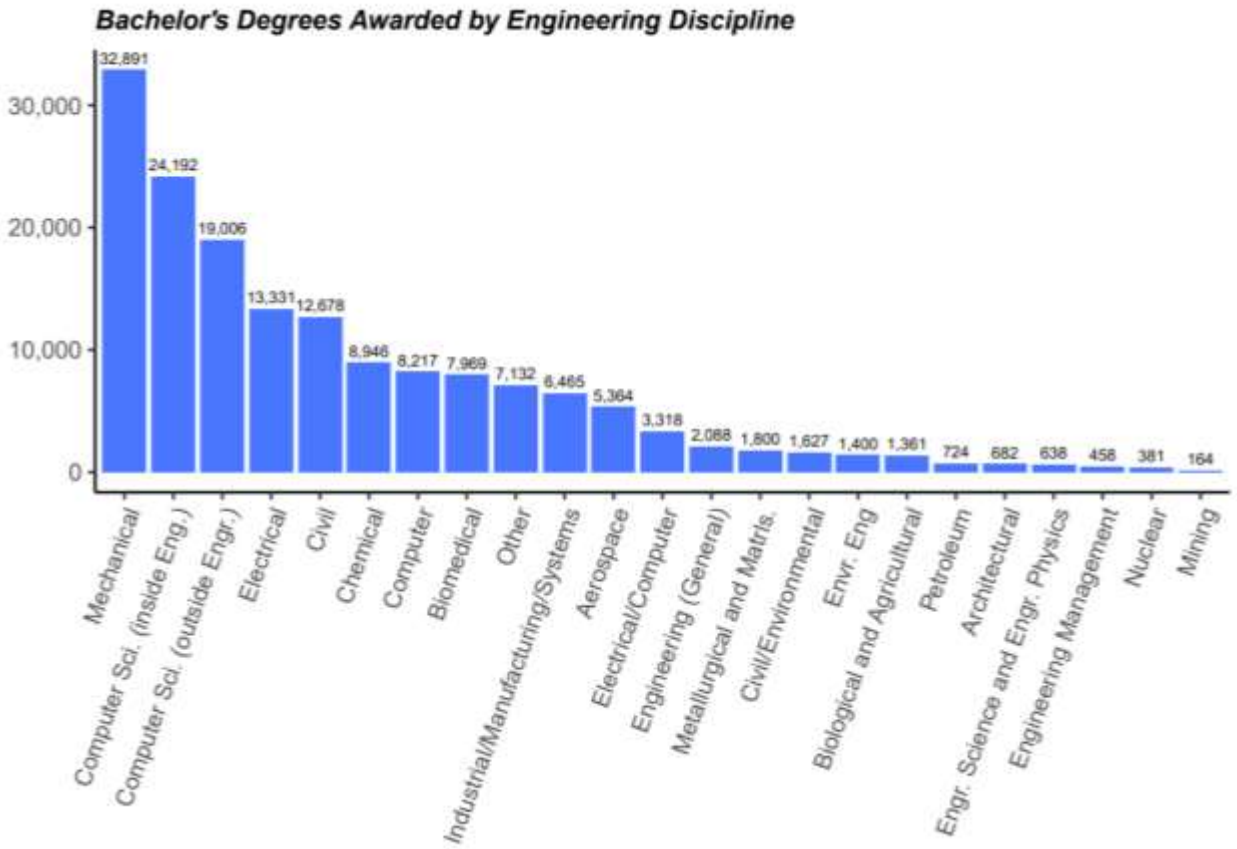


Note(s):
STEM is science, technology, engineering, and mathematics. Numbers are rounded to the nearest thousand. Percent values shown are the shares of the total workforce.

Source(s):
Census Bureau, ACS, 2021.

Indicators 2024: Labor Force

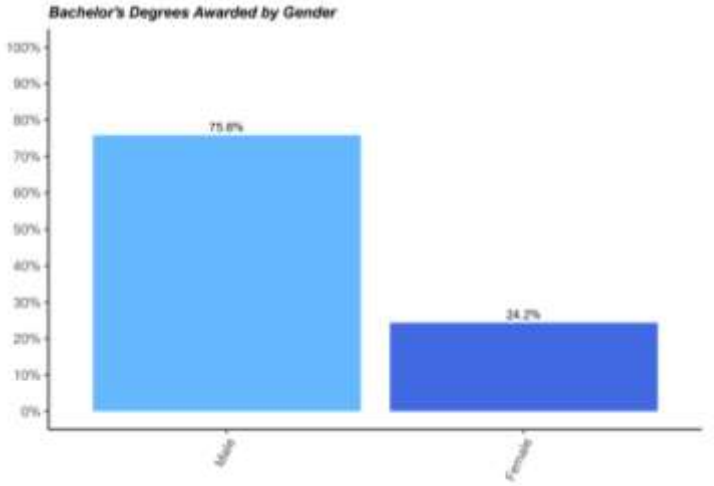
US STEM Education Landscape

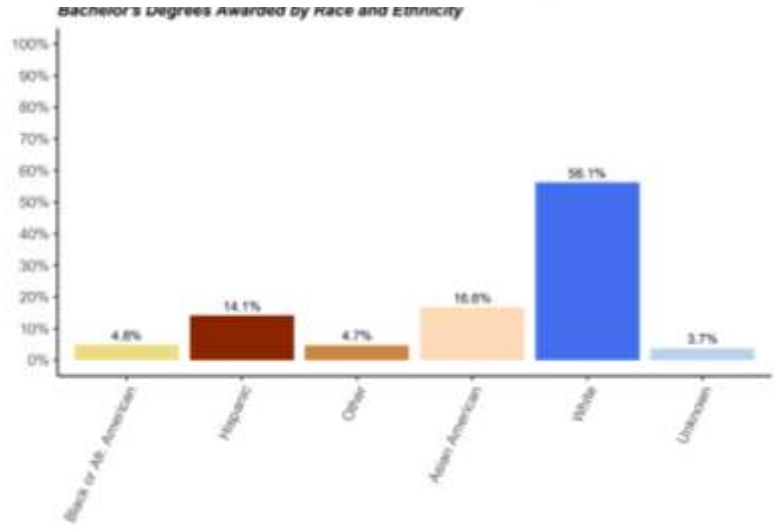


1.1.6 Bachelor's Degrees Awarded by Gender

Table 6: Bachelor's Degrees Awarded by Gender

Gender	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female	17.80%	18.10%	18.40%	18.90%	19.10%	19.90%	20.90%	21.30%	21.90%	22.40%	23.00%	24.00%	24.20%
Male	82.20%	81.90%	81.60%	81.10%	80.90%	80.10%	79.10%	78.70%	78.10%	77.60%	77.00%	76.00%	75.80%





1.1.8 Bachelor's Degrees Awarded by Residency

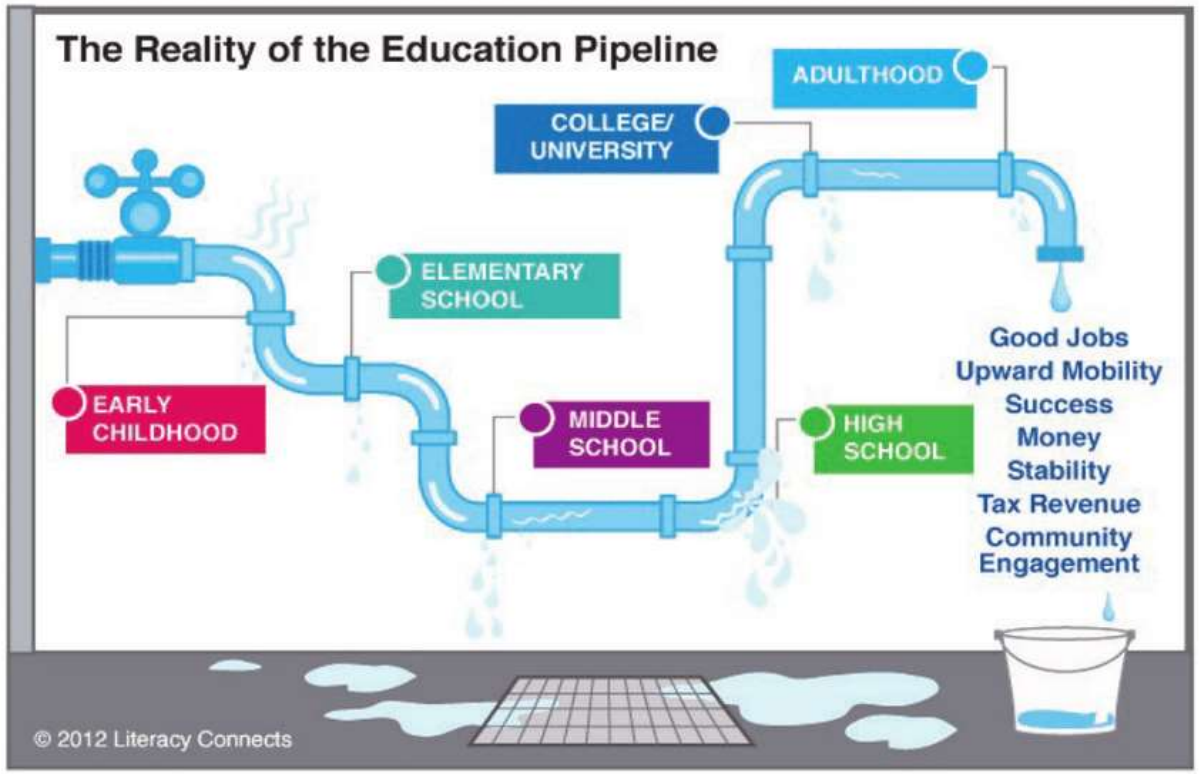
Table 8: Bachelor's Degrees Awarded by Residency

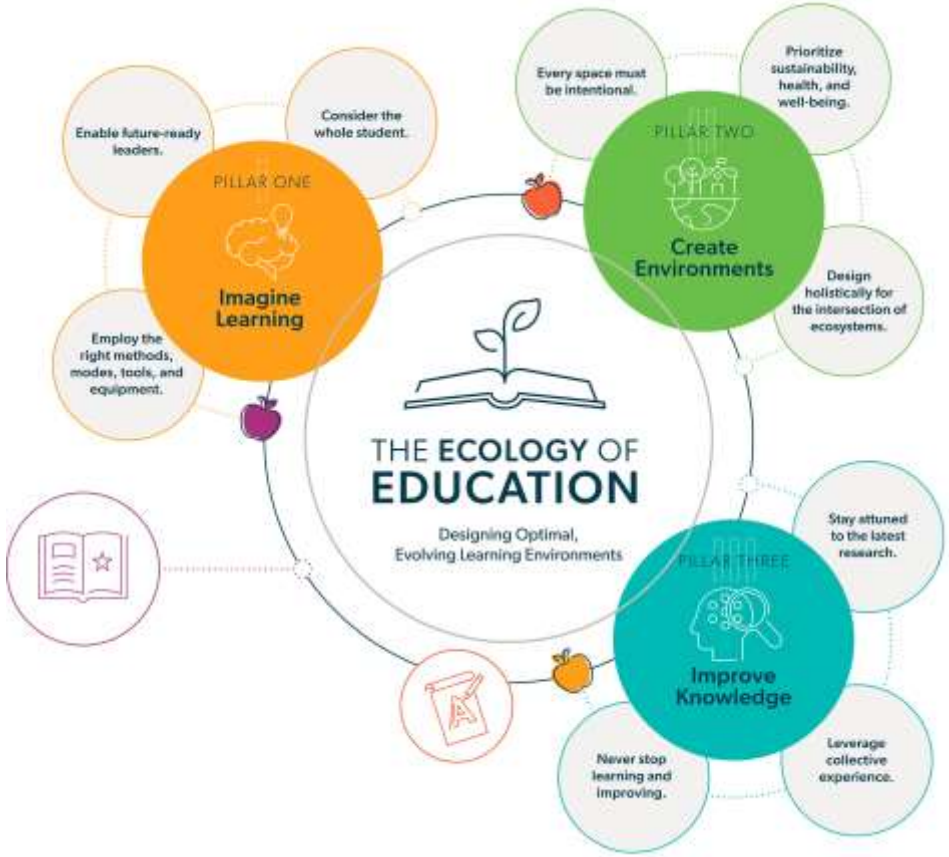
Nationality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Foreign	6.2%	6.2%	6.7%	7.5%	7.8%	8.5%	9.1%	9.6%	10.1%	11.2%	11.2%	10.6%
Domestic	94.0%	93.8%	93.3%	92.5%	92.2%	91.5%	90.9%	90.4%	89.9%	88.8%	88.8%	89.4%

https://ira.asee.org/wp-content/uploads/2024/03/Engineering-and-Engineering-Technology-by-the-Numbers-cover-combined.pdf

STEM Educational Landscape

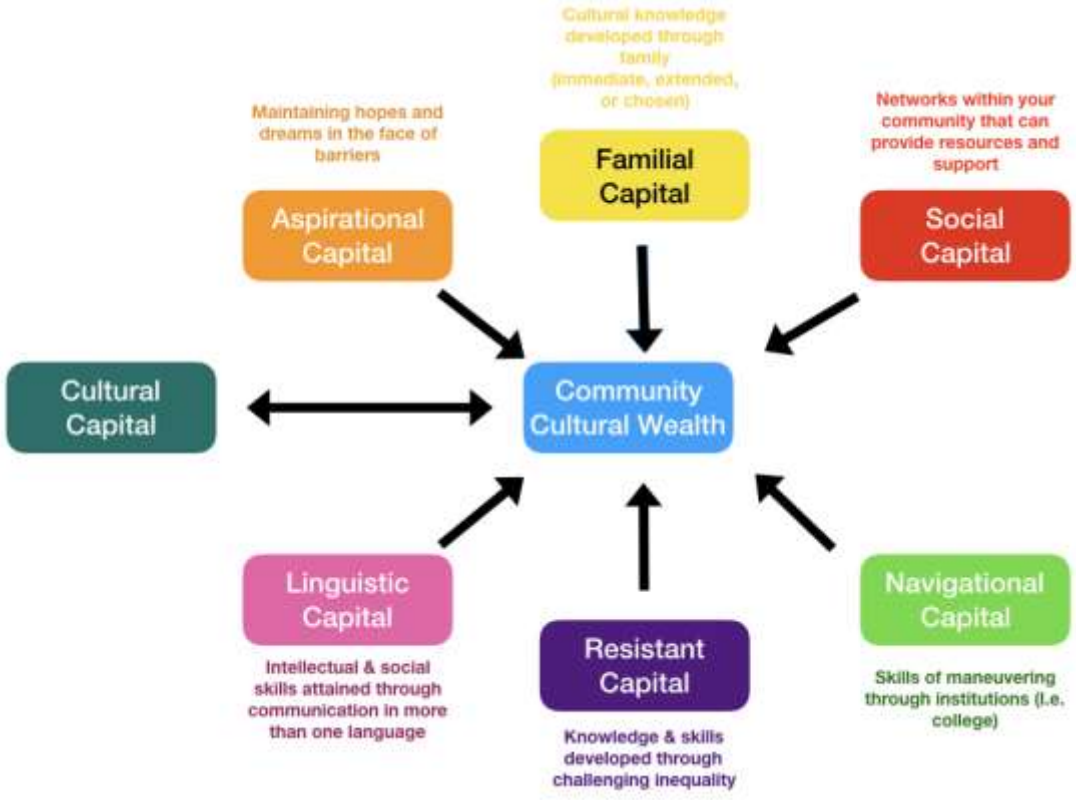
- Leaky ‘pipeline’ (illustrative figure)
- STEM career decision-making starts early
- Educational Ecology (Cushing Terrell) …spaces & places of learning





Educational Models

- Deficit models (e.g. blame game)
- Community cultural wealth (Yosso)
  6 types: Social, Familial, Aspirational, Navigational, Linguistic, and Resistant Capital
- Culturally engaged campus communities (Museus)
- Rightful presence in learning and teaching (Barton & Tan)



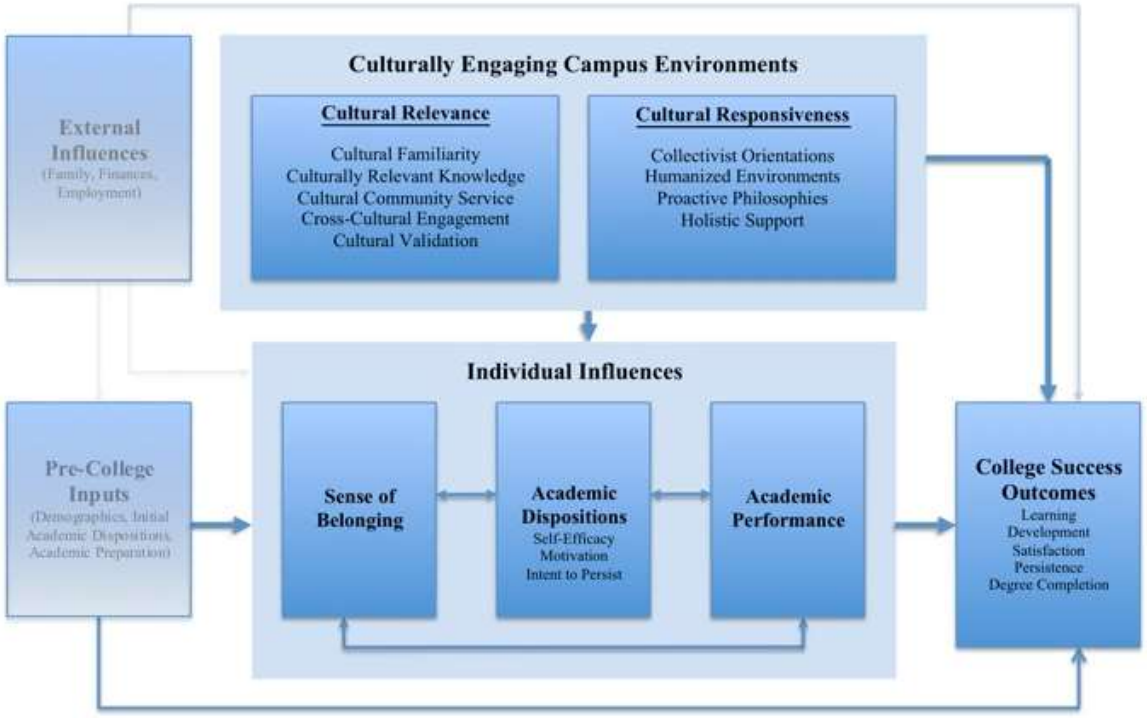


Figure 1: The Culturally Engaging Campus Environments (CECE) Model of College Success

ANS ‘K-12 & Beyond’ Program Goals

- **Clarify common misconceptions** surrounding nuclear science and explore its current and future role in technological applications
- **Build understanding** of and create value for nuclear science and technology
- **Inspire future careers** in the nuclear field – and the pursuit of higher education to achieve this goal

ANS STEM Programs

Navigating Nuclear

- NGSS-aligned nuclear science curriculum for students in grades 3 through 12
- Accessed by 1.8 million students to date

Educator Training

- Professional development webinars and workshops on nuclear science concepts and teaching strategies
- Average educator reach per webinar = 357 (2024)

Pathways To Nuclear

- Showcase career opportunities and inspire students to pursue roles in nuclear science and technology
- 7 in-depth profiles to date

Nuclear Ambassadors

- Nuclear industry professionals trained for outreach to classrooms and informal learning programs
- 80+ trained to date

ANS

Navigating Nuclear

A fact-based, contemporary, and trusted curriculum developed by the American Nuclear Society in partnership with Discovery Education and the Department of Energy Office of Nuclear Energy.

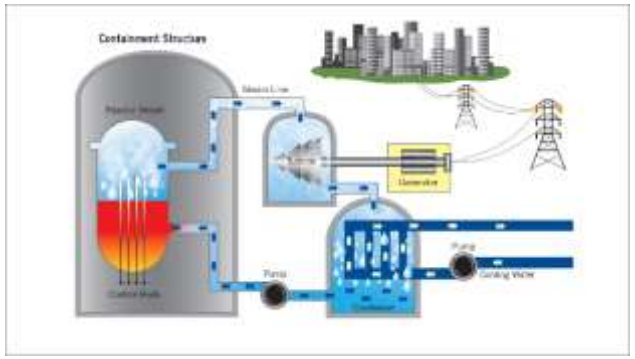
- Fact-based
  - Guided by ANS leaders in nuclear science and technology
  - Reviewed by additional DOE NE SMEs
- Contemporary
  - Resources present the latest in nuclear science and technology
  - Inquiry-based lessons aligned with NGSS
- Trusted
  - Created by Discovery Education curriculum team
  - Featured in subscription resource and free through ANS
  - https://www.ans.org/nuclear/navigatingnuclear/

Elementary 3-5

Take a trip to the moon and back through our virtual field trip!

Middle School

Project Starters



From Atoms to Electricity

How does the energy stored in an atom’s nucleus transform into the electricity that powers our lives?

Fusion and Fission: Think Nucleus

How could nuclear fusion and fission change the way we power our lives?

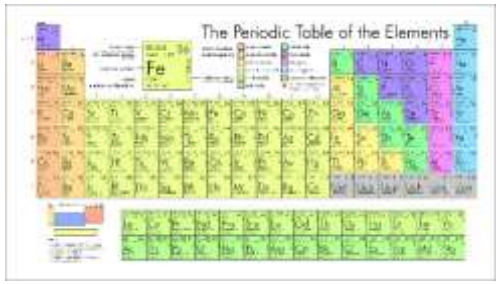
Radiopharmaceuticals

How can a pill that uses radiation help doctors diagnose and treat diseases?

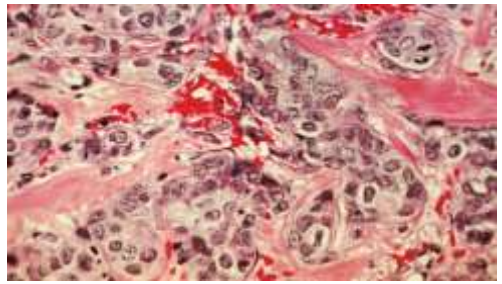
High School

Digital Lesson Bundles (engage, explain, explore)

Realities of Radiation



Decoding Decay



Planting the Seeds for a Better Future for Cancer Patients

Unlocking Energy: Fission vs. Fusion

Fueling the Future

Educator Training

In-person workshops

Monthly Webinars

- Support for Navigating Nuclear
- Lab activities and tools

Pathways to Nuclear

If students can see it, they can be it!

Spotlight on Nuclear Careers

ANS's Young Members Group presents interviews with nuclear researchers and professionals making a positive impact on the world.

Life Sciences

Nuclear science is providing unique solutions to problems in life sciences including medicine and agriculture. Hear Katherina Stapelmann, assistant professor of nuclear engineering at North Carolina State University, discuss her research with plasmas and career in nuclear.

New Nuclear Technologies

Marci Shelton, a senior nuclear engineer at SHINE Technologies LLC. Shelton currently works on the production of radioisotopes for diagnostic and therapeutic applications in medicine, such as cancer therapy and imaging. She talked about her work with SHINE as well as her background in the nuclear industry.

Nuclear Energy

Nuclear energy is an exciting field helping create clean, reliable power. Sarah Camba Lynn, an engineering manager at Comanche Peak Nuclear Power Plant in Glen Rose, TX, talks about her work in nuclear energy.

ANS

Career Profiles

Nuclear Security Researcher →

Radiochemist →

Fuels Reliability Engineer →

Find your pathway to a career in nuclear

PATHWAYS TO NUCLEAR

Energy	Education	Pay Range
Engineer: nuclear, mechanical, civil, electrical, environmental, software	◆◆◆	$$$
Trades: electrician, carpenter, pipefitter, metal worker	◆	$
Technician: engineering, operations, instrument and electrical, control, IT	◆◆	$$
Reactor Operator	◆	$$
Nuclear Operations Technician	◆◆	$$
Radiation Safety Officer	◆◆◆	$$$
Firefighters	◆	$
IT Technical Support Specialist	◆◆	$
Environmental Specialist	◆◆◆	$$
Decommissioning Operative	◆	$

Industrial Applications	Education	Pay Range
Trades: electrician, carpenter, pipefitter, metal worker	◆	$
Technician: operations, instrument and electrical, control, IT	◆◆	$$
Radiation Protection Specialists	◆◆◆	$$
Radiologic Evaluator	◆◆	$$
Radiographer	◆◆	$$
Industrial Radiographer Assistant	◆	$
Radiochemist	◆◆◆	$$$
Engineer: nuclear, industrial, construction, mechanical, computer	◆◆◆	$$$
Industrial Irradiator Operator	◆	$

National Security	Education	Pay Range
Machinists Mate Nuclear	◆	$
Naval Reactors Engineer	◆◆◆	$$$
Nuclear Power School Instructor	◆◆◆	$$$
Electronics Technician Nuclear	◆	$
Nuclear Surface Warfare Officer	◆◆◆	$$$
Submarine Officer	◆◆◆	$$$
Electricians Mate Nuclear	◆	$
Weapons Specialist	◆◆◆	$
Physicist/Nuclear Engineer	◆◆◆	$$$
Nuclear and Missile Operations Officer	◆◆◆	$$$
Cybersecurity Specialist	◆◆◆	$$$

Health Care	Education	Pay Range
Radiation Oncologist	◆◆◆◆	$$$$
Nuclear Medicine Technologist	◆◆	$$$
Radiologic Technologist	◆◆	$$
Nuclear Pharmacist	◆◆◆◆	$$$
Nuclear Pharmacy Technician	◆	$
Health Physicist	◆◆◆	$$$
Radiation Safety Officer	◆◆◆	$$$
Medical Physicist	◆◆◆	$$$
Pharma Manufacturing Technician	◆	$
Cyclotron Engineer	◆◆◆	$$$

Aerospace	Education	Pay Range
Aerospace Engineer	◆◆◆	$$$
Specialty Engineer: Flight, Nuclear Propulsion, Radiation Effects	◆◆◆	$$$
Other Engineer: nuclear, civil, mechanical, electrical	◆◆◆	$$$
Engineer Technician	◆◆	$
Experimental Physicist	◆◆◆◆	$$
Airframe Mechanic	◆	$
Meteorologist	◆◆◆	$$
Drone Technician	◆	$
Assembly Technician	◆	$

Research & Development	Education	Pay Range
Technician: operations, instrument and electrical, control, IT	◆◆	$$
Researcher: physics, computational mathematics, chemistry, biomedical	◆◆◆	$$$
Research Technologist	◆◆	$$
Engineer: nuclear, mechanical, chemical, environmental; software	◆◆◆	$$$
Engineering Technologist	◆◆	$$
Radiation Safety Specialist	◆◆◆	$$

◆◆◆◆ PhD	$ $ $ $	$125-300K+
◆◆◆ Bachelor's/Master's	$ $ $	$70K-120K
◆◆ Associate/Bachelor's	$ $	$50K-90K
◆ Vocational/Training	$	$35K-70K

Your career is more than just a job title—it's an opportunity to do fulfilling work that has a positive impact on the world. There are many jobs in clean energy production in the nuclear industry, but there are other fields and disciplines you might not think of when you think about nuclear science and technology.

American Nuclear Society

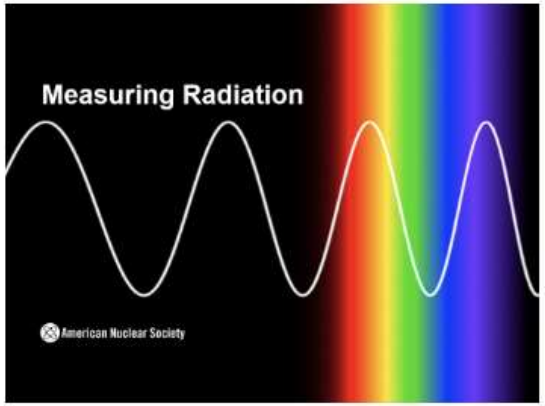
Nuclear Ambassadors

Educational Presentations

Make the complex world of nuclear easier to understand with these presentations. Designed specifically for K-12 students, they provide background knowledge for nuclear science and technology lab activities, such as those in Navigating Nuclear lessons and project starters.

Nuclear energy is a safe, reliable source of clean energy. Introduce students to the facts about nuclear energy and bust some myths, too.

Download



Learn about sources of background and man-made radiation. Then use a radiation monitor to compare radioactive sources.

Download

Radiation is all around us. Cloud chambers are an engaging way to visualize it. Use this presentation to accompany a cloud chamber lab activity.

Download

Certification Initiatives

Professional Development Certificate Courses

Summer 2024 launch

- Nuclear 101
- Regulatory & Licensing
- Additional courses TBD

Certified Nuclear Professional Credential

Summer 2025 launch

Nuclear 101 Course Modules

1. History and legacy of nuclear
2. Nuclear fundamentals
3. Introduction to nuclear fuel cycle
4. Nuclear reactors and power generation
5. Licensing and regulatory concepts
6. Radiation detection and measurement
7. Health physics and radiation safety
8. Non-power applications of nuclear
9. Nuclear safety culture
10-11. Choose 2 from these options:
    - Nuclear Non-Proliferation
    - Decommissioning
    - Advanced Reactor Technologies
    - Simulation Tools in the Nuclear Industry
    - Storage and Transportation of Radioactive Material
12. Industry codes and standards
13. Careers in nuclear

Regulatory & Licensing Course Modules

1. US NRC Regulatory Framework
2. US DOE Regulatory Framework
3. DOE vs. NRC Organization (responsibilities)
4. Types of NRC Licenses
5. Safety Analysis Reports
6. Technical Specifications (TS) and TS Bases
7. Licensing Change Processes
8. Reactor Oversight Process (ROP)
9. Fuel Licensing Considerations
10. Transportation
11. Waste Management
12. Decommissioning (consider reactors vs. other facilities)
13. International Licensing Considerations

Continuing & in the future

- Visualizing Radiation Cloud Chamber kit with lesson plan☑
- Relaunch an ANS K-12 Newsletter
- Add virtual training option to Nuclear Ambassadors
- Future City Nuclear Science Award☑
- ANS Nuclear Science Club *(piloting)*
- ANS K-12 Outreach Museum Exhibit (Discovery Place Science Museum)
- ANS Special Committee on STEM Education☑

Thank you!

lisa.marshall@ans.org

https://www.ans.org/nuclear/