Civil society organizations are in a unique position to build connections with high school educators and students; however, few organizations are engaged in direct outreach at that level. The James Martin Center for Nonproliferation Studies (CNS) Critical Issues Forum, for example, is an annual conference on nuclear-security issues that engages high school students from around the world. Other organizations, such as the Nuclear Threat Initiative (NTI), provide free educational videos online; however, educators may be unaware of these resources. The Council on Foreign Relations recently began an Education Ambassador Program to equip high school and university educators with tools to teach about IR, including online resources and virtual meetings. Organizations such as the NTI, Arms Control Association, and Center for Arms Control and Nonproliferation would be ideally suited for offering similar programs for educators, as well as summer training workshops and nuclear-specific curricula.

Civil society also has been instrumental in direct outreach to young people outside of the classroom. For instance, at the Tenth Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, held in 2022, young professionals hosted a series of meetings to promote youth involvement in non-proliferation and disarmament work. Various organizations, including the CNS, US Women in Nuclear, and the International Campaign to Abolish Nuclear Weapons, provide excellent mentorship and internship programs to students interested in the field.

Nuclear Education Beyond Nukes

Nuclear security and nonproliferation relate to many key policy issues beyond weapons, from energy policy to climate policy and international trade. The expansion of civilian nuclear-energy facilities, for instance, and the public's ability to distinguish between nuclear weapons and nuclear energy for peaceful purposes will be critical for the development of clean-energy policy.

Improved nuclear-security education not only raises awareness about these related issues but also can create job opportunities for young people. Advancements in energy technology, coupled with the wave of expected retirements in the energy and nuclear-security fields, offer promising career paths.

Conclusion

Apathy is not the reason for the unawareness of younger generations about nuclear issues; rather, it is education. There are workforce-development benefits from increasing diversity and representation among young people interested in nuclear issues; however, the primary benefit will accrue to our society as a more widely informed populace understands the challenges and opportunities. With the success of the recent film *Oppenheimer*, nuclear security is back in the public consciousness, and there is no better time to pursue these efforts. Increasing knowledge on the subject requires a truly interdisciplinary approach. Although the focus has long been on STEM education, we also must ensure that the next generation of international-security leaders understands the political and policy implications of nuclear (in)security.

CONFLICTS OF INTEREST

The authors declare that there are no ethical issues or conflicts of interest in this research ■

REFERENCES

Asal, Victor, Justin Conrad, and Steve Sin. 2020. "Back to the Future: Teaching About the End of the World." *European Political Science* 19:302–18. https://doi.org/10.1057/s41304-019-00216-2.

Bidgood, Sarah. 2019. "Undergraduate Disarmament and Nonproliferation Education: Gaps, Opportunities, and New Approaches." *The Nonproliferation Review* 26 (3–4): 329–40. https://doi.org/10.1080/10736700.2019.1646470.

Smeltz, Dina, Craig Kafura, and Sharon Weiner. 2023. "Majority in the US Interested in Boosting Their Nuclear Knowledge." https://globalaffairs.org/sites/default/files/2023-07/Nuclear%20Survey%20Report%20PDF.pdf.

EMERGING TECHNOLOGIES AND NEW VOICES IN NUCLEAR DEBATES

Margaret E. Kosal, *Georgia Institute of Technology, USA*

DOI:10.1017/S1049096525000393

In response to anthropogenic climate change, new policies and investments in alternative clean energy sources are being pursued globally, including emerging technologies for nuclear energy and fusion (White House 2023a). The largely unexplored intersections with nuclear nonproliferation and effects on international security are the subject of an ongoing research project (Kosal and Whitlark n.d.). The relationships among nuclear nonproliferation, climate change, and emerging technologies are interconnected. The emerging nexus between renewed interest in nuclear power for clean energy and responding to nonproliferation challenges is a new space that will both benefit from new voices but may also offer opportunities that more traditional disciplinary domains and narrow policy endeavors may not (Kosal 2024). This is a gap that new voices can address and illuminate with novel solutions. This spotlight essay focuses on new voices in emerging technologies related to nuclear energy and nonproliferation policy.

Analyses from the Intergovernmental Panel on Climate Change, the International Atomic Energy Agency (IAEA), and the International Energy Agency (IEA) show that nuclear energy plays a major role in achieving global net-zero goals (IAEA 2021; IEA 2022). At COP28, the United States announced initiatives to triple nuclear energy capacity globally by accelerating deployments of advanced reactors, including small modular reactors (SMR) globally; securing the nuclear fuel supply chain; and fusion energy research and development (White House 2023b).

Emerging technologies at this nexus that are often cited include "advanced reactors," which is a term used to describe non-light water reactor designs using technologies that differ from those of existing operating reactors, such as passive safety features, or incorporate different fuel or coolants, such as molten salt reactor technologies. Fusion-based reactors are another example of truly nascent technology. Fundamental issues involving advanced reactors range from the appropriate role of federal governments in developing and deploying advanced nuclear power technologies to international regimes and safeguards. New voices leading in this area at the intersection of engineering and nonproliferation include Brenda Garcia-Diaz, who leads Savannah River National Laboratory's Fusion Fuel Cycle Research and Development efforts, which seek to address the technical challenges of developing fusion-based energy and new proliferation challenges of the emerging technology (SRNL n.d.).

https://doi.org/10.1017/S1049096525000393 Published online by Cambridge University Press

The technology that has gotten the most attention recently is SMRs. Although there are successes, they are finding mixed success globally. Employing two SMRs, Russia's Akademik Lomonosov—the world's first floating nuclear power plant—began operating commercially in 2020 (Kuznetsov 2021). At least one land-based SMR in Russia has been licensed (World Nuclear News 2023). China's first SMR began producing energy in 2023 (Howe 2023). Both Russia and China are selling and operating their nuclear technology abroad (World Nuclear Association 2023). While receiving significant initial interest and federal investment, private development of SMRs in the US has met with setbacks. The first attempt to deploy an SMR in the US was canceled because too few corporate customers signed up to receive its power amid rising costs (Duckett 2023). Another major US-led SMR project abroad is waiting for approval (Reuters 2024). Developing and deploying new SMR concepts commercially requires significant innovation.

The emerging nexus between renewed interest in nuclear power for clean energy and responding to nonproliferation challenges is a new space that will both benefit from new voices but may also offer opportunities that more traditional disciplinary domains and narrow policy endeavors may not (Kosal 2024).

There are multiple places where new voices are beneficial, from basic research through entrepreneurial endeavors to international policy. More women are needed in nuclear- and energy-related science and technology fields: engineers and entrepreneurs from underrepresented groups can have a positive influence on the development of new technology. In the United States, only 17% of nuclear engineers are female (Townsend et al. 2022). Globally, women were found to comprise 24% of the workforce in the nuclear sector in 2019 (Nuclear Energy Agency 2023). This trend has held for decades. In the United States, nuclear engineering demographics do not resemble the wider population: 73% are White (Townsend et al. 2022). In context of transitioning applied research to commercial technology, only about 11% of energy sector founders are female versus 20% across all sectors (Johnstone and Silva 2020). New voices are needed from laboratory science and engineering through small, high-tech start-ups.

The publics' willingness to support nuclear energy also needs new voices, especially women. A meta-analysis of the scholarly literature documenting how the general public views nuclear energy reveals a strong negative correlation between concern over climate change and support for nuclear energy (Kosal and Whitlark n.d.). A lower level of support for nuclear power by women than by men has been repeatedly documented (Aegerter 1989; Sundström and McCright 2016). The lack of women in the nuclear sector is causally attributed to be a factor driving the "gaps [that] raise persistent barriers to the application of nuclear technology despite its attributes and benefits" (Nuclear Energy Agency 2023). This is important because opposition to nuclear energy, especially among young people and those most concerned about climate change, could limit its usefulness as an alternative to fossil fuel. This is an area that may be ripe for policy attention and new voices. The organization, Women in Nuclear Canada, is trying to have that influence on the general public through their "SMR Action Plan" (Women in Nuclear Canada, n.d.). As more women, women of color, and other underrepresented groups' voices are heard, they may bring forward ideas that challenge dominant policy thinking globally, nationally, and locally. A detailed discussion about the ways and effects of such is beyond the scope of this short piece.

In international security and nuclear safety policy, there are tremendous opportunities for new voices, especially critical are scholars who are able to bridge across the technical, engineering, geopolitical, and policy realms. For example, advanced reactors are often designed to be more resistant to proliferation than light water reactors through a variety of means including closed systems making the fissile material inaccessible. Being "proliferation resistant" does not necessarily mean that verification and safeguards are no longer needed. In some cases, nuclear accountancy safeguards are made more difficult by advanced reactor designs, which is counter to nonproliferation goals (IAEA 2017). Another area that is ripe for scholarship and new policy approaches is how to integrate fusion-based technologies into nonproliferation regimes (Kalinowski and Colschen 1995), what safeguards are needed technically and politically (Sievert and Johnson 2010), and effects on strategic stability. Women like IAEA Deputy Director General and Head of the Department of Nuclear Safety and Security Lydie Evrard (IAEA 2023), Country Leader for GE Hitachi Small Modular Reactors in Canada Lisa McBride (Innovating Canada, n. d.), and outgoing US National Nuclear Security Agency Administrator Jill Hruby (Arms Control Today 2023) epitomize the bridging of the technical with policy at the intersection of nonproliferation and emerging technologies.

Another area for new voices is exploring the connections (or lack thereof) among climate change, geopolitical stability, and nuclear proliferation. Climate change is expected to create instability and increase the potential for conflict, which may increase the risks of a nuclear exchange, whereas at the same time, states may desire nuclear weapons as a deterrent. The most noticeable gap in the existing literature is the relative lack of work explicitly linking nuclear weapons/nuclear proliferation to climate change. In the rare case that they are mentioned, it is to point out the similarities between these issues in terms of their scale, complexity, and effects. Indeed, both nuclear proliferation and climate change can be considered collective action problems in which critical decisions are made at the national and subnational levels but the effects of such decisions are felt globally.

In conclusion, improving our understanding of the nexus among nuclear weapons, nuclear energy, and climate change will be necessary for developing policies that meet the world's growing energy needs while limiting both fossil fuel emissions and nuclear proliferation. To do this, new voices are needed. Women and underrepresented minorities are untapped talent, and new voices and teams that bridge deep expertise in social sciences and the technical realms are also essential.

https://doi.org/10.1017/S1049096525000393 Published online by Cambridge University Press

CONFLICTS OF INTEREST

The author declares no ethical issues or conflicts of interest in this research. ■

REFERENCES

Aegerter, Irene. 1989. "Women and Nuclear Power." International Atomic Energy Agency. https://inis.iaea.org/search/search.aspx?orig_q=RN:36011040.

Arms Control Today. 2023. "Managing an Arsenal Without Nuclear Testing: An Interview With Jill Hruby of the U.S. National Nuclear Security Administration." December. https://www.armscontrol.org/act/2023-12/interviews/managing-arsenal-without-nuclear-testing-interview-jill-hruby-us-national.

Duckett, Adam. 2023. "Nuscale Cancels First Planned SMR Nuclear Project Due to Lack of Interest." *The Chemical Engineer*, November 27. https://www.thechemicalengineer.com/news/nuscale-cancels-first-planned-smr-nuclear-project-due-to-lack-of-interest.

Howe, Colleen. 2023. "China Starts Up World's First Fourth-Generation Nuclear Reactor." *Reuters*, December 8. https://www.reuters.com/world/china/china-starts-up-worlds-first-fourth-generation-nuclear-reactor-2023-12-06/.

International Atomic Energy Agency. (IAEA). 2017. "Emerging Technologies Workshop Report: Trends and Implications for Safeguards." February. https://www.iaea.org/sites/default/files/18/09/emerging-technologies-130217.pdf.

International Atomic Energy Agency. (IAEA). 2021. "Nuclear Energy for a Net Zero World." September. https://www.iaea.org/zh/resources/brochure/nuclear-energy-for-a-net-zero-world.

International Energy Agency. (IEA). 2022. "Nuclear Power and Secure Energy Transitions." September. https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions/executive-summary.

Johnstone, Nick, and Marta Silva. 2020. "Gender Diversity in Energy: What We Know and What We Don't Know." IEA, March 6. https://www.iea.org/commentaries/gender-diversity-in-energy-what-we-know-and-what-we-dont-know.

Kalinowski, Martin, and Lars Colschen. 1995. "International Control of Tritium to Prevent Horizontal Proliferation and to Foster Nuclear Disarmament." *Science & Global Security* 5 (2): 131–203.

Kosal, Margaret. 2024. "Diplomacy, Defense, and the Nuances of Modern International Security." Georgia Tech, *Professional Education* (blog), June 24. https://pe.gatech.edu/blog/industry-trends/Diplomacy-Defense-Nuances-of-Modern-International-Security.

Kosal, Margaret E., and Rachel E. Whitlark. n.d. "Navigating the Nexus."

Kuznetsov, Vladimir. 2021. "Small Modular Reactors (SMRs): The Case of Russia." In *Handbook of Small Modular Nuclear Reactors*, eds. Daniel T. Ingersoll and Mario D. Carelli, 467–501. Cambridge: Woodhead Publishing.

Nuclear Energy Agency. 2023. "Gender Balance in the Nuclear Sector." Paris: Organisation for Economic Co-Operation and Development. https://www.oecd-nea.org/jcms/pl_78831/gender-balance-in-the-nuclear-sector.

Reuters. 2024. "Romania's Nuclearelectrica Sees Preliminary Decision on SMR Plant in 2025." *Reuters*, March 18. https://www.reuters.com/business/energy/romanias-nuclearelectrica-sees-preliminary-decision-smr-plant-2025-2024-03-18/.

Savannah River National Lab (SRNL). n.d. "Fusion Fuel Cycle Research and Development." https://www.srnl.gov/fact-sheets/fusion-fuel-cycle-research-and-development/.

Sievert, Fabian, and Daniel Johnson. 2010. "Creating Suns on Earth: ITER, LIFE, and the Policy and Nonproliferation Implications of Nuclear Fusion Energy." *The Nonproliferation Review* 17 (2): 323–46.

Sundström, Aksel, and Aaron McCright. 2016. "Women and Nuclear Energy: Examining the Gender Divide in Opposition to Nuclear Power among Swedish Citizens and Politicians." *Energy Research & Social Science* 11:29–39.

Townsend, Lawerence W., Lori Brady, Janice Lindegard, Howard Hall, Elizabeth McAndrew-Benavides, and John Poston. 2022. "Nuclear Engineering Workforce in the United States." *Journal of Applied Clinical Medical Physics* 23 (S1): article e13808.

White House. 2023a. "Fact Sheet: Biden-Harris Administration Leverages Historic U.S. Climate Leadership at Home and Abroad to Urge Countries to Accelerate Global Climate Action at U.N. Climate Conference (COP28)." December 2. https://www.whitehouse.gov/briefing-room/statements-releases/2023/12/02/fact-sheet-biden-harris-administration-leverages-historic-u-s-climate-leadership-at-home-and-abroad-to-urge-countries-to-accelerate-global-climate-action-at-u-n-climate-conference-cop.

White House. 2023b. "International Partnerships in a New Era of Fusion Energy Development." December 2. https://www.whitehouse.gov/ostp/news-updates/2023/12/02/international-partnerships-in-a-new-era-of-fusion-energy-development/.

Women in Nuclear Canada, Smart Action Plan, n.d. https://smractionplan.ca/content/women-nuclear-canada.

World Nuclear Association. 2023. *World Nuclear Industry Status Report 2023*. December. https://www.worldnuclearreport.org/IMG/pdf/wnisr2023-v5.pdf.

World Nuclear News. 2023. "License Issued for Russia's First Land-Based SMR." *World Nuclear News*, April 24. https://world-nuclear-news.org/Articles/Licence-issued-for-Russia-s-first-land-based-SMR.

DOMESTIC COSTS OF NUCLEAR DETERRENCE: VOTER TURNOUT AND NUCLEAR WEAPONS TESTING

Unislawa Williams, *Spelman College, USA*
Mya Whiles, *Spelman College, USA*
Tinaz Pavri, *Spelman College, USA*

DOI:10.1017/S1049096525101315

The US government's testing of nuclear weapons in the desert southwest beginning in 1945 led to widespread radiation exposure, creating dire long-term health consequences for many surrounding communities. We examined the impact on voter turnout almost a half-century later as the US government attempted to respond monetarily by compensating those who fell ill. By combining data on county-level turnout with government reports to examine the effects of compensation on voting, our natural experiment analyzed whether counties that experienced fallout but were not included in the initial compensation differed in voter behavior in the two subsequent presidential elections. Utilizing Difference-in-Difference (DiD) modeling, we tested whether uncompensated counties voted at rates comparable to neighboring counties that were compensated. Our findings show that aggregate voter turnout was significantly higher in these swing states with implications for nuclear weapons policy and international relations (IR) deterrence debates.

Nuclear weapons testing affected the lives and health of voters around the desert southwest. In 1990, the Radiation Exposure Compensation Act (RECA) was enacted to compensate those residents of Arizona, Utah, and Nevada who fell ill with specific medical conditions and simultaneously met stringent residency requirements. However, eligibility was limited geographically. Counties that were located outside of the mapped fallout area—as mistakenly understood by scientific studies at the time—were excluded from compensation in 1990; however, some were compensated in 2000 as the US government expanded the geographic coverage (Boutté 2002). Our study attempted to understand the potential impact of the 1990 RECA implementation on voter turnout. Utilizing county-level data, we examined voter behavior in the subsequent presidential elections that were potentially affected.

We argue that the voters affected by the 1990 RECA implementation influenced nuclear policy and related debates, if indirectly (figure 1). We do not know the extent to which high voter engagement in deterrence-adjacent policy contributed to changes in deterrence or nuclear weapons policies. However, nuclear weapons testing affected voters. They responded, and their response likely contributed to the government's response. Moreover, once the government responded, the deterrence landscape shifted. Therefore, in this adaptation of Downs's (1957) pocketbook-voting hypothesis, nuclear weapons policy can change due to voter pressures even in adjacent policy areas. Other factors contributed to the cessation of testing in 1992,

https://doi.org/10.1017/S1049096525000393 Published online by Cambridge University Press