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RISING TO THE CHALLENGE

Emerging Leaders in Nuclear Security

NTI
BUILDING A SAFER WORLD

Contents

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Introduction

Nickolas Roth

Nuclear security is entering a period of profound transition. Amid rising geopolitical tensions, accelerating technological change, and intensifying domestic political pressures, governments and institutions must confront challenges that extend well beyond traditional technical boundaries. The Emerging Nuclear Security Leaders project brings together analysts and practitioners whose diverse perspectives and professional experiences reflect the complexity of today's global environment. Their work illustrates how the future of nuclear security will depend not only on improved technologies and regulations, but on strengthening the social, political, and organizational systems that underpin them.

A core theme emerging from this collection is the centrality of people—those who produce analysis, manage nuclear materials, regulate facilities, engage communities, or support public debate. Mackenzie Knight-Boyle's examination of rising online harassment targeting U.S. nuclear-policy experts, particularly women and those from underrepresented groups, highlights a growing threat to the integrity of public discourse. Her work underscores that safeguarding nuclear security requires protecting the individuals whose expertise shapes decision-making. A resilient policy ecosystem hinges on ensuring that these voices can participate safely and without fear of targeted abuse.

The pressures on civil society contributors to nuclear security extend far beyond the United States. Building on this human-centered perspective, Shorena Lortkipanidze documents the profound effects of democratic backsliding in Georgia—where shrinking civic space, weakened rule of law, and rising anti-Western rhetoric have undermined long-standing cooperation on nuclear security. Her analysis offers a cautionary example for policymakers: when civic actors are marginalized or silenced, national nuclear-security systems lose critical partners essential for transparency, accountability, and sustained capacity-building.

Domestic political dynamics can also directly affect the strength and reliability of national nuclear-security systems. Jasmine Auda's analysis of political polarization shows how shifting threat perceptions, fluctuating political will, and inconsistent institutional capacity directly affect the adoption and implementation of nuclear-security norms. Her work reminds policymakers that nuclear-security resilience cannot be divorced from the health of domestic governance systems—and that political fragmentation can open vulnerabilities that adversaries may exploit.

While policies, technologies, and regulatory frameworks are indispensable to nuclear security, the effectiveness of any system ultimately depends on having well-trained people who operate it. Ali Alkis advances this argument by analyzing the critical role of crisis-resilient training for operators, regulators, and first responders. He identifies systemic gaps—particularly in realism, standardization, and

adaptability—that hinder effective crisis response. For policymakers, his work highlights an urgent need to modernize national training architectures to ensure personnel can manage high-consequence, low-probability events.

The organizational and cultural environments in which personnel operate also matter profoundly. Dmitry Kovchegin's work on nuclear-security culture shows how national cultural characteristics such as power distance and uncertainty avoidance shape communication, leadership behavior, and security performance. His findings underscore that international best practices cannot be adopted successfully without understanding and, where necessary, adapting to cultural context—a lesson with direct implications for international assistance, capacity-building, and bilateral cooperation.

Individual states' domestic conditions are only one driver of risk; global political dynamics are increasingly shaping nuclear-security challenges. Darya Dolzikova examines the coercive use of threats against civilian nuclear infrastructure—from wartime occupations to psychological signaling aimed at influencing adversaries and third parties. As more states expand nuclear power and conflicts grow more complex, her work highlights the need for policymakers to strengthen international norms and invest in resilience measures that reduce the coercive value of threatening nuclear facilities.

Technological change adds another layer of complexity. Simon Adu explores the opportunities and risks associated with deploying small modular reactors (SMRs) in sub-Saharan Africa, where rising energy demand intersects with political instability, terrorism, cyber vulnerabilities, and limited regulatory capacity. His analysis underscores that the benefits of advanced nuclear technologies can only be realized if accompanied by robust governance frameworks, regional cooperation, and security-by-design approaches—an important reminder as policymakers worldwide promote next-generation nuclear solutions.

Taken together, these papers reveal a nuclear-security landscape in flux—shaped by shifting geopolitical arrangements, domestic political upheaval, digital threats, technological innovation, and questions of institutional resilience. They also highlight a cohort of emerging leaders whose insights point toward more adaptive, inclusive, and sustainable approaches to nuclear security. For policymakers navigating this rapidly changing environment, the perspectives offered here provide timely guidance for strengthening the global nuclear-security architecture at a moment when doing so is essential.

Harassment and Blowback: A Guide for Individuals and the Nuclear Community

Mackenzie Knight-Boyle

In recent years, members of the nuclear policy and broader national security community have increasingly found themselves the targets of politicized media attacks, particularly when their work touches on issues related to diversity, equity, and inclusion. In several cases, individuals' names, photos, and past writings have been highlighted in ways that invite public criticism and harassment—scrutiny that is often disproportionately directed at women and experts from underrepresented backgrounds, even when similar work by their peers goes unnoticed.

Blowback in the form of online harassment, abuse, and hate speech is becoming increasingly prevalent due to the nature of online forums, and the empowerment of online trolls and attackers in the current political environment. Such abuse is disproportionately directed at female issue-experts and those from underrepresented backgrounds and identities. According to PEN America, a nonprofit dedicated to protecting freedom of expression and supporting writers across the United States, multiple recent studies from the journalism field found that "online abuse can damage mental and physical health and, in some cases, escalate to physical violence," resulting in some journalists "censor[ing] themselves… and leav[ing] the journalism profession altogether."[1]

The collective strength of epistemic communities where retention is already a challenge like the nuclear policy community—grassroots activists, academics, nongovernmental experts, even federal workers and others working in various capacities on nuclear weapons policy—will suffer if blowback goes unaddressed, and if diverse voices are pushed out of the field by online abuse.

The information and recommendations provided in this report draw heavily from the existing literature and resources from the journalism and media field,

[1] Viktorya Vilk and Jeje Mohamed, "The Power of Peer Support," PEN America, April 3, 2024, pen.org/report/peer-support/.

which has a longstanding history of establishing protections and protocols for supporting journalists—particularly journalists from marginalized identities and backgrounds—who face harassment, violence, or online abuse in response to their work. Additionally, this report was informed by conversations with experts who have been targets of blowback from their work, aimed at identifying what helped, what did not, and what was missing.

How Individuals Can Prepare for Blowback

Other than refraining from publishing written products or making public statements on social media, at public or community events, or to the media, there is little an individual can do to *prevent* blowback in response to their work. In a field where individual expertise, reputation, and public messaging play a crucial role, staying out of the public eye entirely is likely not a feasible option for many experts, particularly early-career specialists aiming to establish their place. There are, however, actions an individual can take in advance to mitigate the effect of any backlash they may face from their work.

To reduce the initial risk of being targeted, one key step is to bolster the expert's digital safety and online privacy. As technology and the internet evolve, and the line between public and private data blurs, it is increasingly important that individuals do what they can to defend their online accounts from cyberattacks, and to prevent their private information from falling into the hands of, say, someone who *really* did not like something they wrote. A particularly serious threat is doxxing (sometimes spelled "doxing"), a tactic in which sensitive data about a targeted person, like their home address or information about their family members, is discovered by malicious actors and posted to public forums. This privacy intrusion can create physical security concerns for the target.[2]

A helpful starting point for an expert to begin to reduce the risk of digital attack is to look themself up online. This can help reveal what sensitive information is publicly accessible and how easy it would be for an attacker to find it. Numerous free resources exist to guide people on how to do this effectively, like the *New York Times*' "A Guide to Doxxing Yourself on the Internet," published on NYT Open.[3] (See Appendix for additional resources.) A self-search will likely reveal personal information living on data broker websites. Data brokers are businesses that aggregate individuals' personal data, typically without their knowledge, and sell it to other entities, commonly for advertising purposes.[4] Doxxers often use data broker websites to find or confirm information about their targets.[5] Privacy Rights Clearinghouse, a nonprofit dedicated to data privacy issues, comprehensively lays out how data brokers find and use individuals' personal data:

> Data brokers gather your information from numerous sources, creating detailed profiles that can include thousands of data points per individual. Common sources include social media activity, public records such as property and court filings, browsing history captured through website cookies, loyalty and reward programs, mobile app interactions, surveys, and offline transactions such as retail purchases or magazine subscriptions. They also frequently purchase or exchange data with other companies, allowing them to build comprehensive profiles that include your demographic details, interests, financial status, medical history, purchasing habits, and even inferred characteristics like political affiliations and lifestyle preferences.[6]

Fortunately, some avenues exist for removing one's data from these websites. While the process and success rate depend on the company, most data brokers have procedures people can follow to opt out and have their information removed from the site. Investigative journalist Yael Grauer compiled

[2] Adrienne Varkiani, "Bolster Your Digital Security: How to Protect Yourself from Doxxing," ReThink Media, June 2, 2021, rethinkmedia.org/blog/bolster-your-digital-security-how-protect-yourself-doxxing/.

[3] *New York Times*, "A Guide to Doxxing Yourself on the Internet," 2020, docs.google.com/document/d/1WleGh4D3_p7TYPhjfKRHQyMYwhZayYZayYY7AZSSzPs/edit?tab=t.0.

[4] Privacy Rights Clearinghouse, "Data Brokers," privacyrights.org/data-brokers.

[5] Varkiani, "Bolster Your Digital Security."

[6] Privacy Rights Clearinghouse, "Data Brokers."

and made freely accessible a comprehensive list of data broker sites for people to opt out of, organized in order of priority and including links and information for how to request from each entity that your data be removed.[7] Experts should exercise caution when dealing with data brokers, being sure to not provide them with any new information about themselves—especially copies of identification documents like a driver's license or passport—and, for example, using a fake email and virtual phone number to communicate with them.[8]

Ultimately, removing or restricting access to one's personal information online is an important step to prepare for a situation in which blowback from one's work takes the form of online attack. Some other helpful steps include the following (see Appendix for the Committee to Protect Journalists' "Digital Safety Kit" for more tips):

- Enhance your privacy settings for social media sites (see Appendix for NYT Open's Social Media Security and Privacy Checklist)
- Ask family and friends to remove your personal data from their accounts
- Request that Google Maps blur your home on Google Street View[9]
- Establish two-factor authentication for online accounts

In addition to doxxing and other digital safety concerns, backlash from one's work can have a significant impact on mental health. Although it can be difficult to predict which publications or statements might face significant adverse reaction, being prepared for it—to the extent possible—can mitigate the effect on one's mental health by removing some level of uncertainty and surprise.

One way for an expert to prepare for the aftermath of tackling a controversial topic is to have a conversation with a supervisor or mentor prior to publishing. Think through what, if any, blowback might come, establish expectations for how the targeted individual will be supported, and plan what other actions might be taken. Such communication between experts and their supervisors or employers is a minimum requirement for ensuring that those who circulate their opinion or analysis—particularly early-career and more vulnerable specialists—are adequately supported, prepared, and protected. While experts can request that these conversations take place, the primary responsibility is for employers to ensure they are positioning their employees for success.

Preparing for Blowback: The Role of Employers and Partner Organizations

Employers

In addition to having conversations and consistent communication with staff members, management at individual organizations should establish protocols and policies that provide clear guidance for employees on how to navigate abuse, how to tighten digital security, how to use social media professionally, and what to expect from their organization if they become a target of online abuse.

The International Women's Media Foundation (IWMF), an organization that works to support women and nonbinary journalists, recommends that employers establish a reporting and escalation policy that states "what types of abuse a journalist should report, who to report the abuse to and what will happen once it has been reported."[10]

Having such policies established and clearly communicated in advance can reduce the mental and emotional toll an employee may experience when targeted for their work by removing the uncertainty of what steps to take, and by reassuring that the employee is not alone in dealing with the situation. IWMF's full "Guide to Protecting Newsrooms and Journalists Against Online

[7] Yael Grauer, "BADBOOL," GitHub, accessed March 23, 2025, updated version, github.com/yaelwrites/Big-Ass-Data-Broker-Opt-Out-List.

[8] Varkiani, "Bolster Your Digital Security."

[9] Jack Morse, "How to blur your home on Google Street View (and why you should)," Mashable, May 2, 2024, mashable.com/article/how-to-blur-your-house-on-google-street-view.

[10] Ela Stapley, "A Guide to Protecting Newsrooms and Journalists Against Online Violence," International Women's Media Foundation, September 2022, www.iwmf.org/wp-content/uploads/2022/09/IWMF-Guide-to-Protecting-Newsrooms-And-Journalists-Against-Online-Violence.pdf.

Violence" (see Appendix) provides further guidance and recommendations that could be applied by employers in the field.

Another policy that organizations—specifically, publishers and media outlets—should create is a headline policy. Publishers naturally tend to push for punchy headlines that garner attention and generate engagement. However, when an editor chooses or encourages a headline for a writer's piece that is intentionally provocative, "it's the writer of the article—not the editor who selected the headline—who becomes the target of vicious online harassment," according to PEN America.[11] Establishing a policy that allows for or encourages the writer to have a say in the headline-writing process—and that discourages inflammatory headlines—can help prevent harm. This is particularly the case for young experts who may not feel confident pushing back on an editor's suggestions.

Nuclear Policy-focused Nongovernmental Organizations

Resources from the journalism and media field present an often overlooked-but-critical option that nuclear policy-focused organizations and funders could collectively consider: setting up a task force for responding when someone in the field is targeted as a result of their work. Although journalism resources typically recommend that individual newsrooms establish such a task force,[12] some organizations in the nuclear field may not have adequate staff size or resources to do so. Therefore, multiple organizations, funders, or both could create a forum to explore the possibility of a cross-field task force to ensure that whether an expert has access to support does not depend entirely on their workplace.

A field-wide task force could include a reporting mechanism that would allow individuals to safely and privately report that they are facing online abuse. The task force could be composed of members in the field who volunteer for a set term; PEN America recommends that a task force include representatives from various areas of expertise, including information technology, social media and audience engagement, editorial, and so forth.[13] Task force members would ideally be trained on topics including digital safety, online abuse self-defense, psychological first-aid, and bystander intervention. Even in the absence of such a task force, the field would benefit from affordable, accessible training on these topics (see Appendix for training program resources).

How to Deal With Blowback After Getting Targeted

Suddenly becoming the target of a slew of online abuse, harassment, or hate speech is an overwhelming experience. When such blowback might happen is unpredictable; sometimes experts face backlash immediately upon publishing a piece, but in other cases, online attackers might resurrect something an expert wrote years in the past. Arming individuals with tools and best practices for dealing with blowback can help calm the chaos and mitigate the mental toll.

The first and most important step any individual should take, upon receiving targeted abuse online due to something they wrote or posted for work, is to assess whether there is an immediate risk to their physical safety. If an attacker has made threats of violence or posted the person's home or office address to a public forum, the targeted writer should evacuate to a safe location and notify law enforcement or building security. One should also begin documenting the abuse,[14] which can be helpful in communicating the threat to law enforcement or security officials.

Additionally, documenting can assist with reporting comments and accounts to the platform on which they were posted. Reporting harmful or abusive language to online platforms does not always yield the desired results, but it is nonetheless important to do, as it can result in consequences for the attackers and limit one's exposure to abusive content. PEN America has a guide for how to report on various

[11] PEN America, "Best Practices for Employers."

[12] PEN America, "Best Practices for Employers," Online Harassment Field Manual, onlineharassmentfieldmanual.pen.org/best-practices-for-employers/.

[13] PEN America, "Best Practices for Employers."

[14] PEN America, "Documenting Online Harassment," Online Harassment Field Manual, onlineharassmentfieldmanual.pen.org/documenting-online-harassment/.

platforms, since different websites have different community guidelines and reporting mechanisms.[15]

It is also important that a targeted individual report the abuse to a trusted person or use a formal reporting mechanism. Notifying one's manager, mentor, or friend right away can help lighten the mental and emotional burden, and colleagues might help identify next steps or point one in the direction of useful resources. Beyond notifying a trusted individual, PEN America recommends "rally[ing] a supportive cyber community to share the burden of documenting, reporting, blocking and muting the abuse."[16]

Particularly in severe cases, documenting and reporting harassment and abuse can become not only physically burdensome due to the sheer number of comments and messages, but it can take a significant toll on one's mental and emotional wellbeing to have to monitor the slew of harmful speech being lobbed at them. Delegating these tasks to trusted individuals and members of one's community can provide a reprieve, protect mental health, and lessen the burden of protecting oneself. Many online platforms even allow an individual to delegate account access to a third party.

Dealing with Blowback: The Role of Bystanders and Allies

When a friend or colleague faces targeted blowback, it can be difficult to figure out how to help. Often, the impulse is to ask the targeted individual, "What can I do to help?" While it is important to reach out to them personally and determine how they would like to be supported, one should be careful to avoid placing the burden of responsibility entirely on the targeted person's shoulders. Instead of simply asking "What can I do?" offer some options. Targeted individuals may have different preferences for reacting to blowback; some may prefer that the attackers be ignored and the situation not be given more attention, whereas others may benefit from public statements of support or a counterspeech campaign. For those who are comfortable doing so, another way to support a targeted expert is to directly respond to and/or publicly correct sources of abusive and inaccurate comments (for example, using the "Readers Added Context" feature on X, or simply posting in a comment section). Countering the abusive narrative publicly can help prevent further harassment from readers who may have otherwise been encouraged by the original abuser's post. This is an important role for allies, as it may be unsafe for a targeted individual to directly respond to abuse themself.

PEN America offers a guide for bystander intervention in cases where someone is experiencing online abuse. Right to Be, a nonprofit dedicated to stopping harassment and discrimination, offers "The 5Ds of Bystander Intervention": distract, delegate, document, delay, and direct (see Appendix).[17] Ultimately, targets of blowback need communities of acknowledgement and support, and being an effective ally can be as simple as providing a listening ear.

Dealing with Blowback: The Role of Employers and the Field at Large

"When journalists, activists and writers are attacked online for their work, their employers—including newsrooms and publishers—have a responsibility to take the abuse seriously and help address it."
—PEN America

PEN America outlines clear steps for managers and organizational leadership to take to support their staff in situations of online abuse.[18] Managers are recommended to provide mental support by checking in with their workers privately, and to take on the project management-type tasks of dealing with the situation to lessen the mental and emotional toll on the employee. For example, managers can handle risk assessment by gauging the severity and

[15] PEN America, "Reporting to Platforms," Online Harassment Field Manual, onlineharassmentfieldmanual.pen.org/reporting-online-harassment-to-platforms/.

[16] PEN America, "Defining "Online Abuse": A Glossary of Terms," Online Harassment Field Manual, onlineharassmentfieldmanual.pen.org/defining-online-harassment-a-glossary-of-terms/.

[17] PEN America, "Best Practices for Allies and Bystanders," Online Harassment Field Manual, onlineharassmentfieldmanual.pen.org/best-practices-for-allies-and-witnesses/; Right to Be, "The 5Ds of Bystander Intervention," righttobe.org/guides/bystander-intervention-training/.

[18] PEN America, "Best Practices for Employers."

potential for escalation to physical violence and determine whether other parties need to be engaged, such as law enforcement or security personnel for the office.

Employers should share with targeted staff any relevant policies, procedures, and resources for handling online abuse. This can include connecting a targeted individual with resources for psychological assistance, such as a mental health care provider or small group peer support,[19] or granting temporary leave so the employee can have a break from working while dealing with a distressing situation. Another concrete way that managers and employers can help an employee targeted by online abuse is by taking on the role of monitoring, documenting, and reporting.

A simple and potentially overlooked step to help individuals facing online abuse and harassment is acknowledgement. A manager's or employer's affirmation that they see what is happening, that they recognize it as a problem, and that they acknowledge the impact it may be having on the individual can go a long way in making the employee feel supported and not alone. This can be done at different levels, from private conversation with the employee to public statements of support (See IWMF's Guide to Protecting Newsrooms and Journalists Against Online Violence in the Appendix for guidance on writing statements of support).[20]

Conclusion

If employers and others who focus on nuclear policy fail to confront blowback in support of a colleague experiencing such backlash, it can reinforce attackers' goals of undermining an expert's work. Ultimately this growing phenomenon could result in crucial voices being silenced—especially among underrepresented groups—or even intimidated into leaving the field.

The tools and steps outlined in this paper provide concrete ways that individuals, employers, allies, and the field as a whole can prepare for and respond to targeted blowback. The bottom line is that for the most robust response to attacks on those in the nuclear policy field, all must work together to create a supportive community that thrives on a culture of care and empowerment, especially for younger and underrepresented experts.

Appendix: Additional Resources

General Resources

- Online Harassment Field Manual, PEN America
  - Advice and resources for individuals, witnesses/allies, and employers for defending against and responding to online abuse. The manual includes sections on preparing for abuse, responding to abuse, self-care for individuals who are targeted, legal considerations, requesting and providing support, and defining and understanding online abuse.
- Online Violence and Harassment, International Women's Media Foundation
  - Hub with various resources for preventing and addressing online harassment and violence, including online training resources, a mental-health guide, policy recommendations for employers, and more.

Online Security and Doxxing

- Checklist for Protecting Staff Data, The International Women's Media Foundation (IWMF)
  - Template created for journalists and newsrooms—but which applies to experts in other fields of work that involve public-facing internet activity—to help guide individuals in reviewing and securing their online data, including steps for removing data from the internet and securing online accounts.
- Data Broker Opt-Out List (also known as BADBOOL), Yael Grauer
  - Provides individuals a comprehensive list of data broker sites to opt out of, organized in order of priority, and including links and information for how to request data removal from each.

[19] Viktorya Vilk, "The Power of Peer Support."

[20] Ela Stapley, "A Guide."

- "How to Dox Yourself on the Internet," The NYT Open Team
  - Step-by-step guide for discovering what individual-specific personal data is discoverable on the internet and removing it.
- Social Media Security & Privacy Checklists, *New York Times*
  - Guide to recommended settings for social media sites for enhancing privacy and account security to prevent hacking and data compromise.
- Kanary Copilot
  - Doxxing defense software that assists with data removal.
- Bolster Your Digital Security: How to Protect Yourself from Doxxing, ReThink Media
  - Comprehensive guide on both preventing doxxing and what to do if one is the target of doxxing.
- Digital Safety Kit, Committee to Protect Journalists
  - Resource for understanding and preventing online threats such as hacking, phishing, and surveillance.

Miscellaneous Resources

Responding to Online Abuse:

- "Online Abuse: A Self-Defence Guide," Dart Center for Journalism & Trauma
  - Offers advice and recommendations to individuals targeted with online abuse for managing the psychological impact.

Bystander Intervention:

- "The 5Ds of Bystander Intervention," Right to Be
  - Helpful tool for friends, colleagues, and other witnesses and allies who want to safely and effectively support someone being targeted with online abuse and harassment.

Training Programs:

- Online Abuse Defense Training Program, PEN America
  - Trainings and workshops offered:
    - Online Abuse Self-Defense Training
    - Bolster Your Digital Safety: An Anti-Hacking, Anti-Doxing Workshop
    - Bystander Intervention Training: What to Do When you See Online Abuse
    - Employer Best Practices Workshop: Supporting Staff and Freelancers Facing Online Abuse

BIOGRAPHY

Mackenzie Knight-Boyle is a Senior Research Associate for the Nuclear Information Project at the Federation of American Scientists, where she co-authors the Nuclear Notebook—an authoritative open-source estimate of global nuclear forces and trends–and conducts analysis of nuclear weapons programs and policy. She has a particular research focus on U.S. nuclear launch authority and weapons modernization programs. Prior to her current role, Mackenzie was a Herbert Scoville Jr. Peace Fellow at FAS. She holds a master's in Nonproliferation and Terrorism Studies from the Middlebury Institute of International Studies and two bachelor's degrees from Indiana University: Middle Eastern Languages and Cultures, and an individualized degree in Policy and Intelligence Analysis with a concentration in Weapons of Mass Destruction. Her work on nuclear forces and policy has been published and cited widely, including by The Washington Post, Bloomberg, Business insider, The Hill, and Defense One, among others.

Georgia's Democracy in Crisis and Search for New Meaning for Civil Society

Shorena Lortkipanidze

Failing Democracy and Implications for Civil Sector

Hopes for a successful democratic transformation in Georgia have slowly faded, with the country facing increasing concerns over democratic backsliding, especially since Russia's invasion of Ukraine. This erosion is evident across several key areas. The rule of law has been weakened by substantial legislative changes and the adoption of controversial new laws. In turn, there has been political interference in the judiciary, selective application of justice, and a lack of accountability for those in power. At the same time, media freedom is under pressure, with reports of harassment against independent journalists and a clear rise in anti-Western narratives circulated by pro-government media. These shifts are stark signs of a move away from democratic principles.

The space for civil society organizations (CSOs) to operate freely is shrinking. The government is using new laws to restrict access to Western funding, and these same laws also challenge independent media organizations by increasing scrutiny on foreign funding. The restrictive measures are used to hamper international cooperation and aid opportunities for civil society and independent media. These trends have raised concerns among both domestic and international observers about the trajectory of Georgia's democratic development and its commitment to democratic values.

A Georgian version of the American Foreign Agents Registration Act (FARA) took effect on April 1, 2025, amid widespread fears that the vague legislation would be used to further crack down on freedom of expression and association in the country. The law is nearly an exact translation of the U.S. FARA document enacted in 1938. It mandates that those considered "agents of a foreign principal" register within 10 days in a special FARA registry administered by Georgia's Anti-Corruption Bureau. Those who defy the law are subject to harsh

penalties, including criminal prosecution and jail time.[1]

Democratic backsliding significantly hinders cooperation between civil society and government institutions. The nuclear security and nonproliferation field is not an exception. Typically, nuclear security and nonproliferation have been regarded as politically neutral topics, with a clear government interest in cooperating with civil society and international partners to establish an image of a country committed to international principles and standards in the field.

Today, a more limited operational space for Georgian civil society is reflected in anti-Western propaganda and statements opposed to nongovernmental organizations, decreasing the political will for partnership and open communication with local and international stakeholders. In light of all these changes, virtually every sector seems to be perceived as highly political. The Georgian parliament recently adopted legislative amendments modifying the previously mandatory involvement of the non-governmental sector in decision-making processes across various governance sectors.[2] The initiative of the ruling party, "Georgian Dream," effectively excludes from various public decision-making processes civil entities and citizens who advocate for accountable and transparent governance.

One of the functions of civil society, keeping institutions accountable, is now regarded as an action directed against the state. Pro-government propaganda points to Western donors and partners for allegedly sponsoring anti-government actions in Georgia.[3]

"The Law on Grants," which the Georgian parliament passed on April 16th 2025, gives the government broad, opaque, and unrestricted powers to exercise content-based oversight of organizational activities, rendering continued operation of many associations practically infeasible, requiring foreign donors to obtain executive approval before disbursing funds to local organizations.[4] These legal changes are limiting the right to freedom of association, pose a severe threat to civil society in Georgia, and undermine democratic structures and networks across the country.[5]

While civil society is largely advocating for diversity, equity and inclusion in all sectors, the Georgian government is actively undermining progress on these issues; recently, the parliament removed gender quotas from election legislation, which was allowing political parties to promote more women candidates in party lists to secure more funding from the state budget (according to previous legislation if a political party had nominated at least one candidate of the opposite sex in every three candidates on the list, state funding would have increased by 30%). Shortly after this, the ruling party removed from legislation the word "gender," and existing laws on gender equality have been reshaped into a new law on the equality between women and men." There is no more budgetary support for political parties having more gender balanced party lists.

This step is assessed as promulgating anti-gender legislative amendments aimed at completely eliminating gender-sensitive terminology from the legal framework. Consequently, 16 laws have been changed. In each, the term "gender" will be replaced with "woman and man" or "sex."[6] Women's rights defenders worry that reframing the terminology and principles of gender and gender equality in legislation will worsen the situation of women in Georgia.

In Georgia, the integration of the concept of gender into official policy documents and legislative language was a step forward in terms of protecting

[1] See, for example, Nini Gabritchidze, "Georgian Dream's FARA Takes Effect, *Civil Georgia*, May 31, 2025, civil.ge/archives/684669.

[2] "Georgian Dream' Deprives Civil Society Even of the Formal Opportunity to Participate in the Decision-making Process," socialjustice.org.ge/en/products/kartuli-otsneba-samokalako-sazogadoebas-gadatsqvetilebebis-mighebis-protsesshi-monatsileobis-formalur-shesadzleblobasats-artmevs.

[3] civil.ge/ka/archives/586133 about the report of the Media Development Foundation on anti-Western propaganda in Georgia.

[4] civil.ge/archives/676258.

[5] The proposed amendments in Georgia Grant Law aims to dismantle civil society, socialjustice.org.ge/en/products/grantebis-shesakheb-kanonshi-initsirebuli-tsvlilebebi-sakartveloshi-samokalako-sazogadoebis-ganadgurebas-isakhavs-miznad.

[6] The Removal of the Concepts and Principles of Gender and Gender Equality from Legislation Will Worsen the Situation of Women, socialjustice.org.ge/en/products/kanonmdeblobidan-genderisa-da-genderuli-tanastsorobis-terminebisa-da-printsipebis-gakroba-kalta-mdgomareobas-gaauaresebs.

human rights and ensuring equal access to resources. Women's rights defenders and scholars think that, today, the state's focus solely on biological sex undermines the basis of equality policy, as it fundamentally ignores the structural, historical, and complex causes of social inequality against women. As an example, when the concept of gender disappears from legislation, responding to gender-based violence becomes more difficult, as there are no longer legal mechanisms to confront social inequality and hierarchical practices in the process of combating gender-based violence.

Meanwhile, Georgia's journey toward European Union (EU) membership has faced recent turbulence despite a significant milestone. In December 2023, the country was granted EU candidate status, a moment widely celebrated as a symbol of national unity.

However, this historic achievement was soon followed by actions from the country's leadership that have strained its relationship with the EU. The ruling party, Georgian Dream—which retained power after disputed 2024 parliamentary elections[7]—has intensified anti-Western propaganda.[8] This propaganda, which often paints Western partners as adversaries and promotes conspiracy theories, threatens to undermine Georgia's path to EU membership and creates a growing rift with Tbilisi's international allies.

The space for free and open discussions and partnership platforms is shrinking. There is a pervasive sense that the country's major achievements in democratic governance, equality, and inclusive decision-making are in the process of reversal.

For civil-society organizations, the primary question is how to navigate these challenges and continue working to sustain democratic achievements. As previously noted, the future of communication and collaboration between civil society and government institutions on nuclear security and nonproliferation remains unclear, though there is always a chance to return to dialogue.

Echoes of the Past: Path to Secure a Nuclear Future

I belong to the generation that came of age in Georgia during the 1990s, a period marked by the tumultuous early years of our independence. We endured three wars, including a civil war, followed by violent terrorization by armed paramilitaries that wandered across the country. Despite these harrowing circumstances, our parents did everything in their power to shield us. They found the strength to provide us with life and education during those incredibly dark times, which in fact were also full of new impressions, discoveries, and learning for me personally.

As a student of international relations, I was driven by a fervent desire to travel, explore, and learn about the world. Tbilisi in the late 1990s was a unique and transformative place. Through study, I discovered the burgeoning world of civil society, deepened my understanding of the principles of democracy, and was connected with individuals who pioneered in exploring and practicing these concepts in Georgia.

Since the late 1990s, civil society has gradually acquired an important role in shaping public opinion and influencing political decision-making. CSOs with Western conceptual support and funding were able to attract educated and skilled youth, which enabled them to be more proactive, vocal, and visible in the public.[9]

The role of civil society was crucial in the 2003 "Rose Revolution"[10]; the aspirations of civil society for a democratic Georgia were pivotal in supporting significant changes in the historic 2012 parliamentary

[7] See, for example, Natalie Sabanadze, "As the Ruling Party Claims Victory in Georgia's Disputed Election, Western Condemnation is No Longer Enough," Chatham House, www.chathamhouse.org/2024/10/ruling-party-claims-victory-georgias-disputed-election-western-condemnation-no-longer.

[8] gurianews.com/saqarthvelos-mosakhleobis-80-3-mkhars-utchers-evrokavshirshi-gatsevrianebas-iago-katchkatchishvili-kvlevaze/.

[9] Shorena Lortkipanidze and Tamara Pataraia, "Mapping Study of Civil Society Organisations," *Engagement in Policy Dialogue in Georgia*, report, October 2014.

[10] Civil Society and the Rose Revolution in Georgia, a research project that aims to explore the place, character and degree of involvement of the Georgian civil society in the "Rose Revolution," conducted by International Center on Conflict and Negotiation Georgia, iccn.ge/index.php?article_id=310&clang=0.

elections[11] when, for the first time in Georgia's history, a peaceful transfer of power occurred. Civil society played a crucial role in many aspects: CSOs paved the way for individuals to participate in public life, empowered minorities and women, promoted good governance principles, and contributed to Georgia's transformation toward the modern democratic state.

Western development aid and democratic support played a critical role in helping the newly independent states build their institutions and establish their place in the international realm. Georgia's participation in the international nonproliferation regime following independence demonstrated how a new and small state with a nuclear legacy can attempt to grapple with this issue. Georgia's experience shows that deep and comprehensive international cooperation is essential to such a country's integration into the nonproliferation regime.

Over the past 30 years, Georgia has agreed to key international legal commitments and participated in relevant nuclear forums. Tbilisi has pledged to be actively involved in international cooperation on nuclear matters, improve its nuclear safety and security, prevent nonstate actors from obtaining weapons of mass destruction, combat nuclear terrorism, and crack down on illicit trafficking of nuclear and radioactive sources and related materials. Over this period, Georgia has made considerable strides in this direction.

These achievements are now at stake, as Georgia's international image as a trustworthy partner committed to democratic values is declining. In this context, systemic attacks against civil society and labeling civil actors as foreign agents also put at risk making additional such strides.

For those working in this field, promoting democracy and being part of a civil society was never merely a job; it was a mission, a vision, and a dream.[12] I became one of those workers, bearing this dream with me, aspiring for democracy, prosperity, and well-being for ordinary people in Georgia.

With my colleagues, in 2011, we established the Civil Council on Defense and Security (CCDS) as a nongovernmental civil society organization and think tank. The first project implemented by the organization was research on Georgia's nuclear and radiological history. With backing from the Swedish Radiation Safety Authority—supporting the Georgian government's nuclear and radiological security policy implementation—this project encouraged us to deepen our knowledge of nuclear security and nonproliferation, investing in research and analysis in a field that was largely unexplored in Georgia.

In the context of nuclear and radiological security, the role of civil society can be defined as the actions taken by nongovernmental organizations and think tanks to monitor the government's and operators' implementation of nuclear and radiological security policies, regulations, and international agreements; promote awareness, research and education in the field; and support the preparation of a new generation of security analysts. Civil society is also vital in ensuring accountability of relevant authorities and organizations for maintaining high standards of security and preventing incidents; and advocating for stronger security measures, transparency, public participation, and the protection of communities and the environment from nuclear and radiological threats.

Priorities for CCDS have also included contributing to knowledge creation and capacity development for stakeholders, and establishing and strengthening a platform for dialogue in the field.

Georgia's nuclear history book project was an entry point for CCDS to establish itself as a credible partner for diverse stakeholders in the nuclear field. Swedish government support was crucial in conducting this research in collaboration with government institutions, academia, and the international expert community through the peer review process. Support from and collaboration with the Swedish Radiation Safety Authority, along with peer review from the Washington-based James Martin Center for Nonproliferation Studies, were

[11] Civil Society After October, 2012 Parliamentary Elections, http://www.humanrights.ge/index.php?a=main&pid=16578&lang=eng.

[12] Citation from one of the discussions organized with civil society representatives for preparation of this paper, February 2025.

instrumental in compiling research for the 2013 book, *Georgia's Nuclear Odyssey: The Path from Soviet Atomic Legacy to Global Nonproliferation Regime*.[13]

This important initiative aimed at connecting the scientific community with issue-experts and fostering a deeper understanding of Georgia's Soviet past. The effort reflected on developments since the collapse of the Soviet Union and the end of the Cold War, moved to engage a wider audience—both within the country and internationally—in a dialogue about the intersections of history, the present, and the future. The research project, of which I was a part, took authors to libraries and archives to explore key questions. For example, we investigated the level of independence for Georgian scientists, particularly nuclear scientists; how research agendas and directions were defined; who controlled these processes; and how work at the nuclear reactor was regulated. We also examined whether nuclear weapons were kept in Georgia; how the Communist Party oversaw research projects at the reactor; and how a modern nuclear and radiological security and safety system emerged from scratch after the collapse of the Soviet Union.

We studied Georgia's Communist Party archives and discovered reports about the Mtskheta Nuclear Reactor. These detailed not only scientific matters, but also seemingly ordinary issues like scientists and local staff violating rules, not changing their clothes, improper use of laundry rooms, and insufficient milk consumption, when these differed from internal procedures. The archive materials also contained fascinating budget information for the reactor during the period from 1958 to roughly 1968.

History provides context for current events, issues, and challenges. Without understanding the historical background, it can be difficult to grasp the complexities of the present. A knowledge of historical underpinnings helps identify patterns, trends, and cycles. This can help us anticipate potential future outcomes and make more informed decisions.

Specifically, we learned that the history of nuclear physics as a scientific discipline in Georgia originated in parallel with the Soviet atomic bomb project in 1945, at the end of World War II. This led to the emergence of several large scientific centers in the country, which helped legitimize Georgia later as an independent scientific hub.

The research results indicated a lack of participation by scientists in long-term research plans development, which obviously limited their level of independence and ensured the Communist Party Central Committee's strict control over the scientific career service. In addition, material and technical resources of nuclear research facilities also remained under the party's tight supervision, while access to wide-scale financial resources for nuclear research was closely linked to the Soviet military-industrial complex.

While Russian Soviet nuclear physicists enjoyed unusual intellectual autonomy from an authoritarian political system,[14] the given research showed that Georgian physicists experienced very limited scientific freedom compared to their Russian counterparts. Georgia was considered as periphery compared to Moscow, and efforts made by high-ranking Georgian scientists to open up the level of scientific independence and initiate a more innovative program failed every time. Initiators were accused of "disobedience," or in other words, asserting a right to free will that was not permitted. Having experienced the Soviet iron-fist approach to managing scientific research hampered Georgia's ability to advance its own research and development in the long run, even after the breakup of the Soviet Union.[15]

Through working with scientists and listening to their stories, we experienced empathy for the human dimension of nuclear programs, broadening our understanding and challenging our own biases. Georgian scientific history is replete with examples of past successes and failures. Scientists and engineers

[13] Teona Akubardia, Shorena Lortkipanidze, Tamar Pataraia, and Irakli Mchedlishvili,(Miles Pomper, scientific ed.), Georgia's Nuclear Odyssey: The Path from Soviet Atomic Legacy to Global Nonproliferation Regime (Tbilisi, Georgia: Civil Council on Defense and Security: 2013).

[14] The "Islands of Intellectual Autonomy": Historians and sociologists have used phrases like "islands of intellectual autonomy" to describe the specialized communities of scientists, particularly in fields like nuclear and space programs. In these communities, a degree of intellectual freedom was necessary for innovation and problem-solving. This allowed them to diverge from strict Soviet dogma in their work, even as the state maintained political control.

[15] Akubardia et al, "Georgia's Nuclear Odyssey."

of the nuclear research program had very limited, if any, access to the information regarding the general nuclear program they were involved in.

In the book, we have also covered the period after Georgia's independence. In 2000, under the aegis of International Atomic Energy Agency (IAEA), the implementation of the program for decommissioning the reactor was started. As scientists reflected on their role in building a new Georgia, they often expressed their sadness and helplessness at not being able to retain nuclear reactor operations, to serve a new generation of researchers and scientific development.

Our research for the 2013 book had other value. It helped cement cooperation between the government and civil society. While working on the research, the Georgian Ministry of Interior shared information about illicit trafficking cases, and the Institute of Physics and Ministry for Environmental Protection and Natural Resources shared a list of international cooperation projects, as well as a comprehensive accounting of their efforts in the field, since Georgia's independence. The president of Georgia disseminated the publication at the Hague Nuclear Security Summit in 2014. Two years later, the Nuclear Industry Summit, convened in Washington, awarded Georgia with Atoms for Peace prize, recognizing the country's significant steps to become free from highly-enriched uranium.[16]

In response to the widely recognized importance of such partnerships, CCDS coordinated with the Swedish and U.S. governments, along with several Georgian governmental agencies (the ministries of Foreign Affairs, Internal Affairs, and Environmental Protection and Natural Resources), to found the Tbilisi International Forum for Regional Stability. This was created as a platform for dialogue and exchange among government officials, civil society, experts, and academia on challenging issues of nuclear security and nonproliferation. The first forum conference was organized in 2014, and the last was in 2024 without government participation. After Georgia adopted various restrictive and undemocratic laws, partner and donor countries decided to no longer invest in cooperation with the Georgian government.

Over the past decade, five forums were held, bringing to each conference approximately 150 international participants and speakers. One of the forum's most significant achievements has been fostering open dialogue between governments and civil society, an important step toward democratization rooted in accountability, transparency, good governance, and strengthened international cooperation in the field. In today's political climate, such platforms are increasingly vulnerable and at risk of disappearing.

CCDS has also initiated a nuclear security and nonproliferation education and capacity-building program for Georgian universities, with Batumi Summer University as a hub for national and regional nuclear security and nonproliferation experts and interested professionals. The annual educational event has held nine gatherings over the past nine years. However, as of 2025, CCDS was no longer able to conduct the 10th Summer University due to donors' restrictions on supporting initiatives in Georgia.

CCDS has also developed valuable web resources, with www.proliferation.ge being the only civil-society platform that records background radiation across the country. We started this program with Tbilisi State University's physics department, and the first station to measure radiation was installed in one of the Tbilisi public schools that specializes in physics and mathematics. This has been a great opportunity to learn through practice and engage a new generation in learning by doing, offering cooperation and synergy among various stakeholders.

Since Russia's full-scale invasion of Ukraine, CCDS has been publishing monthly updates on radiological security in Ukraine and the consequences for its regional impact. This material is a resource for Georgian experts and news media to report on ongoing nuclear and radiological security challenges in the Black Sea region.

The path from Georgia's tumultuous 1990s to its emergence as a committed partner in global nonproliferation was a testament to the resilience of its people and the vital role of civil society. Driven by a vision for a democratic and secure

[16] https://ghn.ge/news/151069-sakartvelos-jildo-atomebi-mshvidobisatvis-gadaetsa also we have interviewed representative of President's Administration who attended the award ceremony.

future, a generation of Georgians embraced the principles of open dialogue, accountability, and international cooperation. CCDS and similar organizations[17] became crucial bridges, contributing to understanding and translating a Soviet nuclear legacy into a modern nonproliferation regime. Through dedicated research, education, and advocacy, civil society not only monitored government policy, but also fostered a culture of transparency and public participation.

To ensure these achievements remain sustainable, it is essential to maintain a supportive environment for civil society and democratic principles. Protecting the country's international standing requires continued investment in the platforms that enabled this success. This experience demonstrates that national security and democracy are most resilient when supported by a free and vibrant civil society.

Where Georgia Stands: Major Security Threats and Challenges

In parallel with internal challenges to democratic values and stability, Georgia faces a complex security environment characterized by both external and internal challenges.

Georgia's external threats are primarily centered on its relationship with Russia. The most significant and direct threat is the ongoing occupation of 20 percent of Georgian territory by Russia—the regions of Abkhazia and South Ossetia. Russia has established permanent military bases there, and its forces conduct "borderization" efforts, which involve moving the de facto boundary lines further into Georgian-controlled territory. The continued presence of Russian military forces within close proximity (roughly 20 miles) to Tbilisi and a major Georgian highway creates a heightened sense of vulnerability and strategic risk. This not only violates Georgia's sovereignty and territorial integrity, but also poses a constant risk of renewed conflict.

Russia is engaged in a comprehensive hybrid warfare campaign against Georgia. It appears that the ruling party and controlled media outlets are the main disseminators of anti-Western propaganda and disinformation, portraying Georgia's aspirations for EU and NATO integration as a threat to sovereignty and traditional values. They also aim to sow discord and undermine democratic institutions among the population.[18]

Russia has used economic embargos and energy leverage as tools of influence. While Georgia has diversified some of its energy sources, it remains vulnerable to Russian economic pressure. Russia has also sought to influence Georgia's internal and external policies through political co-optation and covert operations.

Georgia is situated in a volatile region where major powers—including Russia, Turkey, and Iran—are competing for influence. The broader conflict between Russia and the West, particularly since the 2022 invasion of Ukraine, has heightened Georgia's geopolitical significance and its vulnerability. The ongoing war in Ukraine has significant implications for Georgia, exacerbating existing tensions and creating new security concerns.

The regional context also contributes to internal challenges within Georgia, including democratic backsliding, high political polarization, and authoritarian tendencies, all of which can weaken the country's resilience and ability to respond to external threats.

Sanctions against Russia: The Role of Civil Society in Addressing Security Challenges

Following the October 2024 parliamentary elections, Georgia's international image and reputation have suffered significant damage. [19] As mentioned, since the adoption of the Foreign Influence Transparency

[17] Educational Centre of Nonproliferation of WMD in Andronikashvili Institute of Physics https://aiphysics.tsu.ge/eab-e.html established in 2005 by team of Institute employees, who took active part in establishment and development of the nuclear and radiation nonproliferation in Georgia.

[18] www.fpri.org/article/2025/03/russian-influence-operations-in-georgia-a-threat-to-democracy-and-regional-stability/.

[19] Foreign Secretary Statement: Situation in Georgia UK Foreign Secretary has announced the UK will reduce its support and engagement with the Georgian Government. Published; 9 December 2024. https://www.gov.uk/government/news/foreign-secretary-statement-situation-in-georgia.

Law in May 2024—the measure that requires non-governmental organizations to register on the government portal and declare all the activities and financial transactions conducted in the framework of the donor support—the registration requirement is for NGOs with 20% or more foreign funding—international partners have begun suspending cooperation with the Georgian government. The U.S. government has suspended its 2009 Strategic Partnership Agreement with Georgia,[20] and the U.K. government has halted its funding to Georgian government institutions after anti-government protests in Tbilisi were violently dispersed in early December 2024. In this case, Georgians were protesting Government's decision to suspend EU integration process until 2028.[21] Destabilization of international cooperation, due to Tbilisi's domestic political challenges, poses a direct threat to Georgia's ability to continue making progress on key nuclear security concerns.

In response to the escalation of the conflict in Ukraine, an international coalition led by the United States coordinated economic measures to uphold regional security standards. This strategy involves restricting access to the capital and technology necessary for military expansion. The scope of these measures encompasses key financial infrastructure, military supply chains, and international suppliers, ensuring that the global financial system is not utilized to support defense-industrial growth during the ongoing crisis. Despite Georgia's historical alignment with EU sanctions on Russia in response to its annexation of Crimea and occupation of Eastern Ukrainian territories in 2014, the Georgian government made a deliberate choice not to formally join the sanctions regime coalition in 2022, citing economic concerns and fears of further Russian aggression. However, subsequent statements from political leaders and senior officials from various agencies, including the Georgian National Bank, asserted that, nonetheless, they would not allow Georgia's customs territory or financial institutions to be used for evading international sanctions.

Still, Georgia's strategic position and transportation infrastructure have rendered it susceptible to Russia's attempts to circumvent sanctions. This has raised significant security concerns, given Georgia's turbulent history of conflict with Russia.[22] Georgia also suspended talks on becoming an EU member nation in 2024, citing the international controversy over its new foreign influence law, and despite public protests.[23]

An analysis of Georgia's foreign trade data—and amid a notable increase in trade volume with specific countries (including Armenia and Kazakhstan)—suggests Russia is actively attempting to evade sanctions by using Georgia as one of its transit countries. As Georgia navigates the complex geopolitical landscape shaped by ongoing conflicts and sanctions regimes, it is imperative for the country to prioritize its security interests while upholding its commitments to international partners.

CCDS has a history of engagement in capacity-building related to sanctions against Iran between 2015 and 2017. Starting in 2022, Georgia collaborated with U.S. partners to provide training to government institutions, private sector representatives, and financial institutions on international regulations governing sanctions against Russia. Regrettably, current legislative provisions preclude cooperation with government authorities on matters of national security, where international engagement and funding are involved, and thereby impede further activities in this domain.

In addition, CCDS facilitated dialogue between respective government institutions and the private sector on sanctions policies, strategic trade control issues and compliance systems. Effectively implementing and enforcing sanctions regimes is a complex challenge that requires a multifaceted

[20] See: U.S. Department of State, "U.S.-Georgia Stratetgic Partnership Commission," 2017-2021.state.gov/u-s-georgia-strategic-partnership-commission/.

[21] https://oc-media.org/georgian-dream-to-halt-eu-membership-bid/.

[22] Policy Paper: International Sanctions on Russia: New Challenges from the Georgian Perspective, civilcouncil.org/activities-products/policy-papers-analysis/policy-paper-international-sanctions-on-russia-new-challenges-from-the-georgian-perspective.

[23] See, for example, Sophiko Megrelidze, "Georgia Suspends Talks on Joining the European Union and Accuses the Bloc of Blackmail," *Associated Press*, November 28, 2024, apnews.com/article/georgia-cabinet-election-russia-european-union-kobakhidze-1291827f76eac552a2918b4b584fa5a0.

approach. Dialogue and collaboration between government, the private sector, and civil society are essential components for success in enforcing trade restrictions. By working together, all sectors could better anticipate and mitigate the unintended impacts of sanctions on legitimate commerce and humanitarian efforts.

CCDS has also trained independent media on sanctions issues, which has helped journalists develop various investigative reports on problematic issues of sanctions implementation by Georgian authorities.[24]

Political instability directly threatens Georgia's ability to address critical nuclear security issues, particularly in the context of international sanctions against Russia.

New legislative provisions that prevent civil society organizations from engaging with the government on national security matters using international funding are widely seen as a significant setback, eroding a key mechanism for ensuring accountability and transparency. Furthermore, the role of CSOs in monitoring compliance, building capacity for sanctions enforcement, and fostering dialogue between the government and the private sector is vital for achieving democratic governance.

The Unraveling Thread: How Democratic Backsliding Endangers Security

A strong and vibrant democracy is crucial for ensuring responsible nuclear oversight. It promotes transparency, accountability, and public participation in nuclear decision-making, while mitigating the risks of nuclear proliferation and use. The erosion of democratic values and institutions poses a significant threat to nuclear security and global stability.

Democracy is crucial for the effective and safe oversight of nuclear and radiological sectors. Democratic systems value transparency—a vital approach in the nuclear sector, where secrecy can breed distrust and suspicion. Other factors also hinder democracy in Georgia, namely political polarization and radicalization, which also feed distrust and diminish cooperation and inclusivity in governance systems. Open access to information about safety measures, regulatory processes, and potential risks allows the public to hold the government and operators accountable.

Regulatory frameworks are essential for functioning democratic institutions, as they provide a stable and predictable basis for regulation. This is essential for the nuclear and radiological sectors, which require stringent and consistently applied regulations.

Democratic backsliding can hamper the operation of independent regulatory agencies. Georgia's Nuclear and Radiological Security Agency was designed to be independent of political influence and responsible for licensing and overseeing nuclear-sector facilities.

Parliamentary oversight is also essential for the democratic process to function effectively. Parliamentary committees can hold hearings, conduct investigations, and scrutinize the actions of the executive branch and regulatory agencies related to the nuclear sector. Displaying the impact of growing authoritarian trends, the Georgian parliament is no longer fulfilling its main function in this capacity.

Georgia is enacting legislation that hampers the media freedom of CSOs. Laws that guarantee public access to government information can be crucial for transparency in the nuclear and radiological sectors, and CSOs have long been a conduit for making facts and data more readily available to the public. These democratic processes are particularly important for the nuclear and radiological field, but this access could become increasingly restricted due to the legislative changes now in place.

Strong government frameworks and effective nuclear security are mutually reinforcing. By fostering an environment where civil society organizations (CSOs) can provide independent analysis, states can enhance the transparency and reliability of their nonproliferation efforts. In Georgia, continued investment in these professional networks is a proactive way to ensure long-term nuclear safety and international cooperation. Strengthening global partnerships with local expertise ensures that nuclear security remains a consistent priority, regardless of the shifting global or national political landscape.

[24] civilcouncil.org/activities-products/conferences-workshops/us-and-eu-sanctions-against-russia-impact-and-implementation-challenges-for-georgia.

Conclusion

Democracy provides an essential framework for ensuring that the immense power and potential risks associated with nuclear and radiological technologies are managed safely, securely, and in a way that is accountable to the public. Without democratic oversight, the potential for accidents, environmental damage, and the erosion of public trust is significantly increased.

Constrained by democratic backsliding, civil society is in search of a new role as a vital actor in safeguarding societal pluralism, promoting inclusive dialogue, and mitigating the negative effects of political polarization. Adaptation and innovation by CSOs to continue their work in this challenging environment are essential for the future of democracy, and the tangible benefits it confers on safety and security. Forming new alliances, employing digital tools, reflecting on past achievements, and upholding them as a foundation for progress are recommended next steps regarding vital nuclear security and nonproliferation issues.

The international landscape is in flux, marked by the significant destabilization of the liberal rules-based order. In this context, cooperation and exchange are the most effective means of creating new opportunities for a better world.

Appendix: Additional Resources

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BIOGRAPHY

Shorena Lortkipanidze is a founder and a board member of the Civil Council on Defense and Security, a think tank/civil society organization based in Tbilisi, Georgia. She is a specialist of International Relations. For 25 years Shorena has been advising government agencies and civil society. Her professional interests include foreign policy, defense and security policy, security sector reform, CBRN security and nuclear non-proliferation, peace and conflict studies. Shorena is a World Bank-IFC international accountability mechanism dispute resolution specialist/mediator. She worked as an advisor to the Defense and Security Committee of the Parliament of Georgia and worked as an analyst at the research center of Georgia's Ministry of Foreign Affairs. She is a founder and initiator of various international education, capacity building and dialogue platforms and programs for various stakeholders in Georgia and internationally on CBRN security and nonproliferation. Shorena is currently teaching International Relations in Georgian Universities. She is an author and coauthor of various publications, textbooks and researches. Shorena is one of the founders of Black Sea Women in Nuclear Network and served as the first Vice President of BSWN in 2021–2024.

Nuclear Security in a Polarized World: Domestic Factors and Challenges to Nuclear Security Norms

Jasmine Auda

One of the primary features of nuclear security is that it is the sole responsibility of the state.[1] This dynamic underscores the importance of a nation's domestic characteristics in shaping its approach toward nuclear security. A nation's political characteristics, for example, can influence its perceptions of the salience and legitimacy of nuclear security norms and affect the government's commitment to associated measures and obligations.

Nuclear security is underpinned by an international legal framework that sets forth states' obligations and commitments to protect civilian nuclear material and facilities from unauthorized acts committed by non-state actors. The transnational nature of any act of nuclear terrorism is generally understood as having the potential for cross-border implications, which necessitates a global effort to address such threats. This international dimension of nuclear security is codified in several international legal instruments and treaties, such as the Amendment to the Convention on the Physical Protection of Nuclear Material, the International Convention for the Suppression of Acts of Nuclear Terrorism, and United Nations Security Council Resolution 1540. Still, nuclear security remains primarily a domestic concern and pursuit. As such, it is important to examine the ways in which domestic phenomena, such as political polarization, can affect the robustness of nuclear security norms, decision-making, and policies regarding critical areas of concern, such as insider-threat mitigation.

In the context of dynamic challenges to nuclear security—such as the threat of non-state actors gaining access to nuclear materials, challenges posed by emerging technologies, and the potential for conflicts to exacerbate nuclear security vulnerabilities—nuclear security can be examined as a normative framework, especially in light of any challenges or contestations to nuclear security

[1] International Atomic Energy Agency (IAEA). *Objective and Essential Elements of a State's Nuclear Security Regime.* IAEA Nuclear Security Series No. 20. International Atomic Energy Agency, 2013. https://doi.org/10.61092/iaea.ajrj-ymul.

norms. These norms play a critical role in shaping state behavior, fostering international cooperation, and ensuring the strength of global nuclear security efforts. The strength and resilience of nuclear security norms are determined not only by formal legal instruments or voluntary measures, but also by the shared expectations and values that influence the actions of states and their perspectives toward nuclear security.

A greater understanding of nuclear security in this context can help demonstrate the ways in which nuclear security is maintained, its evolution over time, and, for the purposes of this paper, ways in which challenges to these norms can undermine their effectiveness. In this context, exploring nuclear security through a normative lens can offer insights to the expert community on strengthening and adapting its approaches to the issue "in the light of the prevailing situation."[2]

Domestic Political Factors

In exploring ways that domestic politics can affect decision-making in the nuclear domain, most scholars have focused on factors that could influence proliferation and nuclear weapons acquisition. Some of the factors considered include regime type and its impact on potential proliferation,[3] the agency of individual political or bureaucratic actors,[4] and personal beliefs and values of leaders,[5] among others. As varied as these factors are, they are not particularly suitable for considering nuclear material security, an endeavor based on different frameworks, assumptions, and approaches than those related to nuclear nonproliferation. In the context of nuclear security, this paper presents an overview of three key domestic factors and their impact on nuclear security, namely: threat perceptions, political will, and institutional capacity. Taken together, these factors can offer an indication of states' perspectives toward the salience and legitimacy of nuclear security. To understand how these factors present across different states, it is important to distinguish between countries that are "norm-makers" versus "norm-takers" in the nuclear security realm.

With respect to nuclear security norm-makers, the United States is undoubtedly and historically the most influential country. It has actively promoted nuclear security norms at critical junctures, including since its emergence in the early 1970s, and in the 1990s following the fall of the Soviet Union. The U.S. role was particularly notable in the post-9/11 world, based on the perception that acts of mass-casualty terrorism demonstrated a willingness and capability of terrorists to carry out large-scale terrorist attacks that could, in other instances, conceivably utilize nuclear material.[6] In this context, the promotion and diffusion of nuclear security norms was based on U.S. threat perceptions that intended to stimulate global collective action toward addressing nuclear terrorism. These threat perceptions—combined with the political will to elevate nuclear security to a top priority on both the domestic and international levels—resulted in a robust national institutional infrastructure tasked with strengthening nuclear security.

For norm-takers, which include most of the international community, the internalization of these norms has varied. Some states have embraced such norms—viewing the urgency of nuclear security similarly to the United States, either due to shared security assessments or a genuine belief in the credibility of the threat—while others have been less receptive. The latter is particularly true for many developing countries or those in the Global South, where the urgency of nuclear security may

[2] Reference made to wording used in Article 16 of the CPPNM in the context of Review Conferences to the Convention, requiring states to review the adequacy of the Convention. "INFCIRC 274/Rev.1: The Convention on the Physical Protection of Nuclear Material." International Atomic Energy Agency (IAEA), 1980. https://www.iaea.org/sites/default/files/infcirc274r1.pdf.

[3] See, for example: Solingen, Etel. *Nuclear Logics: Contrasting Paths in East Asia and the Middle East*. Vol. 103. Princeton University Press, 2007. https://doi.org/10.2307/j.ctt7s0kp.

[4] See, for example: Sagan, Scott D. "Why Do States Build Nuclear Weapons?: Three Models in Search of a Bomb." *International Security* 21, no. 3 (1996): 54–86. https://doi.org/10.2307/2539273.

[5] See, for example: Hymans, Jacques E. C. *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy*. 1st ed. Cambridge University Press, 2006. https://doi.org/10.1017/CBO9780511491412.

[6] See Bowen, Wyn Q., Matthew Cottee, and Sarah Tzinieris. "The Evolution of Global Nuclear Security Governance." In *The Oxford Handbook of Nuclear Security*, 1st ed., edited by Christopher Hobbs, Sarah Tzinieris, and Sukesh K. Aghara. Oxford University Press, 2023. https://doi.org/10.1093/oxfordhb/9780192847935.013.11.

not be as prominent. Several factors contribute to these differing perspectives, including the perceived legitimacy of norms and concerns about their relationship with other aspects of the nuclear domain, such as nonproliferation and disarmament. These countries may approach nuclear security with hesitation, due to a lack of awareness, fear that it could hinder their right to peaceful nuclear uses, or concern that it may exacerbate perceived inequalities in the global nuclear order. These perceptions influence, and are influenced by, the domestic factors discussed below.

Threat Perceptions

Threat perceptions related to nuclear security are recognized as being among the primary factors that could impact a state's adherence to, and implementation of, nuclear security measures. Of course, perceptions vary regarding the credibility and likelihood of nuclear terrorism-related threats. Across states, these perspectives may be influenced by whether or not a state possesses weapons-usable nuclear material, based on an assumption that without fissile material, there is no need for robust nuclear security measures.[7]

Moreover, countries with known terrorist or criminal organizations—or that have experienced terrorist attacks on their soil—may be more likely to recognize the threat posed by non-state actors to nuclear facilities or material. On the other hand, they may also be more concerned with conventional acts of terrorism, and view nuclear terrorism as an abstract and unlikely scenario.

While diverging threat perceptions across states are expected, it should be noted that there is also potential for a divergence of views within states. There are numerous stakeholders involved in nuclear security policy. Threat perceptions can vary significantly among different actors in each country, shaped by factors unique to each sector—whether military, law enforcement, intelligence, or the scientific and technical community.

Political Will

Political leadership significantly influences the level of commitment accorded to nuclear security. The Nuclear Security Summits, held between 2010 and 2016,[8] demonstrated how high-level attention to the issue galvanized significant progress toward furthering the nuclear security agenda internationally. The process also spurred action at the national level across many of the participating states. If a government perceives nuclear security as a priority, it is also more likely to allocate the requisite resources for safeguarding nuclear materials and infrastructure. Or, if it is not able to do so, an interested government can at least seek cooperative partnerships or assistance toward this end. The International Atomic Energy Agency (IAEA) missions, for example—such as the International Nuclear Security Advisory Service—act based on requests from individual states. The efficacy of nuclear security measures can also depend on how well different segments within a state are able to coordinate. This, in turn, can be influenced by political leadership, and its ability and willingness to promote and encourage interagency cooperation.

Institutional Capacity

There is a wide variance in institutional capacity around the world, affected by several factors. These include whether a state has a history of managing nuclear infrastructure, the strength of its legal and regulatory frameworks, and the extent to which it participates in collaborative nuclear security initiatives, which can provide international best practices and knowledge exchange for participating countries. Even in instances where there is political will and recognition of the nuclear security threat, however, countries may not always possess the requisite institutional and administrative capacities that would allow them to fully implement their nuclear security commitments and obligations.

Moreover, in countries with unstable political situations, nuclear security may become vulnerable

[7] Interestingly, NTI's 2023 Nuclear Security Index found that countries without weapons-usable material actually made more progress toward nuclear security implementation, compared to countries with those materials. Source: "NTI Nuclear Security Index: Falling Short in a Dangerous World." Nuclear Threat Initiative, 2023.

[8] The White House, "The Nuclear Security Summits: Securing the World from Nuclear Terrorism," (Fact Sheet), March 29, 2016, obamawhitehouse.archives.gov/the-press-office/2016/03/29/fact-sheet-nuclear-security-summits-securing-world-nuclear-terrorism.

because of domestic political volatility or weakened institutions. Gaps can arise in protecting nuclear materials from theft or misuse. Institutional capacity is related to both threat perceptions and political will; if there is at least recognition of the threat and corresponding political will, then institutions can be directed or supported to develop the processes and measures required for addressing nuclear security.

Political Polarization and Implications for Nuclear Security

Two separate trends related to polarization can currently be observed, namely multipolarization and political polarization. The recent 2025 Munich Security Conference[9] was convened under the theme of multipolarization, which denotes a world in which "an ongoing power shift toward a greater number of states vying for influence is clearly discernible," and that is manifest not just in terms of material power, but also in ideology.[10]

Multipolarization can certainly have an effect on nuclear security. This outcome can be positive, creating an environment in which numerous states project themselves as leaders in the nuclear security realm. However, it can also have a detrimental effect on nuclear security, if global leaders with equal or growing power use their influence to challenge or undermine nuclear security as a global norm.

The second trend, that of political polarization and its impact on nuclear security, is worthy of careful analysis and consideration. Such polarization could complicate efforts to strengthen nuclear security in the context of insider-threat mitigation. In doing so, the analysis here utilizes the previously described domestic factors of threat perceptions, political will, and institutional capacity.

At its core, political polarization refers to "a form of conflict."[11] Among its manifestations are "affective" or ideological polarization,[12] with the former referring to distrust of the other and an "us versus them" mentality. The latter refers to a divergence of views on fundamental beliefs or issues. While this issue has not received much consideration with respect to nuclear security, such effects of increasing polarization in countries around the world warrant further attention. Ramifications include some that are critical to the promotion, diffusion, and strengthening of nuclear security norms. Political polarization may also affect threat perceptions related to nuclear security.

As mentioned, diverse views can actually strengthen nuclear security, but there is also potential for negative effects. Threat assessments guided by a risk-informed approach are identified by the IAEA as critical for nuclear security regimes. They are required for resource allocation and the enactment of measures based on principles of defense in depth and a graded approach.[13]

At the same time, political polarization can contribute to diverging threat assessments within a state, with different sides either exaggerating or understating the risks and likelihood associated with acts of nuclear terrorism. An absence of consensus on these risks—which would be reflected in key nuclear security measures such as using the "design basis threat" to train and plan against realistic adversary profiles[14]—may lead to a lack of preparedness and appropriate response measures in the event of a nuclear security incident. Tied to the issue of threat perceptions is that of political will, which has a significant effect on the attention and priority given to nuclear security. When polarization is characterized by ideological differences, this often results in differing visions of national security priorities and, consequently, in which issues should be given the requisite attention and resources.

[9] See Munich Security Conference website, securityconference.org/en/msc-2025/.

[10] Bunde, Tobias, Sophie Eisentraut, and Leonard Schütte, eds. *Munich Security Report 2025*. 2025. https://securityconference.org/en/publications/munich-security-report-2025/foreword/.

[11] Schedler, Andreas. "Rethinking Political Polarization." *Political Science Quarterly* 138, no. 3 (August 31, 2023): 335–59. https://doi.org/10.1093/psquar/qqad038.

[12] Ibid.

[13] "National Nuclear Security Threat Assessment, Design Basis Threats and Representative Threat Statements." IAEA Nuclear Security Series. Vienna, Austria: International Atomic Energy Agency, 2021. https://www-pub.iaea.org/MTCD/Publications/PDF/P1926_web.pdf.

[14] See, for example, U.S. Nuclear Regulatory Commission, "Backgrounder on Nuclear Security," November 2024, accessed December 4, 2025, www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-enhancements.

This can have a catalytic effect on two areas critical to nuclear security, namely international cooperation and collaboration with industry and civil society. International cooperation can be negatively affected by political polarization if there is a tendency to undervalue the importance of collective efforts toward enhancing nuclear security. Furthermore, if polarization results in a stalemate preventing the enactment or implementation of key nuclear security measures, it can be difficult for states to cooperate on related international agreements and initiatives.

As for the effect of polarization on collaboration with nongovernmental organizations (NGOs), governments may be less likely to leverage crucial expertise on nuclear security if such institutions or their representatives are viewed as partisan or unaligned with the national leadership's broader objectives. Civil society plays a critical role in acting as a knowledge repository and providing objective and evidence-based support, as well as keeping governments accountable, which ultimately serves to strengthen the awareness and implementation of nuclear security. Finally, political polarization can influence the management of nuclear security infrastructure. In line with diverging views on what constitutes a national security priority, political polarization may result in cuts or overhauls of key institutions responsible for maintaining nuclear security. Given that the strength and relative independence of institutions are critical for ensuring the implementation of effective nuclear security measures, changes to institutions could severely limit their efficacy.

In a similar vein, polarization may also result in diminished interagency coordination among stakeholders responsible for nuclear security—including nuclear operators and regulators, law enforcement, the military, intelligence officials, and the scientific and technical communities. Lack of coordination and cooperation can lead to gaps in nuclear security measures, which could ultimately create vulnerabilities through decreased preparedness for, detection of, and response to nuclear security incidents.

Impact of Political Polarization on Insider-Threat Mitigation

As discussed above, political polarization can alter nuclear security in numerous ways. A critical element of nuclear security is the mitigation of insider threats. In the nuclear security field, insiders are defined as individuals with authorized access to nuclear material or facilities, who—if ill-intentioned or exploited—could commit or facilitate criminal or unauthorized acts that could detrimentally affect nuclear security.[15] Political polarization can shape perceptions of insider threats, including in regard to the likelihood or efficacy of such acts taking place.

One of the most salient effects of polarization is its contribution to feelings of mistrust of government institutions.[16] This is important in the context of the "human element," which has long been recognized as critical for ensuring a robust and effective nuclear security culture. In this respect, polarization could potentially offer a pretext for insiders to commit illegal or unauthorized acts directed at nuclear material or facilities. Motivations for insiders to commit such acts may include financial distress or coercion. But they can also be spurred by disgruntlement or ideology,[17] both of which are particularly relevant in the context of polarization.

In a well-documented incident in the 1980s, an anti-apartheid activist stole sensitive documents and sabotaged the facility at the Koeberg Nuclear Power Plant in South Africa. The perpetrator claimed to have been motivated by the African National Congress amid a polarized political environment in South Africa's history, which was salient to the perpetrator's personal views.[18]

[15] *Preventive and Protective Measures Against Insider Threats*. No. 8-G (Rev. 1). IAEA Nuclear Security Series. International Atomic Energy Agency, 2020.

[16] Weber, T.J., Chris Hydock, William Ding, et al. "Political Polarization: Challenges, Opportunities, and Hope for Consumer Welfare, Marketers, and Public Policy." *Journal of Public Policy & Marketing* 40, no. 2 (2021): 184–205. https://doi.org/10.1177/0743915621991103.

[17] Bunn, Matthew. "Insider Threats to Nuclear Security." In *The Oxford Handbook of Nuclear Security*, edited by Christopher Hobbs, Sarah Tzinieris, and Sukesh K. Aghara. Oxford University Press, 2024. https://doi.org/10.1093/oxfordhb/9780192847935.013.9.

[18] Hobbs, Christopher, and Matthew Moran. *Insider Threats: An Educational Handbook of Nuclear & Non-Nuclear Case Studies*. Centre for Science and Security Studies, King's College London, 2015. https://www.kcl.ac.uk/csss/assets/insider-threats-handbook.pdf.

Moreover, threat identification and assessment can be subject to biases,[19] and polarization may exacerbate these biases. Within this context, employees with certain political leanings or ideological views may be seen as more likely to pose an inside threat. Polarization could lead to the exaggeration or overestimation of the risk of insider threats from political foes. Such a phenomenon could result in increased scrutiny of individuals based on their political affiliations, rather than on any real indicators of a threat.

Heightened perception of an insider threat where there may be none can lead to unfounded panic, misguided policies, and an unnecessary burden on both nuclear and security agencies tasked with addressing these issues. Ultimately, these types of biases can affect processes required for monitoring, vetting, and other personal reliability-related measures, leading to biased estimations of insider risk disconnected from objective risk assessments.

Finally, in a polarized political climate, there could be an impact on the selection and appointment of individuals in key positions within facilities and organizations responsible for nuclear security. These appointments may prioritize individuals who share the same ideological beliefs or priorities, potentially at the expense of professional competence. Prioritizing political objectives over nuclear security may result in overlooking or downplaying security breaches, if doing so serves political interests. Moreover, even routine measures designed to ensure human reliability or personnel trustworthiness can be resisted if they are perceived as driven by political agendas. These factors can all minimize the effectiveness of insider-threat mitigation measures, resulting in amplified or unaddressed security vulnerabilities. Ultimately, political polarization can distort awareness and understanding of what actually constitutes an insider threat, while also undermining the efforts required to address them.

Conclusion

Domestic political factors of threat perception, political will, and institutional capacity can play significant roles in shaping a state's approach to nuclear security. Domestic politics are instrumental in determining the strength and extent of a state's commitment to nuclear security and how it engages with broader global nuclear security norms, influenced by perceptions of salience and legitimacy. Political polarization is a unique challenge that can undermine national consensus on nuclear security priorities, including insider-threat mitigation, by weakening institutional responses and potentially interfering with threat assessments.

Ultimately, these factors can affect the vigor and stability of nuclear security norms, with consequences beyond the national domain. International cooperation could become more difficult. Multilateral efforts to protect nuclear material and facilities, or address nuclear terrorism, may be impeded.

Wholly reversing the current global trend toward political polarization, and its mixed effects on a wide array of issues, will be a complex, multifaceted endeavor well beyond the scope of this paper. However, by understanding and addressing the impacts on nuclear security of political polarization and related domestic factors, states can better protect nuclear materials and facilities, mitigate insider threats, and contribute to the broader effort of ensuring global nuclear security. (See Appendix for a list of specific policy recommendations.)

While the global security environment continues to evolve, and the threat of nuclear terrorism remains, it is crucial for both norm-makers and norm-takers to work collectively toward a global nuclear security that remains adaptable and resilient. As states grapple with the challenges posed by domestic factors such as polarization, they can better contribute to worldwide efforts toward enhancing the robustness of nuclear security norms.

[19] Nair, Sneha, Christina McAllister, Annie Trentham, and Annina Pluff. Bias in Nuclear Security Implementation. Policy Paper. The Henry L. Stimson Center, 2023. https://www.stimson.org/wp-content/uploads/2023/11/Bias-in-Nuclear-Security-Implementation.pdf.

Appendix: Policy Recommendations

Promote political consensus

- States should prioritize building support for nuclear security that includes the input of all relevant stakeholders.
- Relevant governmental entities should undertake neutral and nonpartisan threat assessments to ensure that polarization does not undermine the effectiveness of nuclear security measures.

Strengthen legal and institutional frameworks

- Governments and regulatory authorities should equip domestic institutions responsible for nuclear security with the mandate, resources, and technical capabilities required to effectively address nuclear security challenges.
- Governments should allocate resources to strengthen the legal and administrative capacities of relevant institutions, with a focus on enhancing regulatory frameworks, interagency coordination, and nuclear security training.

Enhance multilateral cooperation

- States should engage in ongoing dialogue through international platforms to ensure that nuclear security norms remain relevant and robust. There is a particular onus on norm-makers to maintain global cooperation on nuclear security.
- International partners and assistance providers should encourage norm-takers to actively engage with nuclear security through the provision of targeted assistance in line with their political and economic realities.

Address insider threats in an apolitical manner

- States and facility operators should base insider-threat mitigation programs on objective threat assessments.
- Governments, operators, and regulators should promote a nuclear security culture across the national, organizational, and individual levels that prioritizes professional competence and behaviors required to foster effective nuclear security.

Leverage public-private partnerships

- Governments and NGOs should collaborate to benefit from the latter's provision of independent expertise and best practices.
- Governments, industry, academia, and think tanks should utilize existing partnerships or develop new ones to strengthen nuclear security implementation.

BIOGRAPHY

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Nuclear Security Training: Standards and Resilience Required

Ali Alkis

Training to ensure the competence of personnel in all nuclear facilities is a core element of a robust nuclear security system. Its importance becomes more evident during an emergency or crisis, whether it is human-made—such as a geopolitical conflict, terrorist attack, or cyber-attack—or natural, like an earthquake, flood, wildfire, or pandemic. While there are different definitions, the terms emergency and crisis reflect a common point: a severe and potentially dangerous situation, in which immediate and decisive action is needed to mitigate risks and prevent adverse consequences.

Training plays a key role in preventing such a scenario, but it is almost equally important for the aftermath of such scenarios in nuclear facilities. Therefore, training programs should be designed to develop the skills necessary for ensuring continuity of operations, minimizing disruptions, and swiftly recovering from adverse events. The standing need also requires incorporating crisis resilience into nuclear security training.

This paper refers to resilience as the ability of nuclear facilities and personnel to anticipate, prepare for, respond to, and recover from such crises effectively. With such training designed for potential scenarios, personnel can develop skills to respond effectively under pressure, anticipate vulnerabilities, and uphold the security and functionality of nuclear facilities in complex and uncertain situations.

However, there is no standard practice for building crisis resilience, leaving nuclear facilities potentially exposed during emergencies.

In this context, what the International Atomic Energy Agency (IAEA) calls "National Nuclear Security Support and Training Centers," or "nuclear security centers of excellence," offer consistent resources for helping train and prepare operators, regulators, first responders, and policymakers for extended

nationwide crises affecting nuclear facilities.[1] These centers could also serve as hubs for states in various regions to practice international coordination and response scenarios. This approach could strengthen not only institutional but also regional preparedness, which in turn would reinforce broader efforts to enhance global nuclear security frameworks in an era of emerging challenges.

Importance of Training and Current Practices

The concept of crisis preparedness is not new to the nuclear sector, which has historically prioritized threat scanning and risk evaluation. It has always been part of the nuclear sector's practices to scout for danger, and look for new technologies and their impacts. For many years, constant risk assessment has been used to translate risks into strategic, tactical, and national measures.

Nuclear technologies, by nature, are different from others. Stakeholders are faced systematically with a number of risks, which might be regulatory, reputational, or financial in nature. Many organizations use traditional methodologies—such as analyses termed "SWOT," for strengths, weaknesses, opportunities, and threats, or "PEST," for political, economic, social, and technological—to assess their frameworks. When organizations in the nuclear field want to react effectively to this kind of assessment, they must have resilience training, which should be a prerequisite to every security framework.[2] Furthermore, staff must have sufficient training and understanding of issues to feel empowered to make decisions on the spot at critical points during an incident, when it may not be possible to contact someone higher in authority.

While nuclear security training plays an important role in developing relevant skills, nuclear security is a vast topic, covering multiple elements. It includes physical protection, control over nuclear materials, response to malicious acts, and emergency preparedness, each of which vary from state to state. An example of how multiple, disassociated factors can result in a nuclear facility security failure is documented in the U.S. Department of Energy's Special Report on "Inquiry into the Security Breach at the National Nuclear Security Administration's Y-12 National Security Complex."[3] There is still debate about whether this incident, in which three peace activists broke through perimeter security at the Y-12 National Security Complex and defaced a building containing nuclear materials, succeeded due to insider help or access to facility information. Still, lessons from that incident deserve to be included in training scenarios.

One comprehensive approach has been to focus on developing a "systematic approach to training" model, for which there is room for improvement in general.[4] Whether it is called training or professional development, the goal is to provide the necessary skills and competencies required for routine work, as well as emergencies.

For example, NB Power in Canada has designed a training program that first meets the training requirements set out by the governmental regulator, then branches out to provide supplementary training to ensure competencies are acquired that complement the required knowledge, skills, and abilities. While scenarios used in these training courses are classified or sensitive, training and scenarios have been designed to test against various aspects of the threats facing facilities, an approach known as the "design basis threat." Training programs are reviewed on a regular basis to ensure that desired outcomes are aligned with expectations and changes in industry, as well as cover changes to ongoing threats or the emergence of new threats. Quarterly curriculum and training review committee meetings provide an in-depth look into the overall

[1] Nickolas Roth, Ross Matzkin-Bridger, and Jessica Bufford, *Nuclear Facilities in Times of Crisis*, Nuclear Threat Initiative, 2024, www.nti.org/wp-content/uploads/2024/06/NTI_Paper_FITOC_FINAL_060724.pdf.

[2] Interview with Pierre Legoux (World Institute for Nuclear Security) by the author, March 10, 2025.

[3] U.S. Department of Energy, Office of Inspector General, and Office of Audits and Inspections, *Special Report: Inquiry into the Security Breach at the National Nuclear Security Administration's Y-12 National Security Complex*, DOE/IG-0868, August 29, 2012, www.energy.gov/ig/articles/special-report-ig-0868.

[4] International Atomic Energy Agency (IAEA), *Experience in the Use of Systematic Approach to Training (SAT) for Nuclear Power Plant Personnel*, IAEA-TECDOC-1057, 1998, 10.

nuclear security training program, while the annual health-of-training report summarizes annual training and assigns a rating score.[5]

Challenges in Nuclear Security Training

Although it is widely considered that nuclear security must be a collective responsibility within an organization, putting this principle into daily practice, especially during crises, remains challenging. It is mostly assumed to be the responsibility of security departments, and most training programs do not address the specific needs of other personnel to contribute to the broader nuclear security approach. Additionally, nuclear security training—like any training program—requires funding, which must be balanced with the costs of daily operations. Such programs can also temporarily reduce staff availability, as personnel are required to step away from their regular duties. These challenges are likely to be raised more frequently in commercial nuclear facilities, where operational demands are high, and there is a strong emphasis on return on investment.

Another important deficiency is the lack of industry-wide standardization and commitment to security training. Critically, many training programs fail to make security culture a priority, treating security as a compliance issue rather than a core organizational value. This lack of commitment is reflected financially and logistically: most nuclear security training programs are not afforded the same rigor, resources, and dedicated facilities as other nuclear-related training programs. This disparity likely stems from fundamental differences in prioritizing risk. For example, safety training is integrated into daily operations to manage intrinsic, continuous hazards. In contrast, security training is often viewed as a contingency for low-probability, high-risk events that do not generate immediate operational value. Consequently, this leads to inconsistency across different nuclear security training programs around the globe and training facilities generally lack adequate, real-world model scenarios, which are important for realistic and dynamic practice environments.

Lastly, many nuclear security training programs lack the flexibility to adapt to evolving risk assessments. This approach makes it challenging for security measures to effectively address emerging threats, such as those stemming from crises or new technologies.

At the same time, the prospect of extreme global events is intensifying, from natural disasters like earthquakes and tsunamis, to climate change-driven weather patterns and pandemics such as COVID-19. While it is not possible to prevent some such phenomena, like the tsunami that triggered the Fukushima Daiichi accident in 2011, it is possible to become better prepared for such scenarios.

As things stand, extreme global events pose significant risks to security systems at nuclear facilities. These can affect supply chains, staff availability, and critical resources like water and power. Such unforeseeable events challenge resilience across multiple dimensions, which require training programs to test against these disruptions. Without developing contingency plans for resource shortages or ensuring system functionality during or after disasters, security operations will strain to operate.[6]

The nuclear industry might offer some insights to mitigate these risks. The industry is responsible for evaluating its own risks and understanding their impact on operations, so its insights are important for creating practical and adaptable training solutions. By incorporating industry input, programs can be designed to better meet real-world challenges and ensure that security measures remain effective in a dynamic threat landscape.

In this regard, the nuclear industry contributes by supporting training and capacity-building efforts through collaborations. For example, through its practical arrangement with the IAEA, the United Kingdom's Nuclear Transport Solutions—part of that nation's nuclear decommissioning authority—supports various activities to enhance transport security.[7] Furthermore, these nuclear transport experts collaborate with some IAEA member states

[5] Interview with Geoff McCabe (NB Power) by the author, March 17, 2025.

[6] Interview with a senior British nuclear professional by the author, March 1, 2025.

[7] https://nucleartransportsolutions.com/about-us/.

through various programs to support nuclear security capacity-building globally.[8] These kinds of partnerships exemplify the importance of leveraging industry expertise and international cooperation to develop resilient training frameworks that address evolving threats effectively.

However, there is also a greater need for IAEA member states, with their competent authorities and regulators, to train their personnel for crises and emergencies. Regulatory bodies are expected to maintain the agility to swiftly identify and respond to emerging threats by regularly conducting threat, vulnerability, and risk assessments and updating design basis threats, which inform necessary adjustments to overall security strategies. Such regulative processes require support and active engagement not only from well-trained security departments, but also from senior leadership.

This unified focus will reinforce a collective understanding that nuclear threats are tangible and significant, and demand unified national action to effectively mitigate risks. It is this shared, top-down commitment to mitigating risk that transforms security from a requirement into a foundational element of organizational culture. Building this robust culture is a prerequisite for the practical strategies needed to manage low-probability, high-consequence events.

Incorporating Resilience into Training

While there have been no major nuclear security incidents resulting in a radioactive release, low-likelihood, high-consequence events represent a critical challenge for nuclear security due to their unpredictable nature. These unforeseeable events often materialize in unexpected ways and unfold rapidly, leaving little time for response. Therefore, personnel must be equipped with both technical expertise and soft skills like critical thinking, situational awareness and adaptability. Training programs must go beyond prescribed regulations, and incorporate simulations of such rare scenarios. This will, in turn, help leaders, operators and first responders build resilience and manage high-stress situations.[9]

A resilient emergency-preparedness framework should have clearly defined roles and responsibilities and be regularly tested through exercises to minimize risks during actual crises. To further enhance resilience, teams must be trained in critical thinking and foster a proactive mindset. This might be provided by training programs with strategies like red-teaming and adversary role-playing to anticipate potential attack.[10] Training should also include a clear understanding of worst-case scenarios if participants fail to fulfill their responsibilities.

Furthermore, personnel at all levels, including senior leadership, should have full knowledge of their contingency plan or tactical-deployment plan, and be involved in training and exercises. These will be complemented by familiarity with the specific facility they are tasked with protecting, ensuring preparedness for diverse threats.

Additionally, experienced senior professionals, potentially from other industries, can mentor and sustain the development of newly hired personnel. It is also important to highlight the human impact of responding to emergencies. For example, emergencies cause stress and pressure, to which people respond differently. For this reason, more advanced programs might incorporate realistic, scenario-based exercises to simulate high-pressure environments.

Incorporating resilience requires translating theoretical insights into hands-on experience. This could also be improved with lessons learned from other industries, such as aviation, casino, or pharmaceutical security. This would allow training to address general characteristics of a crisis, as well as unique aspects of nuclear facilities.[11] Additionally, another important aspect of crisis resilience is to have uninterrupted and reliable communication,

[8] Interview with Alex Barrow (NTS) by the author, February 27, 2025.

[9] Interview with a senior British nuclear professional by the author, March 1, 2025.

[10] Interview with senior British professional, March 1, 2025.

[11] Matthew Bunn and Kathryn M. Glynn, "Preventing Insider Theft: Lessons from the Casino and Pharmaceutical Industries," *Journal of Nuclear Materials Management* 41, no. 3 (2013): 4–16.

whether on- or off-site. Given the possible consequences, good communication at the local, national, and international levels plays a critical role in addressing risks during a crisis.[12]

Effective nuclear security also depends on competent personnel with specialized skills, proven capable of performing under extreme stress in both training and emergencies. In this context, the World Institute for Nuclear Security plays an important role by serving as a platform for exchanging lessons and best practices. The institute facilitates collaboration among diverse stakeholders to enhance emergency preparedness—an area where shared experiences are invaluable.[13] To achieve this, the organization creates and disseminates best practices, acting as a catalyst to strengthen the global nuclear security community, though its efforts are just one part of a broader solution.

Building resilience requires organizations to practice responses to small-, medium-, and large-scale emergencies through realistic simulations. It is important to note that theoretical plans might not directly fit into practice due to unforeseen challenges, necessitating adaptability to ensure robust preparedness.[14]

Support and Training Centers to Build Crisis Resilience

Similar to the World Institute for Nuclear Security's initiatives, other platforms and centers focus on national, regional, and international nuclear security training.

National nuclear security support and training centers (NSSCs) are the primary national mechanisms for translating crisis resilience theory into institutional practice. As national hubs, they provide training, technical support, and expertise necessary to help states build and sustain nuclear security capabilities, particularly those required to manage crises. NSSCs support competent authorities, authorized personnel, and other organizations in developing robust, integrated emergency-response frameworks. Indeed, many centers are already actively designing and implementing training courses and exercises focused specifically on crisis scenarios, ranging from natural disaster simulations to responses against malicious attacks.

The IAEA has published a technical document, "Establishing and Operating a National Nuclear Security Support Center," which outlines the role of NSSCs in sustaining nuclear security. It details a step-by-step, systematic process for establishing an NSSC and ensuring its effectiveness over the long term.[15]

NSSCs have become vital to the global nuclear security framework. These centers focus on training a diverse range of professionals on critical nuclear security topics, emphasizing the "human factor" in securing nuclear materials.[16] Support for these centers has grown since 2010, particularly during the Nuclear Security Summit (NSS) process—former U.S. President Barack Obama's initiative in which world leaders met between 2010 and 2016 to collaboratively help prevent nuclear smuggling and terrorism.[17] The most notable NSS-related achievement with regards to training was at the 2014 summit, when Italy led the "Nuclear Security Training and Support Centers/ Centers of Excellence" initiative. More than 30 nations supported this so-called "gift basket," building on the IAEA's establishment of the Nuclear Security Support Center network in 2012.

This political support proved critical and even spurred subsequent growth: the NSSC network has

[12] Interview with Jennie Gromoll (former State Department) by the author, March 15, 2025.

[13] Interview with Legoux, March 10, 2025.

[14] Interview with Legoux, March 10, 2025.

[15] IAEA, *Establishing And Operating A National Nuclear Security Support Centre (Revision Of IAEA-TECDOC-1734)*, 2020, www-pub.iaea.org/MTCD/Publications/PDF/TDL-010_web.pdf.

[16] Bonnie Jenkins, *Nuclear Security Centers of Excellence*, Belfer Center for Science and International Affairs, 2014, www.belfercenter.org/publication/nuclear-security-centers-excellence.

[17] The White House (Office of the Press Secretary), "The Nuclear Security Summits: Securing the World from Nuclear Terrorism," Fact Sheet, March 29, 2016, obamawhitehouse.archives.gov/the-press-office/2016/03/29/fact-sheet-nuclear-security-summits-securing-world-nuclear-terrorism.

expanded significantly since that summit. As of March 2025, the network has 71 member institutions, with a notable concentration of 30 centers within the Asia-Pacific region. Most of these centers are affiliated with regulatory bodies as their parent organizations, underscoring a state-led national framework.

The network's operational focus is mainly on three core functions. The first focus is on human resource development, for which the primary emphasis is training on the top three sub-themes: security of radioactive sources, threat detection, and safeguarding nuclear material. This reflects a strategic prioritization of radiological- and nuclear-material protection competencies. The second focus is on technical support, which prioritizes detection, response, and security of radioactive sources. Arguably, this highlights an investment in technical infrastructure for real-time security interventions. And, the third focus is on scientific support, which prioritizes the detection and security of radioactive sources, and response to threats. This focus relies on a scientific underpinning to enhance detection and response efficacy.[18]

From December 1, 2023, to December 31, 2024, NSSC network members organized a net total of 118 events, encompassing—from most numerous to least—training courses, workshops/seminars, meetings/conferences, technical exchange visits, and exercises. The most active organizers were institutions from Ukraine, Lithuania, and Egypt, with themes on the detection of material out of regulatory control, response to nuclear security events, and security of nuclear material. This thematic focus provides more than a quantitative insight; it demonstrates a direct commitment to building crisis resilience. Personnel received training across the full spectrum of an emergency, focusing on prevention, detection and response skills needed to manage and contain an active crisis.[19]

However, while the thematic focus is correct, the training *method* highlights a significant gap between theory and practice. The high volume of events—118 in just 13 months—stands in stark contrast to the network's long-term record of practical training: only 39 exercises have been conducted since January 1, 2018. This highlights a significant gap in hands-on training experiences.

The limited number of practical exercises suggests two trends. One is that theoretical engagements—workshops and seminars—have been prioritized. And the second trend is that the development of experiential learning opportunities through exercises remains underrepresented. While theoretical engagements remain essential for establishing a foundational knowledge base, an effective training mix must integrate these with practical application. A balanced training should therefore involve a higher proportion of hands-on exercises to ensure that theoretical knowledge translates into operational competence during a crisis. Otherwise, the current trend might undermine the functionality of centers to fully prepare their personnel for real-world nuclear security scenarios, despite the fact that such practical application of skills is critical. Increasing the frequency and diversity of exercises will enhance the overall effectiveness of centers in reinforcing their operational readiness and resilience. Building on the NSSC network's efforts, the IAEA Nuclear Security Training and Demonstration Center (NSTDC) was established in Seibersdorf in 2023 as the world's first international training center. It offers practical, hands-on training in critical areas such as physical protection of nuclear facilities, nuclear forensics, and cybersecurity. The Center helps strengthen the capabilities of member states to address unique challenges and implement complex nuclear security projects. The NSTDC further enhances the assistance provided to member states with specialized technical infrastructure and equipment. Specifically, it offers training directly focused on crisis management, including courses such as "Response to Nuclear Security Events and Emergencies Triggered by Nuclear Security Events" and associated tabletop and field exercises. In these ways, the NSTDC training complements existing national and international nuclear security capacity-building mechanisms.[20]

[18] The data was extracted from the NSSC Network Newsletter, available at www.iaea.org/services/networks/nssc. For more information, contact NSSC Network.

[19] Data extracted from the NSSC Network Newsletter, available at www.iaea.org/services/networks/nssc.

[20] IAEA, *Establishing And Operating A National Nuclear Security Support Centre, (Revision Of IAEA-TECDOC-1734)*.

The NSTDC could be used yet more creatively to engage more senior representatives, much in the way the U.S. Apex Gold exercise was used in 2016. Early that year, the U.S. hosted a scenario-based exercise at Lawrence Livermore National Laboratory, attended by ministers and other senior representatives from 37 countries, along with participants from the IAEA, the European Union, and the United Nations. The objective was to practice their ability to respond effectively to an emerging nuclear security threat, and subsequently use that experience to advise their leaders at a scenario-based policy discussion exercise at the 2016 Nuclear Security Summit.[21]

Most exercises do not engage senior officials. But Apex Gold drove home the important point that leadership cannot lead without having a basic understanding of the problem at hand, and knowing how to identify and use trusted experts to provide advice.

NSSC Member Activities

Certain events in the nuclear industry have shown that NSSC member institutions could develop unified approaches and respond to emergencies with lessons learned. For example, when the Russian invasion of Ukraine started in 2022, the Ukrainian authorities started to develop comprehensive security plans for the protection of other nuclear power plants, with the experience gained from the Russian military's limited Chernobyl plant occupation and the ongoing Zaporizhzhia facility occupation.[22]

The George Kuzmycz Training Center for Physical Protection, Control and Accounting of Nuclear Material of Ukraine (GKTC) played an important role in translating these lessons learned into practical training programs. For example, the center has been developing systematic training for the National Guard of Ukraine and has established advanced physical protection systems beyond the traditional facility fenceline—a critical lesson learned after standard, on-site security proved insufficient to counter adversaries operating as a conventional military force in the vicinity of the nuclear power plants. Further, the Ukrainian authorities started to conduct more hands-on practices for other such power facilities with the participation of different government bodies, as well as all stakeholders in the nuclear field.[23]Tajikistan has also reinforced its nuclear emergency preparedness, especially against natural disasters. For example, Tajikistan's chemical, biological, radiological, and nuclear safety and security agency conducted an exercise that simulated a 7.0-magnitude earthquake that struck the nation's Republican Radioactive Wastes Storage Facility. The scenario assumed damaged storage units, disrupted power supply, and potential radiation leaks. As a result, simulated remediation involved steps beyond the facility, such as national emergency-management agencies, public-safety briefings, and evacuation planning for nearby communities. This hands-on exercise highlighted the critical role of training in building resilience and developing skills to effectively respond to nuclear crises.[24]

Similarly, in line with its aim to deliver comprehensive and practical training, the International Nuclear Nonproliferation and Security Academy (INSA) in the Republic of Korea has focused on the development, management, and continuous upgrading of virtual-reality training equipment. There are currently three types of this virtual training, which include procedural physical-security inspection, security screening at nuclear facilities, and motion tracking force-on-force exercise. In these trainings, a virtual environment is created to meet the requirements of each relevant technical activity.[25] By integrating cutting-edge technology, trainees gain the possibility of developing critical nuclear-security skills in a realistic, yet risk-free, setting.

[21] Nuclear Summit, *Apex Gold Scenario-Based Policy Discussion*, (Washington, 2016), www.nss2016.org/document-center-docs/2016/3/31/apex-gold-fact-sheet.

[22] Interview with a senior Ukrainian nuclear professional by the author, March 1, 2025.

[23] "Energoatom successfully conducted a common-plant emergency response drill," Energoatom, 2024, energoatom.com.ua/en/news/v-energoatomi-uspishno-proveli-zagalnostancijne-protiavarijne-trenuvannya.

[24] Interview with Zarina Sayfieva (WINCA) by the author, March 10, 2025.

[25] Jae-Jun Han, *Diving into Virtual Reality Education and Training of the Korean Nuclear Security Center of Excellence*, Korea Institute of Nuclear Nonproliferation and Control, 2022, mcusercontent.com/958dfcbed8f359a6db0bb9c87/files/bee1d75a-42b9-40cf-d7cc-434668381802/Issue_13_In_Focus_Korea.pdf.

Complementing these virtual environments, the integration of artificial intelligence (AI) also offers opportunities for both operational threat detection and resilience training. In an operational context, AI algorithms can support security personnel by analyzing sensor data much faster to identify subtle anomalies—such as irregular cyber network traffic or unauthorized physical movement patterns—that might elude human observation.

Integrating this technology into training exercises allows for a transition from static scripts to dynamic wargaming. Emerging research suggests that "AI red team agents" can be deployed to simulate opponent responses, forcing trainees to contend with adversaries that adapt to their defensive maneuvers.[26] Furthermore, AI-driven course of action analysis tools can act as decision aids during these simulations, helping leaders evaluate the potential consequences of their tactical choices in real-time. This offers a scalable model for other NSSC member institutions to enhance their training programs and build resilience against diverse threats.

Conclusion

The evolving nature of nuclear security requires a proactive and resilient approach to training. This approach is important to ensure risk-reducing management of both routine operations and crisis scenarios. By integrating crisis resilience into training frameworks, nuclear facilities can better anticipate, respond to, and recover from emergencies—whether human-made or natural—minimizing disruptions and safeguarding global security. NSSCs and the IAEA's Nuclear Security Training and Demonstration Center provide an important opportunity for building these capabilities. Through use of these centers, addressing gaps such as limited hands-on exercises and the lack of global alignment can be addressed with a unified, standardized framework. It will not only strengthen nuclear security training worldwide but also ensure that personnel are technically proficient and adaptable under pressure.

A table summarizing key recommendations and their implementation strategies is provided below.

Table 1. Nuclear Security Training Recommendations

Recommendation	Implementation Strategy	Expected Impact
Scenario-Based Drills	Use simulations for malicious attacks, natural disasters	Improved response time and adaptability
Focus on Soft Skills	Train in communication, leadership, and decision-making	Enhanced coordination during crises
Leverage Technology	Implement virtual reality for training, and artificial intelligence for threat detection	More realistic, risk-free efficient training
International Cooperation	Share best practices, conduct joint exercises	Strengthened global nuclear security
Continuous Learning	Update training based on new threats, case studies	Better preparedness for future crises

[26] Anna Knack and Rosamund Powell, Artificial Intelligence in Wargaming, Centre for Emerging Technology and Security (CETaS), June 2023, https://cetas.turing.ac.uk/sites/default/files/2023-06/cetas_research_report_-_ai_in_wargaming.pdf

BIOGRAPHY

Ali Alkis is a Junior Associate Fellow at the NATO Defense College and a PhD candidate in Türkiye focusing on nuclear security and the protection of nuclear facilities during armed conflict. His research addresses nuclear nonproliferation, nuclear terrorism, and nuclear security governance. He is known for introducing the concept of "nuclear piracy" into contemporary policy discourse to describe unlawful coercive interference with nuclear facilities. His work engages the legal, institutional, and normative dimensions of nuclear security in conflict settings as well as Turkish foreign and nuclear policies.

National Differences in Nuclear Security Culture

Dmitry Kovchegin

The concept of "nuclear security culture"—typically focused on a set of societal characteristics that reinforce useful standards—includes the influence of human strengths and weaknesses on "hard" nuclear security tools, such as nuclear security equipment and procedures. While there are always some unknowns in the operation of hard nuclear security elements due to laws of nature, uncertainties can be calculated, designed into the system, and compensated via redundancy and defense-in-depth. If such a system is operated and procedures are followed "as designed," then we can guarantee a certain level of nuclear security.

A problem, however, is that equipment is operated and procedures are implemented by humans, and the "as-designed" result is far from guaranteed. "Culture," in general, explains the variability of behavior of personnel, and nuclear security culture, as a tool, is intended to mitigate human weaknesses and leverage human strengths to achieve desired security outcomes. That said, current nuclear security culture discussion tends to be more focused on mitigating weaknesses rather than leveraging strengths.

A notion of culture was first introduced to the nuclear industry as a "safety" measure following investigations of incidents at nuclear power plants in Three Mile Island and Chernobyl, which identified human factors as a root cause for the failures.[1] "Nuclear security culture" rose to prominence at the turn of the 21st century, with growing attention paid first to challenges associated with the collapse of the Soviet Union beginning in 1991, and, second, the realization of the potential for nuclear terrorism threats after the devastating non-nuclear terrorist attacks of September 11, 2001, in the United States.

Nuclear security culture was initially institutionalized through an amendment to the Convention on

[1] Christopher Hobbs and Matthew Moran, "Exploring the Human Dimension of Nuclear Security: The History, Theory, and Practice of Security Culture," *The Nonproliferation Review 28*, no. 4-6 (2021): 275–295, doi.org/10.1080/10736700.2020.1811532.

Physical Protection of Nuclear Material, and then elaborated in the International Atomic Energy Agency (IAEA) Nuclear Security Series recommendations. The IAEA Nuclear Security Series Publication No. 7, "Nuclear Security Culture: Implementing Guide,"[2] defines nuclear security culture as "the assembly of characteristics, attitudes and behavior of individuals, organizations and institutions which serves as a means to support and enhance nuclear security. An appropriate nuclear security culture aims to ensure that the implementation of nuclear security measures receives the attention warranted by their significance."

The introduction of the concept of nuclear security culture coincided with growing international cooperation in the nuclear sector. Many countries have been exposed to the concept of nuclear security culture and have started implementing it as part of their national nuclear programs. While the IAEA publications note the impact of national cultural specifics on nuclear security culture, little attention has been paid to systemic analysis of their impact on nuclear security and the use of analytical results to improve nuclear security. There are several examples[3] of country-specific studies of nuclear security culture, but there is no analysis of the mechanisms by which the cultural specifics of the analyzed countries affect nuclear security.

National Culture Impact on Human and Organizational Behaviors

In the meantime, there is much evidence that differences in national cultures result in differences in human behavior and organizational subcultures, including in safety and security-critical applications.

An authoritative study of differences in national culture and their impact on human behavior and organizational culture was conducted roughly 50 years ago by the Dutch organizational sociologist and psychologist Geert Hofstede.[4] Hofstede's methodology was developed through extensive research, initially based on a large-scale survey of IBM employees across multiple countries in the 1960s and 1970s, which he later expanded and refined. He developed a quantitative analytical framework[5] for understanding differences between national cultures, consisting of six *national culture dimensions* that represent independent preferences for one situation over another. These preferences distinguish countries from each other. Hofstede's approach has become the foundation for multiple cross-cultural studies in management, organizational behavior, and social psychology.

Hofstede provides multiple examples[6] of the impact of national culture differences on safety and security-related behavior: Designers from the culturally different United States and France create different cockpits for Airbus and Boeing. Certain cultures appear to be more inclined toward risky behaviors or violence. Doctors and patients in culturally different countries use different approaches in prescribing and using antibiotics. More anecdotal, but still a rational and tragic example, is the import of Marxist ideas from Germany to culturally different Russia, which resulted in a perverse application and catastrophe of historical scale.

When this lens is applied to previous nuclear security cooperation between Russia and the United States, multiple examples arise of the impact of cultural differences on the implementation of nuclear security practices imported from the United States to Russia.

[2] International Atomic Energy Agency, *Nuclear Security Culture: Implementing Guide*, IAEA Nuclear Security Series No. 7 (Vienna: IAEA, 2008), www-pub.iaea.org/MTCD/Publications/PDF/Pub1347_web.pdf.

[3] See, for example: Igor Khripunov and James Holmes, eds., *Nuclear Security Culture: The Case of Russia* (Athens: Center for International Trade and Security, University of Georgia, 2004), www.nti.org/wp-content/uploads/2021/09/analysis_cits_111804.pdf; Karl Dewey et al., Nuclear Security Culture in Practice: A Handbook of UK Case Studies (London: Centre for Science & Security Studies, King's College London, 2021), www.kcl.ac.uk/csss/assets/nuclear-security-culture-in-practice-2021.pdf.

[4] There are other studies that use different research methodologies. For most authoritative alternatives see, e.g.: World Values Survey, www.worldvaluessurvey.org; Robert J. House et al., eds., *Culture, Leadership, and Organizations: The GLOBE Study of 62 Societies* (Thousand Oaks, CA: Sage Publications, 2004). However, all these studies come to a common conclusion that differences in national cultures affect the lives of people.

[5] Geert Hofstede, *Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations*, 2nd ed. (Thousand Oaks, CA: Sage Publications, 2001).

[6] Geert Hofstede, Gert Jan Hofstede, and Michael Minkov, *Cultures and Organizations: Software of the Mind*, 3rd ed., rev. (New York: McGraw-Hill, 2010).

Based on Hofstede's study, Russia and the United States are cultural opposites in many aspects critical for organizational culture.

Hofstede's six national culture dimensions are:

1. **Power Distance:** This is the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally. Institutions are the basic elements of society, such as the family, the school, and the community; organizations are the places where people work.
2. **Individualism vs. Collectivism:** Individualism pertains to societies in which the ties between individuals are loose; everyone is expected to look after themselves and their immediate family. Collectivism, as its opposite, pertains to societies in which people from birth onward are integrated into strong, cohesive in-groups, which throughout people's lifetimes continue to protect them in exchange for unquestioning loyalty.
3. **Masculinity vs. Femininity:** A society is called masculine when emotional gender roles are clearly distinct; men are assumed to be assertive, tough, and focused on material success, whereas women are assumed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap; both men and women in this case are characterized as modest, tender, and concerned with the quality of life.
4. **Uncertainty Avoidance:** This is defined as the extent to which the members of a culture feel threatened by ambiguous or unknown situations. This feeling is, among other manifestations, expressed through nervous stress and in a need for predictability—a need for written and unwritten rules.
5. **Long-term vs. Short-term Orientation:** Long-term orientation is indicative of fostering virtues oriented toward future rewards—in particular, perseverance and thrift. Its opposite pole, short-term orientation, describes fostering virtues related to the past and present—in particular, respect for tradition, preservation of "face," and fulfilling social obligations.
6. **Indulgence vs. Restraint:** Indulgence indicates a tendency to allow relatively free gratification of basic and natural human desires related to enjoying life and having fun. Its opposite pole, restraint, reflects a conviction that such gratification must be curbed and regulated by strict social norms. As a cultural dimension, indulgence versus restraint rests on clearly defined research items that measure very specific phenomena. Note that the gratification of desires on the indulgence side refers to life enjoyment and playfulness, not to gratifying human desires in general.

These dimensions were developed based on the results of an extensive survey asking respondents in many countries about their preferences in work, life, and relationships with others.[7]

For each dimension, Hofstede and his colleagues introduced quantitative scales that allow measuring the degree of manifestation of each cultural dimension in each evaluated country. Based on survey results, dimension scores were calculated for 76 countries for dimensions 1–4 and 93 countries for dimensions 5–6. Countries on opposite poles of a specific dimension demonstrate opposite cultural features, which potentially indicates opposite approaches to certain activities. There are countries from the "NTI Nuclear Security Index"[8] list of 22 countries with 1 kilogram or more of weapons-usable nuclear materials on opposite poles of every dimension. This suggests that where nuclear security must be a priority, nations potentially demonstrate opposite behaviors in some nuclear security-related activities.

Elements of Nuclear Security Culture

The IAEA Model of Nuclear Security Culture is based on the concept of organizational culture introduced by the American psychologist and management theorist Edgar Schein.[9]

[7] Hofstede et al, *Cultures and Organizations*.

[8] Nuclear Threat Initiative, *NTI Nuclear Security Index 2023* (Washington, DC: Nuclear Threat Initiative, 2023), www.ntiindex.org/wp-content/uploads/2023/07/2023_NTI-Index_Report.pdf.

[9] Edgar H. Schein and Peter A. Schein, *Organizational Culture and Leadership*, 5th ed. (Hoboken, NJ: Wiley, 2017).

Schein's model of organizational culture comprises three interconnected levels that progress from the deepest, most unconscious layer to the most visible and observable. At the foundation lie **basic underlying assumptions**—fundamental, taken-for-granted beliefs about reality, human nature, relationships, and the organization's environment that develop through collective learning, and become so ingrained that they operate unconsciously to guide perception and behavior. The middle layer consists of **espoused values**—the consciously articulated principles, ideals, and beliefs that the organization's leadership wants to embody in action. The surface level encompasses **artifacts and behaviors**—the visible, tangible manifestations of culture, including physical environments, technology, documented procedures, observed behaviors, language, rituals, and symbols that can be directly observed.

Foundational levels of the IAEA nuclear security culture model (see fig. 1[10]) consist of "beliefs and attitudes" (Schein's basic underlying assumptions) and "principles for guiding decisions and behavior" (Schein's espoused values). Schein's artifacts and behavior in the IAEA model are interpreted through three groups of nuclear security culture characteristics and nuclear security culture indicators associated with them. These three groups are "management systems," "leadership behavior," and "personnel behavior." The nuclear security culture indicators are essentially sample behaviors and artifacts that can be observed in an organization working with nuclear materials or operating a nuclear facility. The nuclear security culture characteristics and indicators associated with them are captured in several IAEA guidance documents to guide member states in developing nuclear security culture and provide them with a tool for self-assessment.

Effects of National Culture on Nuclear Security Cultural Characteristics and Indicators

To analyze the impact of national culture on nuclear security culture, a cross-comparison of the IAEA nuclear security culture characteristics and indicators with Hofstede's national culture dimensions is instructive. For the analysis, dependence of organizational behavior on national culture characteristics identified by Hofstede was adapted to reflect nuclear security culture characteristics and desired behaviors contributing to nuclear security defined by the IAEA.

The scope of this paper does not allow a comprehensive analysis of the impact of national culture on nuclear security culture across all six national culture dimensions and 30 nuclear security culture characteristics. Instead, this paper takes two dimensions with the strongest impact on organization management, and reviews areas where these dimensions have the most impact on nuclear security culture.[11]

Out of all six national culture dimensions, power distance and uncertainty avoidance have the most robust effect on managing organizations. According to Hofstede, "organizing always requires answering two questions: (1) Who has the power to decide what? and (2) What rules or procedures will be followed to attain the desired ends? The answer to the first question is influenced by cultural norms of power distance; the answer to the second question, by cultural norms about uncertainty avoidance."

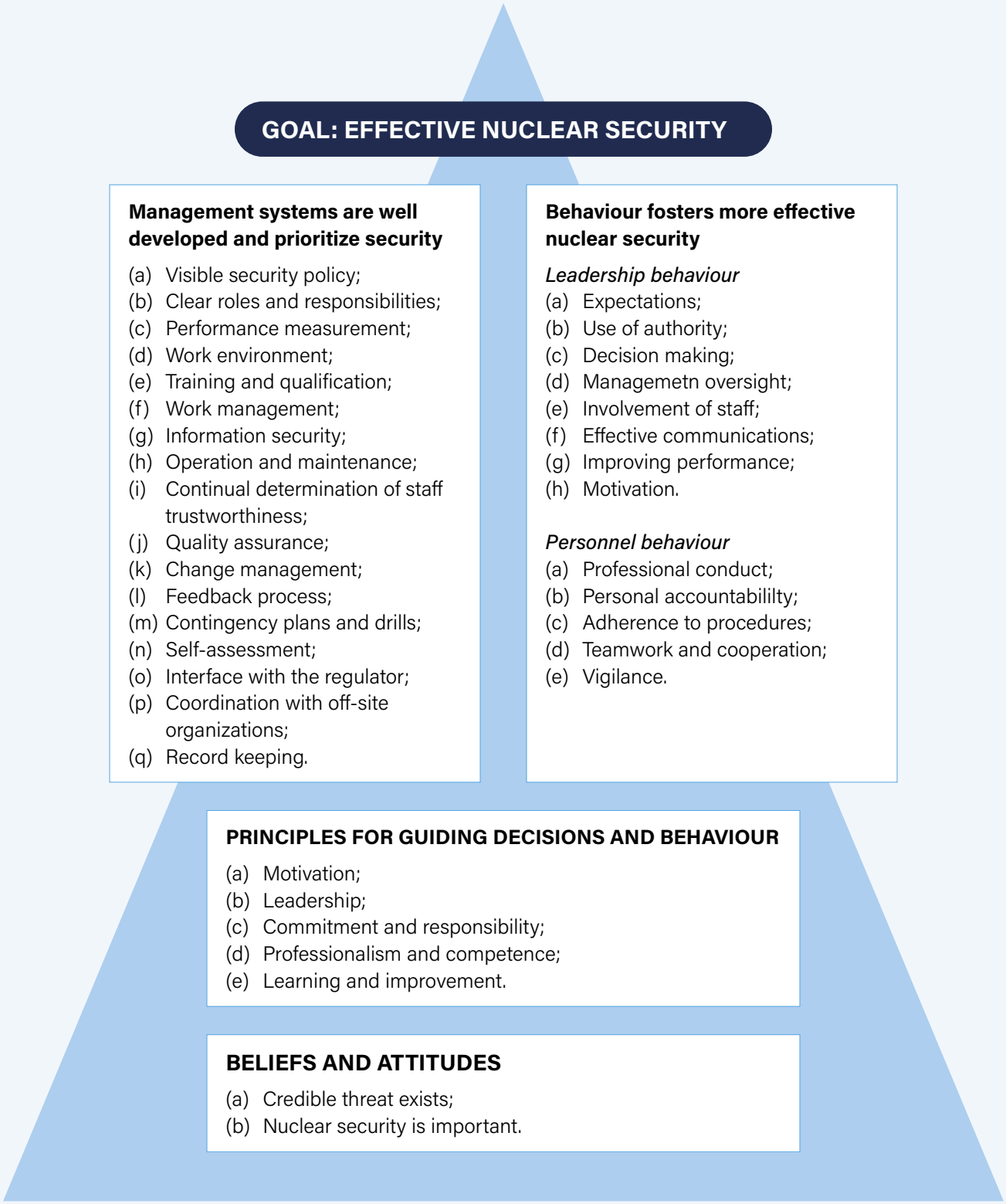
In addition to the nuclear security culture characteristic most affected by power distance and uncertainty avoidance, the analysis includes nuclear security strengths and weaknesses associated with a country being on each of the poles of these two national culture dimensions. Results of the analysis highlight the fact that there is no good or bad national culture, and each culture has its strengths and weaknesses from a nuclear security point of view.

Analysis of the impact of power distance and uncertainty avoidance on nuclear security culture, including the most affected characteristics and strengths and weaknesses associated with each pole of specific national culture dimension, is captured in tables 2 to 4.

[10] International Atomic Energy Agency, *Nuclear Security Culture*, IAEA Nuclear Security Series No. 7 (Vienna: IAEA, 2008), 17–35, www.iaea.org/publications/7977/nuclear-security-culture.

[11] Real-life evaluation of a specific country would require evaluation against each of six dimensions, as each of them may have a strong impact on nuclear security culture depending on the degree of manifestation.

Figure 1. Characteristics of Nuclear Security Culture



Source: IAEA Nuclear Security Series No. 28-T. Technical Guidance. Self-assessment of Nuclear Security Culture in Facilities and Activities, IAEA, 2017, page 6.

Table 1. Top Five Nuclear Security Culture Characteristics Affected by Power Distance

Nuclear Security Culture Characteristic	How Affected by National Culture Dimension
Use of Authority (Leadership Behavior). Management establishes the responsibility and authority of each position within the nuclear security organization. Authority should be clear and documented.	Power Distance (PD) affects how management and employees interact in establishing, exercising, and accepting nuclear security authority. A Power Distance Index (PDI) also determines whether authority is questioned, how managers exercise their authority, and whether staff feel empowered to challenge authority when nuclear security is at risk.
Clear Roles and Responsibilities (Management Systems). Members of all organizations need a clear understanding of who is responsible for what, in order to achieve the desired results. It is particularly important to review and update this responsibility system when organizational change is being planned and executed.	PD influences how management and employees interact in defining, communicating, and accepting nuclear security roles and responsibilities. PD determines whether roles are imposed top-down or developed collaboratively.
Involvement of Staff (Leadership Behavior). Performance is improved when people are able to contribute their insights and ideas. Mechanisms should be in place to support this objective for nuclear security.	PD influences the degree to which leaders involve staff in risk assessment, decision-making, and nuclear security improvement processes.
Visible Security Policy (Management Systems). A policy document is needed that states the commitment of the organization to nuclear security. This document should establish the highest expectations for decision-making and conduct, and should be supported by an atmosphere of professionalism in the security field.	PD affects how management and employees interact in developing, implementing, and enforcing nuclear security policies throughout the organization. Policy effectiveness depends on commitment to formal policy at all levels regardless of power distribution, as well as top-down authority and bottom-up engagement, with PDI determining the balance between these approaches.
Effective Communications(Leadership Behavior). An important part of an effective nuclear security culture is to encourage and maintain the flow of information throughout the organization.	PD influences whether communication flows bidirectionally and whether staff feel comfortable reporting nuclear security concerns upward.

Table 2. Nuclear Security Strengths and Weaknesses Associated with High and Low Power Distance Index (PDI)

Pole	Pros for Nuclear Security Culture	Cons for Nuclear Security Culture
High PDI	◆ Clear command structures and unquestioned authority during emergencies ◆ Top-down role clarity with unambiguous responsibility assignments ◆ Efficient decision-making without extensive consultation ◆ Strong policy implementation through formal hierarchy ◆ Formally appointed superior can be a real source of motivation	◆ Suppressed upward communication of security concerns ◆ Limited input from operational staff in policy and role development ◆ Reduced questioning of potentially flawed authority decisions ◆ Political rather than strategic thinking compromises long-term planning ◆ Fear of reporting problems to superiors creates information bottlenecks
Low PDI	◆ Open bidirectional communication and comfortable reporting of security concerns ◆ Participatory role development that reflects operational needs ◆ High staff engagement in security processes with valuable operational input ◆ Healthy questioning of authority decisions and collaborative problem-solving ◆ Strategic thinking and control systems that trust subordinates	◆ Potentially slower emergency response due to questioning of authority ◆ Time-consuming consensus-building with potential for decision paralysis ◆ Slower policy implementation and potential policy dilution ◆ Role ambiguity through excessive consultation ◆ Information overload with potential for conflicting messages

Table 3. Top Five Nuclear Security Culture Characteristics Most Affected by Uncertainty Avoidance

Nuclear Security Culture Characteristic	How Affected and Why This Dimension Matters
Adherence to Procedures (Personnel Behavior). Procedures represent cumulative knowledge and experience. It is important that they are followed to avoid repeating errors that have already been identified and corrected.	Uncertainty Avoidance (UA) influences whether staff strictly follow established nuclear security procedures or allow flexibility in interpretation depending on the situation. An Uncertainty Avoidance Index (UAI) determines whether procedures are viewed as rigid rules or flexible guidelines.
Clear Roles and Responsibilities (Management Systems). Members of all organizations need a clear understanding of who is responsible for what in order to achieve the desired results. It is particularly important to review and update this responsibility system when organizational change is being planned and executed.	UA affects preferences for formal, documented role definitions and responsibility matrices versus flexible, adaptive role interpretations based on situational needs. Role clarity provides certainty about responsibilities and reduces ambiguity in security operations, which high UA cultures value. Low UA cultures may prefer flexible role boundaries.
Quality Assurance (Management Systems). The security function demands the same degree of rigor, control and assessment as any other major program area. Security performance is documented to earn trust and support for the organization and the people in it.	UA affects the emphasis placed on formal quality systems, documentation requirements, and systematic verification processes. Quality assurance provides certainty and predictability in nuclear security operations. This may appeal to high UA cultures, but potentially is seen as bureaucratic in low UA environments.
Training and Qualifications (Management Systems). An effective nuclear security culture depends on staff having the necessary knowledge and skills to perform their functions to the desired standards. Consequently, a systematic approach to training and qualifications is essential for an effective nuclear security culture.	UA influences preferences for formal training programs, certification requirements, and structured learning approaches. Formal training provides certainty about competence levels, which high UA cultures value, while low UA cultures may prefer experiential learning.
Work Management (Management Systems). All work should be suitably planned in order to ensure that nuclear security is not compromised.	UA affects preferences for detailed work planning, contingency preparations, and structured operational approaches. Structured work management reduces uncertainty in nuclear security operations, appealing to high UAI cultures but potentially constraining flexibility valued in low UA environments.

Table 4. Nuclear Security Strengths and Weaknesses Associated with High and Low UAI

Pole	Pros for Nuclear Security Culture	Cons for Nuclear Security Culture
High UAI	◆ Consistent security performance with reduced human error ◆ Strong compliance culture with comprehensive documentation ◆ Formal responsibility matrices and structured accountability systems ◆ Preference for prescription-based regulations that alleviate anxiety ◆ Detailed planning that reduces security risks through systematic approach	◆ Excessive rigidity in procedure application reduces adaptability ◆ Countries more likely to harbor extremist minorities and native terrorists ◆ Overly rigid role definitions with reduced flexibility ◆ Bureaucratic overhead with focus on documentation over effectiveness ◆ Suppressed innovation in security approaches
Low UAI	◆ Flexible procedure application with adaptability to novel situations ◆ Innovative security approaches with situational judgment emphasis ◆ Adaptive responsibility assignments with flexible role boundaries ◆ Practical quality focus with efficiency over documentation ◆ Adaptive management approaches with efficient planning processes	◆ Inconsistent security performance with potential for procedural shortcuts ◆ Increased human error risk due to reduced compliance reliability ◆ Potential role confusion with unclear responsibility boundaries ◆ Inadequate documentation and inconsistent quality standards ◆ Inadequate planning increases security risks

Case Study in Nuclear Security Culture Differences[12]

As noted, no systemic analysis of the impact of national culture on nuclear security culture across multiple nations has been conducted. There is a limited volume of studies about country-specific nuclear security culture, but these studies are mostly descriptive, lack methodological rigor, and do not tie national culture in general to national nuclear security culture.

However, there is an ongoing effort to evaluate the impact of national culture on the nuclear safety culture. The Country Specific Safety Culture Forum (CSSCF) was conducted jointly by the Nuclear Energy Agency (NEA) under the Organization of Economic Cooperation and Development (OECD) and World Association of Nuclear Operators (WANO) to provide host countries and their principal nuclear institutions and organizations with an opportunity to reflect on national cultural characteristics, and engage in exercises to assess the influence those characteristics could have on the overarching nuclear safety culture.[13] Since 2018, CSSCF has conducted evaluations of nuclear safety culture dependence on national culture in several countries.[14]

The general structure of the CSSCF methodology consists of five steps, as displayed in fig. 2.[15] The first step is designed to collect insightful information about the underlying characteristics of the national culture, and how national culture attributes interact to frame and influence safety culture. This information is collected through interviews and focus groups with personnel of licensees and the regulator. The data gathered is then analyzed to propose initial findings regarding identified national culture characteristics relevant to nuclear safety culture. As part of step 2, the study results are used to inform the scenario script and to direct the development of the event's content and the discussion questions to be used at the forum in step 3. The observations gathered at the forum constitute the second round of data-gathering and analysis validation, performed in step 4, which leads to the development of the CSSCF report, as the fifth and final step of the CSSCF structured framework.

Evaluation of each country starts from scratch, and national culture is evaluated independently (i.e., no structural basis like Hofstede's national culture dimensions is used). CSSCF reports note that there is no good or bad culture. These evaluations are not intended to compare countries. Rather, they are intended to encourage self-reflection, and the process of analysis is to understand the impact of national culture on nuclear safety culture.

While CSSCF focuses on safety culture, many insights captured in country reports are relevant for nuclear security culture, as well. This paper uses CSSCF analysis for countries opposite on Hofstede's scales for power distance and uncertainty avoidance to provide examples of the dependence of nuclear security culture on national culture. Results of this analysis are captured in tables 5 and 6, in the form of strengths and weaknesses for nuclear security culture resulting from national culture specifics and resulting behaviors of nuclear sites and regulatory authorities personnel.

Regardless of differences in practices driven by national culture differences, countries analyzed demonstrate good nuclear security performance, as evidenced by the NTI Nuclear Security Index. This serves as another confirmation that there is no good or bad national culture, and every culture has strengths that can be leveraged for nuclear security.

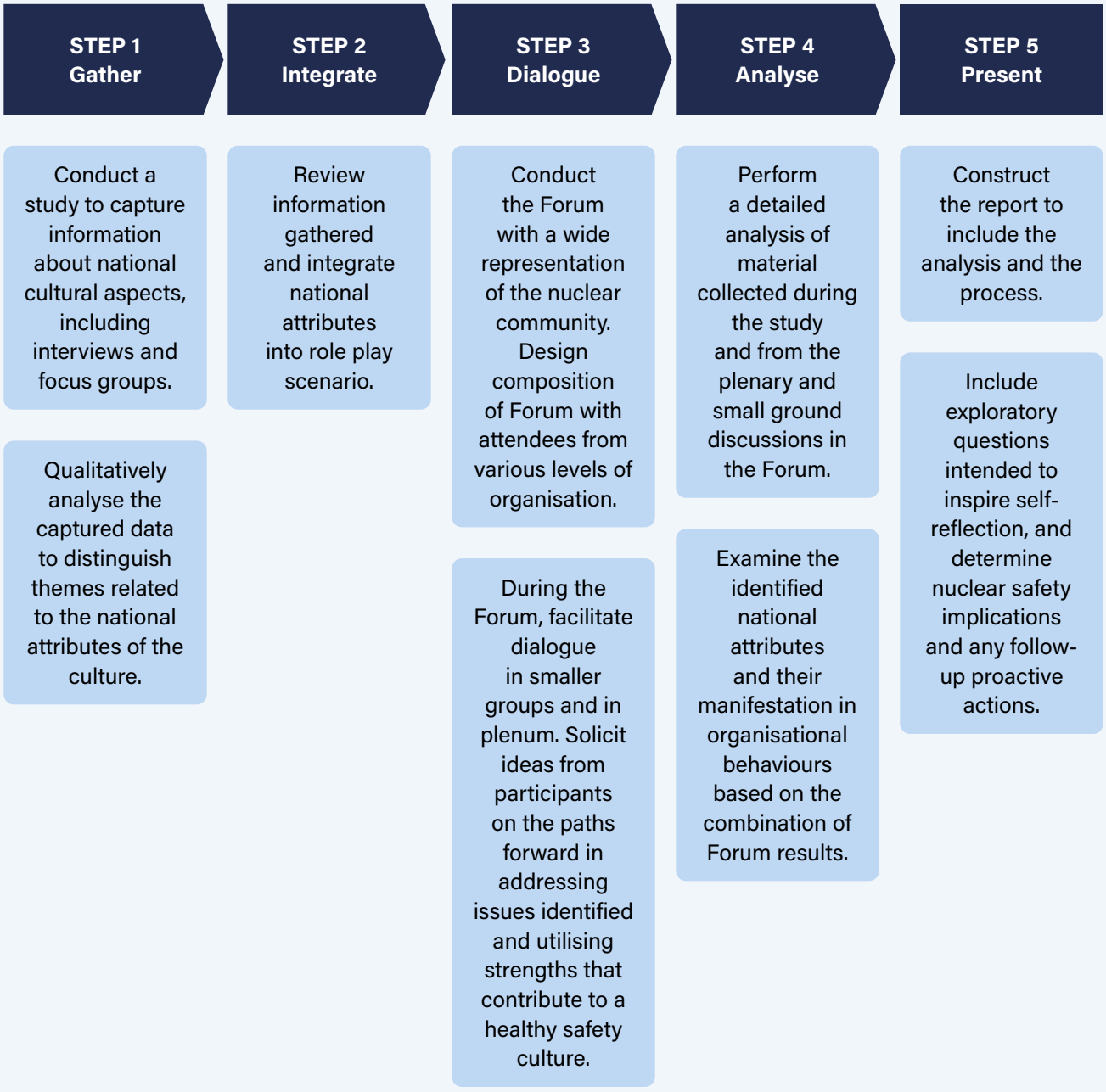
[12] This section is based on real analysis of specific countries, but their names are omitted to minimize reader bias.

[13] OECD Nuclear Energy Agency, "Country-Specific Safety Culture Forum (CSSCF)," accessed September 25, 2025, www.oecd-nea.org/jcms/pl_29571/country-specific-safety-culture-forum-csscf.

[14] Country reports are published at CSSCF website. OECD Nuclear Energy Agency, accessed February 16, 2026, www.oecd-nea.org/jcms/j_231/portail-application?histstate=4&text=&opSearch=true&jsp=plugins%2FMainPlugin%2Fjsp%2Fsearch%2FcustomQuery.jsp&types=generated.NEAPublication&contentId=pl_29571.

[15] OECD Nuclear Energy Agency, *Country-Specific Safety Culture Forum: Japan*, NEA No. 7680 (Paris: OECD, 2024), 31–32, www.oecd-nea.org/jcms/pl_94644/country-specific-safety-culture-forum-japan.

Figure 2. Five Steps for Analyzing the Effects of National Culture on Nuclear Safety



Source: OECD, 2024, Country-Specific Safety Culture Forum: Japan. https://www.oecd-nea.org/jcms/pl_94644/country-specific-safety-culture-forum-japan.

Table 5. Impact of Power Distance on Nuclear Security

Pole	Pros for Nuclear Security Culture	Cons for Nuclear Security Culture
High PDI	◆ There is a lot of discussion before a decision is taken, but as soon as it is made, companies demand everyone's acceptance. The decision-making process is based on all those consulted being given the opportunity to give their opinion frankly, which can lead to fundamental changes to initial suggestions. Some people may disagree with the final decision, but they must support it and work as hard as anyone else to implement it.	◆ Decisions in pyramid-shaped organizations are made by senior people. This leads to a lack of horizontal cooperation. The principle of subsidiarity—when decision-making authority is best placed where responsibility for outcomes will occur and in the closest appropriate proximity to where actions will be taken—does not fit well pyramid-shaped organizations. There are many cases that must be brought up to the director's office, which is difficult to do. ◆ Licensees view the regulator's attitude as requiring their obedience to superiors, to the extent that licensees see themselves as subordinate to the regulator. The licensees interviewed expressed a strong feeling of perceived unfairness, as they have had difficulties in engaging effectively with the regulator.
Low PDI	◆ Decision-making is characterized by involvement of everyone and striving for consensus. It is viewed as necessary that a person who is to take part in implementing an action must understand the decision for the action and its basis. ◆ While whistleblowing is unusual, talking to the authority informally to voice one's views on a particular issue is more common. ◆ Open dialogue between license-holders and the nuclear regulator follows the model of nuclear regulation through self-supervision.	◆ It is an imperative for employees to feel that they are involved in the process and given an opportunity to voice their opinion. It can otherwise result in the decision not being adhered to, or sub-optimization occurring, and the person in question doing as they feel would be best. It can also result in deviations as a result of an actor not knowing the broader context or perspective. ◆ It is generally easier to provide upward feedback in an organization than downward. Most managers said that it can become problematic to provide feedback to employees. A form of hypersensitivity has developed, in which accepting criticism can be challenging. This could explain why following up with subordinates and providing feedback typically goes against the grain.

Table 6. Impact of Uncertainty Avoidance on Nuclear Security

Pole	Pros for Nuclear Security Culture	Cons for Nuclear Security Culture
High UAI	◆ The high level of compliance with regulations and procedures is facilitated—and even advanced—by the national cultural trait of diligence; people, especially in the nuclear field, have a strong tendency to follow procedure or not take shortcuts.	◆ Questioning the safety policies, procedures, and behavior, and avoiding complacency (i.e., demonstrating a questioning attitude) could be impeded by the tendencies to be conservative, to not speak up, and to work as part of a group collective. Desire for conformity and cohesiveness in a group leads all members to minimize conflict and critical evaluation of ideas, and to discourage diversity of thought and curiosity.
Low UAI	◆ Staff expect to be provided with frameworks for work rather than to be micromanaged, as it gives the necessary freedom to solve tasks by oneself based on skill. If one does not understand why a job must be done in a certain way, according to decisions or rules, there is a tendency for people to do as they think is best. ◆ Managers have an important role to play in explaining the rules so as to bring about shared understanding. The term "pedagogical approach" was used to describe this cultural expression. In this manner, respect for, and adherence to, procedures was said to be strong in operations, enhancing safety and security. ◆ Several focus groups said that they acknowledged responsibilities for safety at the employee level, and all focus groups agreed that there was no lack of emphasis on safety in terms of the responsibility of the plant manager.	◆ The cultural trait of not questioning individual judgment can go so far as employees making an assumption that coworkers who work without protective equipment (i.e., violating safety procedures) must have a good reason for not following instructions. ◆ If one does not understand why a job must be done in a certain way, according to decisions or rules, there is a tendency for people to do as they think is best. The logic is that understanding drives action. As a result, there may be a higher risk that things do not turn out as intended because of divergent understandings. People often feel they have a preferential right of interpretation of the decision. ◆ It is common for formal job descriptions to be missing or generally unclear. Employees can take on more responsibilities than had been formally agreed. This particularly applied to questions of who is responsible for safety, which could lead to confusion and decreased effectiveness.[16]

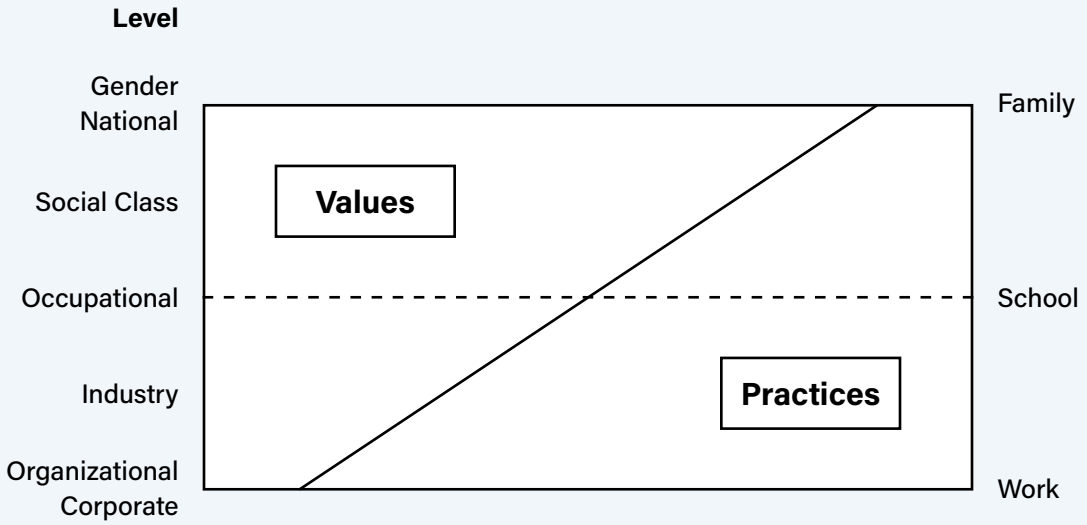
[16] Hofstede highlights the paradox that although rules in countries with weak uncertainty avoidance are less sacred, they are often better followed. People think that rules should be established only in case of absolute necessity (with nuclear safety or security highly likely being such a case). On the other hand, the emotional need for laws and regulations in a strong uncertainty-avoidance society can lead to rules or rule-oriented behaviors that are purely ritual, inconsistent, or even dysfunctional.

Impact of Individual Personnel Characteristics, and Occupational and Industry Culture

National culture provides the strongest impact on organizational culture. However, other layers of culture also have a noticeable impact. These layers include industry and occupational culture. Nuclear industry—and more specifically, nuclear security professionals from different national cultures—may have common values, attitudes, and behaviors that are driven by their profession. Affiliation with a certain profession may mitigate, to some extent, otherwise-significant national culture differences.

According to Hofstede, national culture has the most substantial impact on values; absent migration, a person is typically immersed in their national culture since birth and throughout their lives. The impact of industry and occupational culture is limited to the years a person is active in a specific profession and the time they spend doing this job. Thus, the impact of industry and occupational culture on values is limited; instead, they affect job-related practices (see fig. 3).[17] Deeper layers have more impact on values that are hard to change, while higher layers affect practices that are easier to change, for example, through training.

Figure 3. Effect of Industry and Occupational Culture on Values vs. Practices



Source: Hofstede, et al, *Cultures and Organizations.*

[17] Hofstede, Hofstede, and Minkov, *Cultures and Organizations*, 347.

This phenomenon provides an opportunity to use targeted interventions to mitigate potential nuclear security weaknesses driven by the national culture. These targeted interventions can be initiated either by local managers of an international organization cognizant of the effect of national culture on nuclear security culture, or within the framework of international cooperation. Effective shared practices are the reason that multinational corporations can function at all.[18] Employing personnel from a variety of nationalities, leaders cannot assume common values. They coordinate and control their operations through worldwide practices that are inspired by their national origin, but that also can be learned by employees from a variety of other national origins. Likewise, nuclear security best practices—either from some advanced country or from the IAEA recommendations—can be learned by nuclear security practitioners.

However, deeply ingrained national culture values are still a strong factor imposing limits on potential adaptation and affecting its process. Intervention still requires understanding national culture to develop compatible practice adaptations and introduce them in a way that would not result in culture-driven resistance from averse national personnel.

Another form of adaptation can include selecting and hiring personnel with behavioral characteristics that differ from "average" for a specific national culture, but contribute to a better nuclear security culture. Yet again, this requires understanding strengths and weaknesses driven by national culture to determine proper selection criteria.

Impact of National Culture Differences on International Cooperation

Interest in nuclear security culture first emerged as part of the nuclear security cooperation between the United States and Russia and other countries of the former Soviet Union, when leaders of the cooperation program realized that the provision of funding and equipment does not resolve all the challenges. Rather, performance of the nuclear security system depends on the "human factor," and more specifically on nuclear security culture as "the assembly of characteristics, attitudes and behavior of individuals, organizations and institutions which serves as a means to support and enhance nuclear security."

As a result of this realization, substantial effort was made within the framework of the U.S. cooperation with Russia to improve nuclear security culture between the late 1990s and 2014. Cooperation, however, focused on attributes and behavior, rather than values and overlooked national culture characteristics that define values and provide a foundation for specific behaviors. This essentially means that no baseline was determined to serve as a basis for future nuclear security culture improvements. Thus, cooperation in the nuclear security culture had limited success.

Looking at all international development assistance in general, Hofstede notes that "the effectiveness of much of the spending has been dismal. […] Nobody can develop a country but its own population. Development is in the minds, not in the goods. Foreign money and foreign expertise are effective only to the extent that they can be integrated into local knowledge. Success stories in the development literature always stress the emancipation of the locals from foreign expertise."[19]

International cooperation programs are typically planned by donor country personnel, who usually reflect the donor country's national culture characteristics—and often with additional political and institutional constraints, as well. Such planning fails to recognize the national culture specifics of the recipient country and the associated institutional structure, and personnel attitudes and behaviors. When international programs are planned and implemented by international institutions, such as the IAEA or World Bank, donor national culture issues are mitigated, while not eliminated; however, the recipient country's national culture specifics are still not always taken into account.

[18] Hofstede et al, *Cultures and Organizations*, 348.

[19] Hofstede et al, *Cultures and Organizations*, 417.

Conclusion

This paper reviews the dependence of nuclear security culture in any particular country, in light of a country's national cultural characteristics. The analysis reviews nuclear security culture characteristics and associated indicators introduced in the IAEA Model of Nuclear Security Culture through the prism of Hofstede's six national culture dimensions, an authoritative framework used as the foundation for multiple cross-cultural studies in management, organizational behavior, and social psychology. A case study of the national differences in nuclear security cultures, which is far from comprehensive, but rather used for demonstration purposes, is based on materials from the Country Specific Safety Culture Forum, an ongoing effort implemented by the NEA and WANO, and supplemented by the author's own experience participating in international nuclear security cooperation.

The following are conclusions and recommendations from the analysis:

- Nuclear security culture has long been acknowledged as an important element in ensuring the security of nuclear materials and facilities from theft, attack, and sabotage. The concept and guidelines for implementation and evaluation are captured in IAEA documents and national regulations. Improvements in nuclear security culture are a focus of multiple international cooperation efforts.
- While IAEA publications note the impact of national cultural specifics on nuclear security culture, little attention has been paid to systemic analysis of this impact on nuclear security and the use of any such analytical results to improve nuclear security. There are several examples of country-specific studies of nuclear security culture, but there is no analysis of the mechanisms by which the cultural specifics of analyzed countries affect nuclear security.
- Available research provides multiple evidence that differences in national cultures result in differences in human behavior and organizational cultures, including in safety and security-critical applications.
- National culture affects nuclear security culture and, hence, the security of nuclear materials and sites. Countries with different national cultures can demonstrate opposite behaviors in many nuclear security practices. For example, personnel in some countries have problems following detailed procedures and prefer flexibility in achieving the nuclear security goals. For personnel in other countries, a "performance-based" approach that does not provide a detailed step-by-step procedure to achieve the nuclear security goal is a source of anxiety. However, there is no good or bad culture. Every national culture has elements that constitute strengths or weaknesses from the standpoint of nuclear security.
- Evaluation of the national culture impact on nuclear security culture must be conducted to plan nuclear security operations in a way that leverages strengths and mitigates weaknesses. Evaluation of multiple countries can be used to facilitate best-practice exchange in managing the impact of national culture; however, such an evaluation must avoid comparisons between countries and cultures. Instead, it should encourage in-country analysis and self-reflection. The model of the Country Specific Safety Culture Forum, established jointly by NEA and WANO, can be used as a basis for evaluations.
- The IAEA Model of Nuclear Security Culture provides a convenient starting point for evaluation. Countries conducting evaluations can review the implementation of nuclear security culture characteristics and the availability of associated indicators established by the model in the context of their national culture.
- The nuclear industry—and more specifically nuclear security professionals from different national cultures—have some common values, attitudes, and behaviors that are driven by their profession. Affiliation with a certain profession mitigates otherwise significant national culture differences. However, deeply ingrained national culture values are still a strong factor imposing limits on the adoption of imported practices.
- Planning and implementation of international cooperation in nuclear security must account for cultural differences between cooperating

countries and institutions. This issue is particularly important when there is an obvious "donor" and "recipient" in cooperation, as such a situation assumes intrinsic inequality and creates temptation for the donor to impose its vision. Best practices transferred from one country to another, or IAEA recommendations adopted by the country, must be adapted to reflect local cultural specifics. Introduction of new practices that are not supported by local cultural traits must include a process to manage change that reflects national culture specifics, aimed at avoiding sabotage or open resistance to change.

- Organizations with responsibility for nuclear security—including operators, regulators, and industry associations—need behavioral experts or teams to identify behaviors that are helpful or harmful for nuclear security, and leverage or mitigate them.

BIOGRAPHY

Dmitry Kovchegin is a researcher and consultant working with the U.S. government organizations, non-profits, and research institutions on a broad range of nuclear security and non-proliferation topics. He has over 20 years of experience supporting international cooperation in improving nuclear security in multiple countries.

Reducing the Coercive Salience of Military Threats Against Civilian Nuclear Infrastructure

Darya Dolzikova

The risks of using military force against nuclear facilities have received considerable attention in recent months and years, prompted by the Russian occupation of Ukraine's nuclear facilities following Moscow's full-scale invasion of the country. The use of military force against, or in the vicinity of, nuclear installations is not a new phenomenon. Iraqi strikes on Iran's Bushehr Nuclear Power Plant—then under construction—during the Iran-Iraq War, and Israeli attacks on both Iraq's Osirak research reactor and Syria's al-Kibar site, are among some of the better known earlier cases of armed attacks on nuclear facilities.

Besides the potential material impact of such attacks, threats of military attack can also be used for their psychological impact, as part of efforts to change an adversary's behavior. This paper builds on limited existing literature on this subject to consider the psychological and coercive—not just material—effects of military threats to civilian nuclear installations. It proposes policy recommendations aimed at reducing the coercive salience of military threats to nuclear installations. The author argues that, while ensuring the physical resilience of nuclear installations remains key—especially in states that face a high risk of military aggression—efforts must also be committed to increasing whole-of-society resilience and response, both through the development of effective public communication strategies and through emergency-preparedness efforts.

Nuclear Installations as Targets for Coercive Threats

As of November 2024, 31 countries had committed to tripling global nuclear energy generation by the year 2050, as part of efforts to reduce global greenhouse

gas emissions.[1] The feasibility of achieving such an ambitious goal has been questioned[2]; nevertheless, the role of nuclear power in the global energy mix is expected to increase in the coming years, as more countries seek to move to lower CO_2-emitting energy sources. According to the World Nuclear Association, as of May 2025, 70 new nuclear power reactors were under construction globally, with more states at various stages of considering and planning for potential future nuclear-energy generation.[3] Several operational, new and planned reactors and other nuclear facilities are located in regions of geopolitical instability, potentially placing them at risk from future military activity. Nuclear installations may become targets or unintended victims of military force for a number of reasons, depending on the nature of the facility and the objectives of the military operation in question.[4]

Nuclear installations may become targets of military attack for counter-proliferation purposes, to disrupt or co-opt energy production, to release radioactive material for area-denial purposes, or because a facility lies on an axis of military advance.[5] The material effects of a strike on a given nuclear installation will vary depending on the particular facility, the extent of passive and active defenses—and other resilience factors—afforded to a given site, the effectiveness of emergency response efforts, and the nature of the attack. In practice, radioactive release on the scale of the 1986 Chernobyl accident—often the reference point for worst-case scenario nuclear accidents—is unlikely in most instances, even if such severe outcomes cannot be ruled out.[6]

Short of the direct use of military force, however, states may also issue threats against nuclear facilities as a way of escalating tensions and inciting panic, to divert attention and resources from other national defense efforts, to deter an adversary and any allies from pursuing a certain course of action, or to compel a targeted state toward desired behavior. The unique nature of chemical, biological, radiological, and nuclear (CBRN) threats—namely, their unpredictability and manufactured nature (as opposed to "acts of God"), their propensity to cause "severe and unusual conditions", and their impact on children and future generations—make them particularly effective at terrorizing populations.[7] Such fears can, in themselves, produce significant effects, irrespective of the actual material consequences of an attack. Adversaries can leverage these psychological effects as a means of coercion.

Issuing threats against civilian nuclear infrastructure for coercive purposes has historical precedent. Low-altitude flights by Yugoslav aircraft over Slovenia's Krško nuclear power plant during Yugoslavia's 1991 invasion have, in later accounts, been interpreted as an intentional threat to the facility—perhaps as a way of inducing concessions or even surrender from Ljubljana.[8] During an escalation of tensions between Armenia and Azerbaijan in 2020, Baku threatened to carry out high-precision strikes

1 "Six More Countries Endorse the Declaration of Triple Nuclear Energy by 2050 at COP29," World Nuclear Association, 13, world-nuclear.org/news-and-media/press-statements/six-more-countries-endorse-the-declaration-to-triple-nuclear-energy-by-2050-at-cop29#:~:text=The%20historic%20Declaration%20to%20Triple%20Nuclear%20Energy,COP28%20UN%20Climate%20Change%20Conference%20in%20Dubai.&text=Net%20Zero%20Nuclear%20aims%20to%20recognize%20and,nuclear%20industry%2C%20scientists%2C%20civil%20society%2C%20and%20activists.

2 Arnaud Leroi et al., "What Will It Take to Triple Nuclear Energy by 2050?" Bain and Company, April 2004, www.bain.com/insights/what-will-it-take-to-triple-nuclear-energy-by-2050/#:~:text=Unprecedented%20investment%20levels%2C%20for%20starters,and%2C%20of%20course%2C%20safety.

3 World Nuclear Association, "Plans for New Reactors Worldwide," , updated June 19, 2025, https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.

4 Darya Dolzikova, "Nuclear Facilities as Targets of Military Attack," *Occasional Paper*, Royal United Services Institute, April 25, 2025.

5 Darya Dolzikova, "Nuclear Facilities as Targets of Military Attack," *Occasional Paper*, Royal United Services Institute, April 25, 2025.

6 For a more detailed discussion of possible drivers and effects of attacks on nuclear facilities—including material and psychological—see, for example: Dolzikova, "Nuclear Facilities as Targets," 14–25.

7 Kenneth C. Hyams, Frances M. Murphy and Simon Wessely, "Responding to Chemical, Biological, or Nuclear Terrorism: The Indirect and Long-Term Health Effects May Present the Greatest Challenge," Journal of Health Politics, Policy and Law (Vol. 27, No. 2, 2002), 276.

8 Andrej Stritar et al., "Some Aspects of Nuclear Power Plant Safety Under War Conditions," Nuclear Technology (Vol. 101, February 1993), 194.

against Armenia's Metsamor nuclear power plant—apparently in an effort to deter further Armenian escalation.[9] More recently, Russian behavior at Ukraine's Zaporizhzhia Nuclear Power Plant has been characterized—including by this author—as nuclear blackmail. Threats to the safety of the facility may be used by Russian forces to deter any future Ukrainian effort to militarily retake the facility, to prevent further support to Ukraine by its partners, to divert Ukrainian resources and international attention away from operations elsewhere on the front lines, or to generate leverage in diplomatic negotiations.[10] Attacks and threats of attack on South Korean and Taiwanese nuclear facilities have also been considered as possible pathways for escalation or as a diversionary tactic in potential future military conflicts in the region.[11] As with other instances of coercive behavior in international relations, the precise intent of an apparently coercive action—as well as its effectiveness in changing the behavior of the targeted actor—can be notoriously difficult to isolate and assess.

The intended audience for threats against nuclear installations may be either the political leadership or the civilian population. By convincing a target state's general public or elite stakeholders that nuclear facilities face credible threats of attack should their government take action contrary to the targeting state's demands—for instance, refusing to cede contested territory or to capitulate in an armed conflict—the coercing state may be able to generate sufficient internal political pressure to achieve its objectives.

Threats against nuclear infrastructure may also be intended to generate a change of behavior in a third party. This may be done to discourage granting military assistance to a country whose nuclear infrastructure may be threatened as retribution for such support.

Conversely, threats to attack nuclear infrastructure could also be used in a kind of ally-entrapment strategy, whereby the state issuing the threats against an adversary's nuclear facilities—or warning of risks to their own installations—may do so in an effort to compel an ally to engage more actively in a conflict, armed or otherwise, to prevent such an eventuality.

This may be done by highlighting the risks of the spread of radioactive material in case of an attack, including to the territory of the third party. The risk of further escalation in the conflict following any such strike—potentially to levels that would directly threaten the security interests of the third party—could also be stressed. In some instances, such warnings may be perfectly appropriate; in other cases, they may be purposefully exaggerated to elicit a response from third parties.

As such, in many ways, attacks or threats of attack on civilian nuclear installations may be leveraged for coercive ends in a similar way that a state may threaten the use of nuclear weapons. While the material effects, as well as both the strategic and operational implications of attacks on nuclear facilities, differ considerably from the use of even low-yield nuclear weapons, the unique physical and psychological effects of radioactive release mean that attacks—or threats of attack—on nuclear installations may also be used as a kind of "half-step" between conventional weapons and escalation to nuclear-weapons use. In the absence of a nuclear-weapons capability, non-nuclear weapons states may see an opportunity for escalation or deterrence signaling by threatening to target an adversary's nuclear facilities. Alternatively, a state that possesses nuclear weapons could attack, or threaten to attack, a nuclear installation as a less escalatory alternative to a limited nuclear strike or a step up the escalation ladder short of nuclear weapons use.[12]

[9] Brendan Cole, "Azerbaijan Threatens Missile Strike on Armenian Nuclear Power Plant," *Newsweek*, July 17, 2020, www.newsweek.com/kim-kardashain-west-armenia-azerbaijan-nuclear-1518583.

[10] Darya Dolzikova and Jack Watling, "Securing Zaporizhzhia with Diplomacy and Deterrence," *War on the Rocks*, June 16, 2023, warontherocks.com/2023/06/securing-zaporizhzhia-with-diplomacy-and-deterrence/.

[11] Larry Diamond and James O. Ellis, Jr, "Deterring a Chinese Military Attack on Taiwan," *Bulletin of the Atomic Scientists*, March 13, 2023; Sylwia M Gorska, "Nuclear Safety and Energy Security in Taiwan: A Divided Society," *Global Taiwan Brief* (Vol. 9, No. 17, 2024); Ian Easton, "Ian Easton on Taiwan: Are Taiwan's Nuclear Plants Safe from Beijing?" *Taipei Times*, April 12, 2021; Henry Sokolski, "Assured Distraction: How Attacks on South Korea's Nuclear Reactors Could be a Smoke Screen for Wider Conflict," *Bulletin of the Atomic Scientists*, March 5, 2025.

[12] Chester L Cooper, "Nuclear Hostages," Foreign Policy (No. 32, Autumn 1978), 131; Bennett Ramberg, *Nuclear Power Plants as Weapons for the Enemy: An Unrecognised Military Peril* (Berkeley, CA: University of California Press, 1984), 73; Dolzikova, "Nuclear Facilities as Targets," 38.

This raises the question of whether and how to factor in threats to nuclear facilities on the spectrum of conventional and nuclear escalation dynamics and deterrence calculations. For instance, how do attacks on nuclear infrastructure fit into the stability-instability paradox?[13]

Threatening strikes against nuclear infrastructure creates a number of risks. First, and most obviously, effective coercion—by definition—limits the coerced state's freedom of action. This may result in a state's political leadership feeling it has little choice but to take decisions that undermine its security and that of its population in other ways; the same goes for coerced third parties and allies, as discussed above.

Second, threats of attack against nuclear installations—even if only bluffs—could result in unintended nuclear-safety incidents as a result of miscalculation. For instance, a state trying to demonstrate its ability and willingness to threaten the safety of a nuclear site may undertake actions it believes relatively unlikely to cause a nuclear-safety incident, but which could be used to bolster the credibility of threats to the facility. One example might be launching unmanned aerial vehicles at reactor buildings or damaging redundant auxiliary systems. However, such actions run a very high risk of miscalculation and could trigger a serious nuclear-safety incident.

Furthermore, the incitement of public worry can also have material effects independent of any political pressure or decision-making processes. As an example, mass evacuations away from facilities of concern—either internally or to neighboring states—will create pressure on civil services, emergency response and potentially the armed forces, as efforts are put in place to manage the flow of people. Concerns about the availability of food, water and other basics may lead to shortages.[14] Such panic may occur in the absence of any attack or nuclear-safety incident having occurred, if the public is convinced of the credibility of the risk.

Should an attack or incident indeed take place—or if misinformation or disinformation spreads that an incident has occurred—the "worried well" may overwhelm medical services. Misinformation, disinformation or an overabundance of caution also could lead people to self-medicate, for instance, by unnecessarily consuming sodium iodide, or to take other unnecessary measures like early evacuations. Such responses could result in avoidable adverse consequences, such as a loss of access to regular medical care.[15]

Any combination of these potential reactions to threats against nuclear facilities could stretch social, political, economic, military, and other critical capacities and resources to an extent that undermines a state's ability to defend against and mitigate other—potentially more credible, acute or impactful—threats to national security, and could be further exploited by an adversary to achieve its broader objectives.

Reducing the Coercive Salience of Threats Against Nuclear Infrastructure

For these reasons, measures to decrease the risks posed to nuclear installations by threats of military attack must be focused not only on the physical protection and resilience of the facilities against potential attacks, but also on reducing the incentives and effectiveness of leveraging the particular psychological aspects of nuclear facilities as a target set for coercive aims.

These are, of course, not mutually exclusive lines of effort. Making nuclear installations harder targets for military attack will help reduce the credibility of threats by increasing the costs, and reducing the likelihood, of an attack that would result in serious health and environmental consequences. Nuclear installations and auxiliary infrastructure (like power lines, electrical substations and water supply) can be hardened through passive or active defenses, or both. This may include the construction of containment structures around facilities that do not yet benefit from them, erecting berms or other protective mechanisms around sites, burying sites underground, or ensuring that sites benefit from effective air defense or other active defenses.

[13] Mariana Budjeryn, remarks at Carnegie Nuclear Policy Conference, Washington, April 21, 2025.

[14] Dolzikova, "Nuclear Facilities as Targets," 19–21.

[15] Dolzikova, "Nuclear Facilities as Targets," 19–21.

By increasing the scale of the operation that would be necessary to seriously damage a hardened nuclear installation, one also raises the escalatory risks of pursuing such a course of action, making it less credible in instances where such an escalation would outpace the existing scale of the conflict. However, approaches that hinge on active or passive defenses can be costly and otherwise impractical. They may also, in some instances, exacerbate threats to facilities—for instance, if an installation comes to be seen as a legitimate military target due to presence of military equipment at the site. Or, such defenses might increase the likelihood of low-level attacks that may be perceived as less likely to inflict serious harm to a facility, but may nevertheless lead to a miscalculation of risks. As such, any measures to physically harden nuclear installations need to be informed by risk assessments that consider the particular circumstances, vulnerabilities and threats that may face a given nuclear facility, as well as any relevant trade-offs.[16]

In addition to improving the physical resilience of nuclear installations themselves, decreasing the coercive salience of attacks and threats of attack on nuclear infrastructure will require increasing societal resilience to such threats and to potential nuclear safety incidents. This must be predicated on a combination of effective emergency response by public authorities (including medical services), public education and individual preparedness, as well as effective risk communication—both pre-emptively and during a crisis.[17] For the purposes of decreasing the coercive salience of threats against nuclear installations in particular, efforts must be dedicated to educating the general public on the nature of potential threats from nuclear safety incidents and what they can do to take care of themselves in the first instance.

Such education can help reduce the psychological salience of threats to nuclear installations by mitigating somewhat—though not entirely eliminating, understandably and rightly—the anxiety stemming from the perceived unknown and unpredictable nature of CBRN threats, as well as from an assumed lack of control in the face of such threats.[18] It can also help counter disinformation or misinformation that may be leveraged by malign actors to stoke public fears in order to make their threats more salient.

Pre-emptive efforts to this end may include information campaigns on likely risk exposure in the case of various kinds of nuclear safety incidents and basic measures members of the public can take to protect themselves—things like getting and staying indoors and closing windows or other sources of ventilation. Stressing that such measures should, in most cases, be sufficient for preventing exposure to harmful radioactive materials can help limit panic and unnecessary or even harmful countermeasures, like self-evacuation or self-medication. Exercises involving emergency responders, politicians and other government decision-makers, as well as other relevant stakeholders across society, can also help build resilience and could be conducted in coordination across multiple countries.

At the same time, encouraging households and businesses to think through emergency preparedness measures—like maintaining several days of drinking water and non-perishable food, comprehensive first aid kits and emergency light and energy sources—can help with both actual and perceived preparedness. Most governments, including in the United States and United Kingdom, already make much of this information readily available on relevant government webpages.[19]

[16] For a more detailed discussion of passive and active defense of nuclear installations, see: Dolzikova, "Nuclear Facilities as Targets," 47–51.

[17] For more research and recommendations on emergency response and crisis communication related to CBRN threats specifically, see, for example: Hyams et al, "Responding to Chemical, Biological, or Nuclear Terrorism," 273–92; Moran Bodas et al., "The Effect of Risk Communication on Public Behavior to Non-Conventional Terrorism—Randomized Control Trial," *International Journal of Environmental Research and Public Health* (Vol. 19, No. 1, 2022); Kristian Krieger, Richard Amlôt and M. Brooke Rogers, "Understanding Public Responses to Chemical, Biological, Radiological and Nuclear Incidents—Driving Factors, Emerging Themes and Research Gaps," *Environment International* (Vol. 72, November 2014), 66–74.

[18] Krieger et al, "Understanding Public Responses," 66–74.

[19] "What to do in a radiation emergency," U.K. Health Security Agency, www.gov.uk/government/publications/radiation-emergencies-information-for-the-public/what-to-do-in-a-radiation-emergency, accessed September 11, 2025; "Be Ready for Radiation Emergencies," U.S. Centers for Disease Control and Prevention, August 18, 2025, accessed 11 September 2025, www.cdc.gov/radiation-emergencies/features/be-ready.html.

However, it may be worth considering whether more widespread dissemination and efforts to bolster preparedness may be appropriate, especially in countries that host a large number of nuclear facilities or face credible threats from an adversary.

Communication strategies will need to be informed by relevant state- and community-level risk assessments, so as not to have the opposite of the intended effect and needlessly stoke fears among the public. However, waiting until a nuclear safety risk—or the weaponisation of such risks by malign actors for coercive purposes—is imminent may be too late. As others have noted elsewhere, trust and a perception of credibility in public authorities is paramount in effective crisis communication;[20] this takes time to establish. Making clear to the population that its government is conscious of and prepared to deal with nuclear safety risks well in advance of any incident, or threat thereof, can help to bolster that trust and credibility.

Furthermore, normalizing the need and ability of the general public to be aware of and put in place basic preparatory measures to deal with a nuclear safety incident may also help to somewhat reduce alarm and material shortages at the time of an incident or threat. A baseline understanding among the public of the best ways of managing risk exposure in case of an incident, or in response to threats of one, can also help take some of the burden off medical services and emergency responders by reducing the risks that these will be overrun by the so-called "worried well."[21] Of course, a certain degree of anxiety and even panic in response to threats or expectations of a nuclear incident will be unavoidable. As such, governments will need to be prepared to deal with the consequences of widespread public worry regardless of the pre-emptive education and societal resilience measures put in place.

The experiences of Ukraine and the Nordic states may be instructive here. Since the start of the full-scale Russian invasion, Ukrainian authorities and society have unfortunately had direct experience with ensuring self-sufficiency of communities and businesses in the face of frequent and sustained power outages. Information on how to protect oneself and access services during air raids, or how to minimise disruption to the work of emergency response workers, is disseminated widely and made accessible to the general public. Groundwork for such responses and communication efforts should be laid well before they are actually needed. Finland's *72 tuntia* (72 hours) campaign encourages homes to be self-sufficient for 72 hours and offers guidance to this end.[22] The country has also hosted annual national preparedness exercises (TIETO) since the 1970s, bringing together various organisations across society, government and private sector to practice responses to large-scale disruptions to society.[23]

Conclusion

A growing body of academic and policy literature has emerged over the recent years on the military threat to civilian nuclear installations, spurred in large part by Russia's invasion of Ukraine. Most of the work has rightly focused on approaches to strengthening norms and international regulations restricting the use of military force against civilian nuclear infrastructure, to improving the physical protections and defense of nuclear installations, and to adapting national risk assessment and regulatory approaches for managing threats to nuclear safety and security. Much less attention has been paid to the psychological and coercive effects of attacks and threats of attack against nuclear installations. This psychological aspect is part of what makes nuclear installations a distinct—albeit not entirely unique—target set.

As such, understanding the ways in which malign actors may leverage this particularity should be central to efforts aimed at decreasing the military risks to and from nuclear installations—both to limit the material consequences of such attacks and to reduce the coercive salience of related threats. This will require engagement from a range of national

[20] M. Brooke Rogers et al., "Mediating the Social and Psychological Impacts of Terrorist Attacks: The Role of Risk Perception and Risk Communication," International Review of Psychiatry (Vol. 19, No. 3, 2007), 279–88; Bodas et al., "The Effect of Risk Communication," Krieger et al, "Understanding Public Responses," 66–74.

[21] Fred P. Stone, "'The "Worried Well' Response to CBRN Events: Analysis and Solutions," *Counterproliferation Papers Future Warfare Series*, No. 40, Defense Technical Information Center, June 2007.

[22] https://72tuntia.fi/en/.

[23] https://www.huoltovarmuuskeskus.fi/en/a/tieto24-exercise-develops-societys-preparedness-for-hybrid-threats.

authorities responsible for national defense and security and emergency response but also—just as critically—with and from the broader population.

Legitimate concerns exist regarding the potentially serious health and environmental hazards of military action against nuclear facilities. But countering misinformation and disinformation related to such threats to nuclear installations, as well as cultivating a sense of responsibility and ability to manage the most immediate risk exposure among the general public, may help reduce panic, limit the likelihood of harmful countermeasures and reduce some of the burden on emergency services. Existing academic research on CBRN emergency response and crisis communication, as well as ongoing efforts to bolster whole-of-society resilience to threats to national security—for instance, in Ukraine and in the Nordic countries—can help inform the further expansion of both education and emergency-preparedness efforts.

Such efforts of course will not be a panacea for preventing the exploitation of threats against nuclear facilities for coercive ends—far from it. However, when combined with measures for passive and active defense of nuclear installations, as well as efforts to strengthen existing restrictions on the use of force against and in the vicinity of nuclear installations, they can contribute to disincentivizing and deterring military attacks on civilian nuclear installations or the dangerous leveraging thereof.

BIOGRAPHY

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Prior to joining RUSI, Darya had served as the manager of government relations and policy development at Canada's national aerospace industry association. She also has experience working in the due diligence sector and on defence-related issues in Canada's Parliament.

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Small Modular Reactor Deployment in Sub-Saharan Africa: Balancing Benefits and Risks

Simon Adu

Sub-Saharan Africa's energy demand is rising rapidly due to population growth, urbanization, and industrialization.[1] The growing desire for clean and reliable energy has rekindled interest in nuclear energy. Dr. Lassina Zerbo, current Chairperson of the Rwanda Atomic Energy Board, emphasized this point in the 2025 Long Form Podcast, stating that Africa will never develop without nuclear power.[2] At least 16 African countries—Algeria, Angola, Burundi, the Democratic Republic of Congo, Egypt, Ethiopia, Ghana, Kenya, Morocco, Rwanda, Sudan, Tunisia, Tanzania, Uganda, Zambia, and Zimbabwe—have expressed their desire to add nuclear power to their energy mix.[3]

Small Modular Reactors (SMRs) are emerging as a promising energy solution due to claims of their lower capital costs, adaptability to weak power grids, and scalability compared to traditional nuclear reactors.

A number of Sub-Saharan African nations have begun exploring the possible development or acquisition of SMRs, though no deployments have occurred to date.[4] South Africa is perhaps the farthest

[1] Brickstone Editor. (2022, October 27). *The IEA's Africa Energy Outlook 2022*. Brickstone Africa. https://brickstone.africa/the-ieas-africa-energy-outlook-2022/.

[2] PHXE 60 sec AdamWebinarIntro Epic 169Video 040325.

[3] International Atomic Energy Agency. (2025). *More than 20 African countries exploring potential of nuclear energy – IAEA report*. be Intelli News. Retrieved December 2, 2025, from https://www.intellinews.com/more-than-20-african-countries-exploring-potential-of-nuclear-energy-iaea-report-396890/?utm_source=chatgpt.com.

[4] See, for example, Lassina Zerbo, "The Small Reactor Revolution Can Transform African Energy Systems," The Atlantic Council, Feb. 20, 2025, www.atlanticcouncil.org/content-series/global-energy-agenda/the-small-reactor-revolution-can-transform-african-energy-systems/.

along among these countries, with officials there saying they might take their Pebble Bed Modular Reactor out of mothball status as early as the first quarter of 2026.[5]

This paper assesses the benefits and risks of SMR deployment in Sub-Saharan Africa, exploring their impact on energy security, economic growth, and industrial development. It underscores the importance and benefits of robust security measures in the introduction of SMRs in Sub-Saharan Africa. The conclusion underscores the criticality of instituting national and regional nuclear-security regulations and enforcement to ensure the secure and sustainable implementation of SMRs in Sub-Saharan Africa.

Energy Demand in Sub-Saharan Africa

Energy infrastructure in Sub-Saharan Africa will have to expand dramatically to meet growing demand. Currently, 600 million people, or 43 percent of the population, do not have access to electricity, making it the region with the lowest electricity consumption per capita in the world. With population growth, urbanization, and industrialization rates on the rise, demand is expected to double by 2050. According to the International Energy Agency's (IEA) 2022 "Sustainable Africa Scenario," achieving universal electricity access in Sub-Saharan Africa by 2030 will require adding 90 million grid connections each year.

Sub-Saharan Africa's energy deficits pose significant obstacles to economic development, industrialization, and overall quality of life.[6] Today, Sub-Saharan Africa contributes less than 1 percent of the world's manufacturing output.[7] At the same time, many Sub-Saharan African countries are home to energy-intensive industries such as uranium mining, gold extraction, oil and gas operations, large-scale agriculture, and chemical processing. These sectors consume a substantial portion of the national electricity generated, resulting in load shedding in urban centers and limited access to electricity in rural communities. Increasing electricity generation is therefore essential not only to growing major industrial sectors, but also to stimulating economic diversification by making energy more affordable for small and medium-sized businesses reducing the overall cost of goods and services, and making the region more competitive in the global market.

Energy security also impacts social services such as schools, health, and transportation. Unstable electricity supply, particularly in rural areas, has critical consequences on overall quality of life. For example, it is estimated that approximately 70 percent of hospital equipment is either non-functional or unavailable due to poor electricity quality or frequent power outages.[8]

By stimulating both macro and micro-economic development and increasing access to critical services such as education and healthcare, securing an abundant energy supply can create a foundation for long-term growth and stability across the region. Sub-Saharan nations' willingness to embrace the United Nations (UN) Sustainable Development Goal no. 9 to "ensure that by 2030 all people enjoy peace and prosperity"[9] to "build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" cannot be achieved without a reliable and clean source of energy.

Integrating SMRs into hybrid energy systems could help meet the high energy demands of these industries, enhance overall grid stability, and ensure more equitable energy distribution across regions.

[5] See, for example, Wendell Roelf, "South Africa Aims to Revive its Small Nuclear Reactor Technology," *Reuters*, Oct. 22, 2025, www.reuters.com/sustainability/boards-policy-regulation/south-africa-aims-revive-its-small-nuclear-reactor-technology-2025-10-22/.

[6] International Energy Agency, *Africa Energy Outlook 2022*, www.iea.org/reports/africa-energy-outlook-2022/key-findings.

[7] Müller, Patrick. "Impacts of Inward FDIs and ICT Penetration on the Industrialisation of Sub-Saharan African Countries." *Structural Change and Economic Dynamics* 56 (2021).

[8] Byaro, M., and Mmbaga, N.F. "What's New in the Drivers of Electricity Access in Sub-Saharan Africa?" *Scientific African* 18 (2022): e01414. doi.org/10.1016/j.sciaf. 2022.e01414.

[9] United Nations Development Program, "What Are the Sustainable Development Goals?" www.undp.org/sustainable-development-goals#:~:text=The%20Sustainable%20Development%20Goals%20(SDGs)%2C%20also%20known%20as%20the,people%20enjoy%20peace%20and%20prosperity.

What Is an SMR, and What Are the Benefits and Risks?

SMRs are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit, and modular, streamlined designs that enable scalable factory production to cut down on construction time and cost. They typically incorporate safety features such as passive cooling systems to mitigate risks in case of emergencies or malfunctions.

Some studies have raised concerns about increased neutron leakage in SMRs due to their smaller core sizes. When more neutrons escape from the reactor core, they can contaminate surrounding materials, making components like the reactor vessel or shielding more radioactive. These highly activated materials pose serious radiological risks to workers and emergency responders, especially during maintenance or in the event of sabotage. Additionally, increased neutron leakage can distort neutron flux profiles, making it difficult to accurately monitor the reactor's behavior. This complicates International Atomic Energy Agency (IAEA) safeguards efforts and may hinder the detection of undeclared nuclear material or diversion activities, particularly in countries with weaker regulatory frameworks.[10]

SMRs remain an emerging technology. To date, no SMRs are commercially operational, though dozens are in development and a few, including China's ACP100, Russia's RITM-200N, and GE Vernova Hitachi's BWRX-300, are under construction. Many SMR designs rely on established technology and low-enriched uranium fuel that large nuclear reactors have employed for decades. Others, however, use novel coolants such as gas or molten salt, and will be fueled with high-assay low enriched uranium, a fuel with an under-established supply chain.

Opportunity for Deploying SMR Technology in Sub-Saharan African Countries

SMRs present a transformative opportunity for Sub-Saharan countries to meet their growing energy demands through innovative and sustainable means. Their scalable and flexible nature makes them well-suited to address the region's unique energy challenges, particularly in remote or underserved areas.

Due to their compact size and modular design, SMRs require a lower initial capital investment and can be deployed more rapidly than conventional large-scale nuclear reactors. This shorter construction timeline and predictable cost due to factory fabrication reduce financial risks and ease the investment burden on governments and private stakeholders.[11, 12]

SMRs can be integrated into smaller grids, however, the IAEA recommends that SMR units to be introduced for electricity generation should be less than 10% of the country's total grid capacity to avoid overwhelming the country's existing electrical grid capacity to maintain stability and reliability.[13, 14] With electrical generation of 300 MWe or less, SMRs are more appropriate than large reactors for Sub-Saharan countries with smaller grids. Compared to traditional reactors, which are typically built on-site in complex construction projects, their modular design enables gradual additions to the grid as demand increases. This flexibility facilitates a phased approach to expanding capacity, mitigating potential risks to grid stability.

The modular and decentralized architecture is also well-suited to energy generation in remote or off-grid places, improving electricity access for rural

[10] Brown, N. R., Worrall, A., & Todosow, M. (2017). Impact of thermal spectrum small modular reactors on Performance of Once-Through Nuclear Fuel Cycles with Low-Enriched Uranium." *Annals of Nuclear Energy* 101 (2017): 166–173. doi.org/10.1016/j.anucene.2016.11.003.

[11] Yim, Man-Sung. "Position Paper on Global Nuclear Power Development and Nuclear Non-proliferation." 2021.

[12] Hussein, E.M.A. "Generation Modular Reactors: A Framework." *Nuclear Engineering and Design* 417 (2024): 112809. doi.org/10.1016/j.nucengdes.2023.112809.

[13] Gao, B., Kuznetsova, K., Ma, Z., & Miller, K. (2024, April 18). *Nuclear small modular reactors (SMRs): Key considerations for deployment* (Report). International Energy Forum & Johns Hopkins School of Advanced International Studies.

[14] International Atomic Energy Agency. (2012). *Electric grid reliability and interface with nuclear power plants* (IAEA Nuclear Energy Series No. NG-T-3.8). International Atomic Energy Agency. https://www.iaea.org/publications.

areas. Integrating SMRs into hybrid energy systems can help meet the high energy demands of mining and chemical processing industries, enhancing overall grid stability and ensuring equitable energy distribution across regions. Deploying SMRs in remote or offgrid locations raises potential nuclear security challenges such as longer response times for armed forces, over reliance on digital and remote monitoring systems (cyber security concern), and the need to maintain robust physical protection and safeguards across a dispersed fleet of sites if a country decides to deploy multiple SMRs.

Adoption of SMRs can also boost economic growth by driving infrastructure development, job creation, and technical innovation.[15] SMRs can attract foreign investment through international partnerships, bringing in capital and advanced nuclear science and technology expertise. This inflow not only strengthens the region's technical capacity, but also enhances energy reliability far into the future.

SMRs also offer advantages for Sub-Saharan Africa's geographic conditions. Several SMR designs (for example, molten salt reactors)[16] require less water compared to traditional water-cooled reactors, making them ideal for arid countries such as Namibia, Botswana, Angola, and part of Northern Kenya, as well as landlocked countries such as Burkina Faso, Mali, Niger, and Uganda. As a low-carbon option, SMRs can enable the region to fulfill rising energy demands sustainably while reducing vulnerabilities related to reliance on expensive fossil fuels, which are subject to price fluctuations and supply disruptions.[17, 18, 19]

Nuclear Security Risks of Deploying SMR Technology in Sub-Saharan Africa

The introduction of SMRs in Sub-Saharan Africa presents a promising opportunity to meet the region's energy needs. However, deployment would require addressing significant security challenges, including political instability, terrorism, weak cybersecurity, porous borders, and persistent regulatory gaps.

Political instability in the area presents serious hurdles to the deployment and operation of nuclear facilities. Countries with unstable political regimes often lack effective regulatory frameworks or suffer breakdowns in the oversight of nuclear installations. This can result in inadequate safety standards, weak regulatory supervision, and limited capacity to respond to or mitigate the risks associated with a successful attack on a nuclear facility. Political instability can also lead to delays in regulatory approvals, disruptions in construction timelines, and challenges in maintaining the skilled workforce needed for operation. Widespread corruption can also increase the likelihood of insider threats. Additionally, governments on weak footing may struggle to enforce strict nuclear safety and security measures, raising proliferation concerns.

Risks specific to Sub-Saharan Africa include the ongoing conflict in the Democratic Republic of Congo, as well as recent coups in Guinea, Burkina Faso, and Niger, which have led to weakened rule of law and disrupted enforcement of protective measures.[20, 21] Countries such as Burkina Faso,

[15] Cissokho, L., and Seck, A. "Electric Power Outages and the Productivity of Small and Medium Enterprises in Senegal." *Trust Africa* (2013). www.trustafrica.org/icbeDakar.

[16] International Atomic Energy Agency, "Molten Salt Reactors, www.iaea.org/topics/molten-salt-reactors.

[17] Cherp, A., and Jewell, J. "The Three Perspectives on Energy Security: Intellectual History, Disciplinary Roots and the Potential for Integration." *Current Opinion in Environmental Sustainability* 3, no. 4 (2011): 202–212. doi.org/10.1016/j.cosust.2011.07.001.

[18] Jewell, J. "Ready for Nuclear Energy? An Assessment of Capacities and Motivations for Launching New National Nuclear Power Programs." *Energy Policy* 39, no. 3 (2011): 1041–1055. doi.org/10.1016/j.enpol.2010.10.041.

[19] Sadekin, S., Zaman, S., Mahfuz, M., and Sarkar, R. "Nuclear Power as Foundation of a Clean Energy Future: A Review." *Energy Procedia* 160 (2019): 513–518. doi.org/10.1016/j.egypro.2019.02.200.

[20] Ali, Marium. "Mapping the Human Toll of the Conflict in DR Congo." *Aljazeera*, 2025

[21] Economic Cooperation & Development, 2009. Ogbe, Michael Abimbola, Malanta Sabiu Abdullahi, and Yibing Ding. "Measuring How Armed Conflict Impacts Economic Growth in Sub-Saharan Africa through Spatial Analysis." Frontiers in Political Science 6 (2024): 1433584. doi.org/10.3389/fpos.2024.1433584.

Mali, Niger, and Nigeria are grappling with insurgent groups that challenge state authority and compromise territorial control. Burkina Faso and Zimbabwe have additionally faced protests and social unrest that could jeopardize safe operations and security at nuclear facilities.[22]

Terrorism is one of the most pressing security threats in Sub-Saharan countries. Across Africa, terrorist groups have launched significant attacks on critical facilities, highlighting the continent's complex security challenges. Groups such as Boko Haram, Al-Qaeda in the Islamic Maghreb, and the Islamic State in West Africa Province have conducted brutal attacks on essential infrastructure, undermining political stability.

Terrorists can potentially choose from a variety of facilities to attack, but attacking a nuclear power plant may be more attractive than others because of the global attention it generates. A historical example is the 1982 bombing of the South African nuclear power plant, carried out by the African National Congress during the facility's construction to protest the apartheid regime.[23, 24] The prevalence of terrorist groups in countries considering or planning to deploy SMRs poses major security dangers, necessitating substantial steps to reinforce defenses.[25, 26] SMRs deployed in remote locations may be more susceptible to various security threats such as material theft, cyber-attacks, sabotage from potential terrorist actions, particularly in areas with weak governance, civil unrest, and insufficient security measures.[27, 28]

Several notable incidents involving the illegal handling and attempted smuggling of nuclear and radioactive sources further underscore the regional challenge of securing nuclear materials and preventing their diversion to illicit channels.[29, 30, 31, 32] In November 2013, for example, officials in Durban, South Africa seized 1 kilogram of yellowcake, a powdered form of uranium concentrate used in the enrichment process for nuclear fuel and weapons. Shortly prior to that, a person described as a "Sierra Leonean" was arrested at John F. Kennedy International Airport in August 2013 for possessing powdered uranium in his shoes and attempting to transfer a significant quantity to Iran.

The recent decision by Niger, Mali, and Burkina Faso to withdraw from the Economic Community of West African States (ECOWAS) further exacerbates regional insecurity[33] as it threatens the cooperative security framework essential for protecting critical infrastructure. Terrorist organizations in the region such as Da'esh, also known as ISIS, ISIL, or the Islamic State, al Qaeda, and their affiliates, take advantage of domestic instability and public dissatisfaction to spread their operations beyond

[22] Carothers, T., & Press, B. (2022, October). *Understanding and responding to global democratic backsliding* (Working paper). Carnegie Endowment for International Peace. Retrieved December 2, 2025, from https://carnegie-production-assets.s3.amazonaws.com/static/files/Carothers_Press_Democratic_Backsliding_v3_1.pdf.

[23] UNOCT. "Global Counter-Terrorism Strategy: Regional Developments and Trends in Africa." *United Nations Office of Counterterrorism*, 2022.

[24] Van Wyk, J.-A., and Van Wyk, A.-M. "The African National Congress and Apartheid South Africa's Nuclear Weapons Program." *Nuclear Proliferation International History Project*. Wilson Center, 2020. www.wilsoncenter.org/npihp.

[25] Miller, Erin. "Al-Shabaab Attack on Westgate Mall in Kenya." *Global Terrorism Database* (2013) Moss, Todd. "Does Africa Have a Nuclear Power Future?" 2018.

[26] UN News. "Terrorism Intensifying Across Africa, Exploiting Instability and Conflict." *Global Perspective Human Stories*, 2022.

[27] Boldon, L., Sabharwall, P., and Liu, L. "The State of Progress and Associated Challenges in the Global Deployment of Small Modular Reactors." *International Journal of Nuclear Governance, Economy and Ecology* 4, no. 3 (2019).

[28] Shobeiri, E., Genco, F., Hoornweg, D., and Tokuhiro, A. "Small Modular Reactor Deployment and Obstacles to Be Overcome." *Energies* 16, no. 8 (2023): 3468. doi.org/10.3390/en16083468.

[29] International Atomic Energy Agency (IAEA). *IAEA Incident and Trafficking Database* (ITDB) 2025 Factsheet. Vienna, 2025.

[30] Wild, Sarah. "Yellow Cake Not as Scary as Those Dealing with It." *Mail & Guardian*, November 22, 2013.

[31] U.S. Immigration and Customs Enforcement. "Sierra Leone Man Arrested for Brokering Uranium Deal for Iran." Miami, FL, 2013.

[32] Mutua, John-Mark. "Uranium Yellowcake Trafficking Incidents in Africa: Proliferation Threat or Non-proliferation Opportunity?" *African Security Review* 24, no. 2 (2015): 162–189. doi.org/10.1080/10246029.2015.1034737.

[33] Al Jazeera. "Niger, Mali, Burkina Faso Announce Withdrawal from ECOWAS." *News | Military*, January 28, 2024.

borders. Without ECOWAS's coordinating mechanisms, which facilitate intelligence sharing and collaboration on counterterrorism strategies, it will be challenging for countries to respond to such transnational terrorist threats. The nations' exit from the ECOWAS could also disrupt the stability and coordination of the West African Power Pool, a specialized ECOWAS association of public and private power entities meant to supply energy to the region that relies on cross-border trade.[34]

The threat of cyberattacks on nuclear facilities is another growing concern. According to the World Economic Forum, over one-third of African business leaders and cybersecurity experts lack confidence in their country's preparedness to respond effectively to sophisticated cyberattacks. Cybercriminals exploit these vulnerabilities through hacking, malware, and ransomware, endangering both nuclear facilities and sensitive data. Illicit tools such as Trojan horses and data stealers, which are readily available on dark web forums, further facilitate cyberattacks, making it more difficult for law enforcement agencies to investigate and prevent such crimes. Historical incidents, such as the Stuxnet worm (primarily targeting Iran) and the breach of nuclear facilities in South Korea and India, illustrate how malware can take advantage of digital weaknesses to infiltrate systems and cause severe damage. The rapid adoption of artificial intelligence could also introduce new vulnerabilities if proper safeguards are not considered in system designs.

SMRs, being highly automated and digital, are particularly susceptible to cyber threats, such as ransomware attacks, system breaches, and cyber-induced sabotage. These reactors rely heavily on industrial control systems, digital sensors, and remote operation capabilities, making them attractive targets for malicious actors.[35] Cyberattacks could lead to the theft of sensitive information or sabotage of reactor controls, posing significant risks to the safe operation of a nuclear facility, and could even facilitate the theft of nuclear materials.[36] A successful cyberattack on an SMR could disrupt power grids, halt operations, or create serious safety concerns. This underscores the urgent need for robust cybersecurity measures and regional cooperation to ensure the security and resilience of these next-generation energy systems.

Another important concern is the issue of financing needed for SMR initiatives.[37, 38, 39]

Despite their more affordable initial cost compared to traditional nuclear reactors, SMRs still require substantial upfront investment, which can be challenging for countries with lower Gross Domestic Product (GDP) and limited financial resources. Studies indicate that the average overnight capital cost of constructing an SMR ranges from $2,000 to $6,000 per kilowatt.

Most countries in Sub-Saharan Africa have such constraints and would find it challenging to mobilize substantial initial capital to support an SMR project. Lower GDP tends to correlate with greater economic instability, which raises perceived risk for investors and limits access to affordable international finance, often resulting in higher borrowing costs. High debt to GDP ratios in countries such as Zimbabwe (92.8%), Ghana (88.8%), Senegal (75%), and Kenya (67%) further constrain their ability to secure sufficient financing to support SMR deployment, workforce training, associated infrastructure, and the development of robust response forces to address potential attacks. A low GDP could also lead to an inability to allocate sufficient funding for the security of nuclear facilities, introducing vulnerabilities in securing the nuclear materials and facilities. Political instability might also deter foreign investments and

[34] West African Power Pool, www.ecowapp.org/.

[35] *Global Cybersecurity Outlook 2025*. 2025.

[36] *Africa Défense Forum*. "Forecast Warns of Cyberattacks Against Key Infrastructure." *ADF Magazine News Alerts*, 2025

[37] International Atomic Energy Agency. (1976). *INIS Repository*. https://inis-temp.iaea.org/search/search.aspx?orig_q=author:%22Polliart,%20A.-J.%22.

[38] Meierding, Emily. "Energy Security and Sub-Saharan Africa." *Revue Internationale de Politique de Développement* 2, no. 2 (2011): 744. doi.org/10.4000/poldev.744.

[39] OECD Publishing. *Nuclear Development: The Financing of Nuclear Power Plant*s. Organization for Economic Cooperation & Development, 2009.

complicate the long-term planning required for nuclear projects.[40, 41]

Safe and secure deployment of commercial nuclear power requires a robust domestic nuclear security regime, technical and human capacity and an independent regulatory authority to enforce it.[42, 43] Most countries in the area, aside from Ghana, Nigeria, Kenya, and Senegal, do not have comprehensive nuclear security regulations in place for their nuclear facilities. Only a handful have independent regulatory bodies. Even in those countries that do have such bodies, however, with the exception of South Africa, which has a nuclear power plant in operation, nuclear governance frameworks are weak when it comes to managing nuclear reactors due to lack of experience with commercial nuclear energy.

Furthermore, governments have failed to recruit highly qualified nuclear scientists to support the establishment of essential infrastructure for SMR projects and provide training to local workforces. Without trained human resources, it will be impossible to sustainably and securely operate nuclear facilities.[44]

Risk Mitigation Strategies for SMR Deployment in Sub-Saharan Africa

To ensure the safe and secure deployment of SMRs, countries in Sub-Saharan Africa should:

Strengthen border controls and regional cooperation

Given that the illicit trafficking of nuclear materials is one of the most potent threats to nuclear security in the Sub-Saharan region, it is vital that countries pursuing nuclear energy strengthen border monitoring and controls. Countries should adopt advanced radiation-detection systems and improved customs-screening measures to prevent the unauthorized transfer of nuclear material.

Moreover, it is important to strengthen regional and bilateral cooperation through legal instruments and intelligence-sharing mechanisms. Regional cooperation and bilateral arrangements should include nuclear security measures, as advanced nuclear countries do. The African Union and African Commission for Nuclear Energy (AFCONE), in collaboration with West African, Central African, East African and Southern African countries, should prioritize nuclear security policies and encourage members to ratify legal instruments to strengthen nuclear security in the region. This will not only reduce nuclear security risks, but will also assure investors that their equity will be protected. Countries should take advantage of contemporary communication technology and data-sharing platforms to expedite the exchange of information and facilitate prompt action in the event of possible nuclear security breaches at borders.

Additionally, as SMRs are a novel technology, the Convention on the Physical Protection of Nuclear Material and other international nuclear security legal instruments currently do not cover the transportation of SMRs from the vendor to the deployed country. Specific security provisions for the transport of SMRs must be proactively established and should be included in national and regional regulations.

Incorporate physical and cyber security mechanisms by design

Countries deploying SMRs should account for terrorist and cybersecurity threats. Nuclear facilities should incorporate sturdy confinement structures, access-control systems, and perimeter-security measures to prevent unauthorized access to sensitive

[40] *The Economics of Small Modular Reactors*. "Public SMRs in IRPs." February 2020. smrstart.org/wp-content/uploads/2020/02/SMR-Start-Public-SMRs-in-IRPs-APPROVED-2020-02. Feenstra, Randy. "The National Debt Is Undermining Our National Security." *Op-Ed*, January 17, 2025.

[41] Rosatom. "New Documents Show Cost of Russian Floating Nuclear Power Plant Skyrockets." *Bellona*, 2015.

[42] International Atomic Energy Agency (IAEA). *Evaluation of the Status of National Nuclear Infrastructure Development*. Vienna, 2016.

[43] Deo, W. "Can Nuclear Hit Its Stride in Africa? Power to the People: Evaluating Nuclear as a Bridge to Sustainable Energy in Africa," 2020.

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areas and materials. Countries should also establish protocols to identify and address insider threats within facilities.

Secure and resilient internet infrastructure is also critical for SMRs to enable continuous remote monitoring, control, and automated response systems, all of which are essential for safe operation. As Sub-Saharan countries face challenges with internet connectivity and the availability of a reliable network, SMR designs should incorporate offline control and human oversight mechanisms to provide back-up monitoring in order to respond to threats or malfunctions in real time.[45]

Countries must also implement robust cybersecurity measures to defend against data breaches, operational disruptions, and sabotage. The secure future of Sub-Saharan Africa's nuclear infrastructure will require a balanced approach, integrating enhanced cybersecurity protocols and localizing human efforts to prevent and protect against evolving cyberattacks.

Establish domestic regulatory frameworks

Extensive bureaucratic licensing processes could delay the construction and operation of a nuclear power plant. As diverse, novel SMR technologies emerge in Africa and around the globe, it will be critical to develop a licensing and regulatory framework that can deliver timely approvals without compromising rigorous safety and security standards.

The African Forum for Nuclear Regulatory Bodies is a network of nuclear regulatory authorities in Africa aimed at ensuring an effective regulatory system on the continent. The forum should leverage its platform to encourage the region to establish independent regulatory bodies and develop a clear licensing process consistent with international standards.

Pursue international cooperation to build domestic capacity

Sub-Saharan countries looking to deploy SMRs should engage with the IAEA and partner countries experienced in nuclear energy management to establish robust regulatory and nuclear security regimes, build trained domestic workforces, and accelerate technological advancements through joint research initiatives. Knowledge-sharing initiatives among nations around the globe that have successfully deployed large traditional reactors and are in the process of deploying SMRs could help harmonize regulatory standards and facilitate smoother implementation. Countries such as the United States, China, Russia, and Canada, each with extensive experience in SMR development, could share valuable insights and regulatory approaches that could benefit sub-Saharan countries. For instance, the United Kingdom has collaborated with Canada and the United States on SMR research and development projects, focusing on overcoming regulatory barriers, resolving reactor-design issues, and creating safety standards.[46]

Conclusion

The evolving energy landscape in Africa underscores the urgent need for clean, reliable, and sustainable energy solutions. SMRs offer a promising pathway to enhance energy security, drive economic growth, and support industrial development across Sub-Saharan Africa. However, realizing these benefits requires a careful and balanced approach that fully accounts for the associated risks, particularly in the areas of nuclear security, safety, and non-proliferation. Given the limited global operational experience with SMRs, security considerations must be integrated at the design stage to prevent vulnerabilities and ensure resilience against emerging threats. While many Sub-Saharan countries have expressed interest in adopting SMRs, the region's existing security challenges and institutional gaps must be critically assessed and addressed. To support the safe and secure deployment of SMRs in this area, it is imperative to establish a comprehensive nuclear security framework tailored to the regional context. This should include capacity-building, regulatory independence, international collaboration, and the promotion of a strong nuclear security culture. Public education and transparent engagement will also be vital in building societal trust and acceptance. With proactive regulation, diligent oversight, and strategic

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investment in human and institutional capacity, Sub-Saharan Africa could responsibly harness SMR technology. Doing so would not only strengthen the region's energy resilience, but also contribute meaningfully to its scientific, technological, and socioeconomic advancement.

Appendix: Additional Resources

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