The Reactor Around the Corner

Understanding Advanced Nuclear Energy Futures

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TECHNOLOGY ASSESSMENT PROJECT REPORT

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About the Authors

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About the Collaboration

This project was an interdisciplinary collaboration at the **University of Michigan** between the Science, Technology, and Public Policy Program and the Fastest Path to Zero Initiative in the Department of Nuclear Engineering and Radiological Sciences.

The University of Michigan's **Science, Technology, and Public Policy** (STPP) Program is a unique research, education, and policy engagement center concerned with cutting-edge questions that arise at the intersection of science, technology, policy, and society. It is dedicated to a rigorous interdisciplinary approach and working with policymakers, engineers, scientists, and civil society to produce more equitable and just science, technology, and related policies. Housed in the Gerald R. Ford School of Public Policy, STPP has a vibrant graduate certificate program, community partnerships program, experiential learning activities, and a lecture series that brings experts in science and technology policy from around the world to campus. Our affiliated faculty do research and influence policy on a variety of topics, from national security to energy.

The University of Michigan's **Department of Nuclear Engineering and Radiological Sciences** (NERS) is consistently ranked as having the best nuclear engineering program in the United States. It seeks to advance the benefits of nuclear, radiological, and plasma technology for society through cutting-edge research in sustainable energy solutions and nuclear security and defense. NERS houses the **Fastest Path to Zero Initiative** (FPTZ), which supports research, policy, and tool development related to zero-carbon energy sources. NERS is also the home of the Michigan Memorial Phoenix Project, devoted to the peaceful, useful, and beneficial applications and implications of nuclear science and technology for the welfare of the human race.

If you would like additional information about this report, the Technology Assessment Project, or the University of Michigan's Science, Technology, and Public Policy Program, you can contact us at **stpp@umich.edu** or **stpp.fordschool.umich.edu**.

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Acronyms and Definitions

ACS	Analogical case study; a methodology for predicting the impact of emerging technologies
AI	Artificial intelligence
AEC	United States Atomic Energy Commission
CCS	Carbon Capture and Storage
CNNC	China National Nuclear Corporation; China's state-owned nuclear enterprise
DAPL	Dakota Access Pipeline
DOE	United States Department of Energy
DOE-NE	United States Department of Energy Office of Nuclear Energy
EPA	United States Environmental Protection Agency
EV	Electric vehicle
FAA	United States Federal Aviation Administration
FERC	United States Federal Energy Regulatory Commission
GW	Gigawatt; one billion watts
HALEU	High-assay low-enriched uranium
High-level radioactive waste	The most radioactive type of nuclear waste, requiring strict management and permanent disposal
IAEA	International Atomic Energy Agency
LLM	Large language model
LWR	Light-water reactor
Microreactor	A compact, typically portable nuclear reactor
MOU	Memorandum of Understanding
MW	Megawatt; one million watts
NEA	Nuclear Energy Agency
NRC	United States Nuclear Regulatory Commission
Nuclear fuel cycle	The life cycle of nuclear energy, including the extraction of uranium, the production of electricity in a reactor, and the management and disposal of radioactive waste
RECA	Radiation Exposure Compensation Act
Rosatom	State Atomic Energy Corporation Rosatom; Russia's state-owned nuclear enterprise
SMR	Small modular reactor
SNF	Spent nuclear fuel
STS	Science and Technology Studies; a field of study that investigates the historical, social, and political dimensions of science and technology
WHO	World Health Organization

Executive Summary

Nuclear energy, a source of stable, carbon-free electricity, has long been considered essential for meeting growing global energy demands. Amid the climate emergency, geopolitical instability, and energy insecurity, it has recently regained attention as a key solution to these issues. However, nuclear power remains controversial due to its history of severe accidents, the risks of proliferation and potential use of nuclear material in weapons, challenges in managing long-lived nuclear waste, and high construction costs for nuclear power facilities. Advanced nuclear energy technologies, particularly small modular reactors (SMRs), promise to solve the problems of nuclear power through improved designs. Governments, industries, and publics have shown increasing interest in SMRs and other advanced reactors as central to solving the world's energy crisis and have been supporting their rapid development.

The potential expansion of the global nuclear industry introduces—and in some cases reinforces—problems that technological solutions alone will not be able to fix. To help ensure that advanced nuclear energy serves the public interest, we must have robust governance frameworks in place.

However, the potential expansion of the global nuclear industry introduces—and in some cases reinforces—problems that technological solutions alone will not be able to fix. To help ensure that advanced nuclear energy serves the public interest rather than predominantly corporate and geopolitical actors, we must have robust governance frameworks in place *before* the widespread implementation of SMRs.

To understand advanced nuclear energy's potential impacts, we look to historical cases of science and technology in society. We know that every new and emerging technology, no matter how novel, has commonalities with past technologies and that societal responses to new technologies demonstrate recurring patterns. In this report, we analyze the implications of the widespread adoption of SMRs and other advanced nuclear reactors using what we call the analogical case study (ACS) method. This method examines the history of past technologies—similar in form, function, potential impacts, or some combination of the three—to anticipate the implications of emerging technologies.

This report first gives an overview of the global history and regulatory environment of nuclear energy and outlines the current landscape of advanced nuclear energy development. Then we analyze the social, environmental, ethical, equity, economic, and geopolitical implications of SMRs and other advanced reactors through the ACS approach. We anticipate that SMRs, while having the potential to benefit countries and communities, are likely to have significant negative social impacts without robust governance frameworks. From our analysis, we find that the implementation of SMRs is likely to: entrench global disparities, privilege markets over the public good, overlook local and Indigenous knowledge, intensify environmental injustices, and abandon promises of local development and empowerment. Building on these insights, we provide policy recommendations for the governance of SMRs and the uranium supply chain. These policy recommendations are not exhaustive, and not all of them are necessarily unique to SMRs or other advanced nuclear reactors. They serve as a starting point for the responsible governance needed in the face of a potentially expanding nuclear industry to maximize the potential benefits and minimize the likely harms of the widespread adoption of these new nuclear energy technologies.

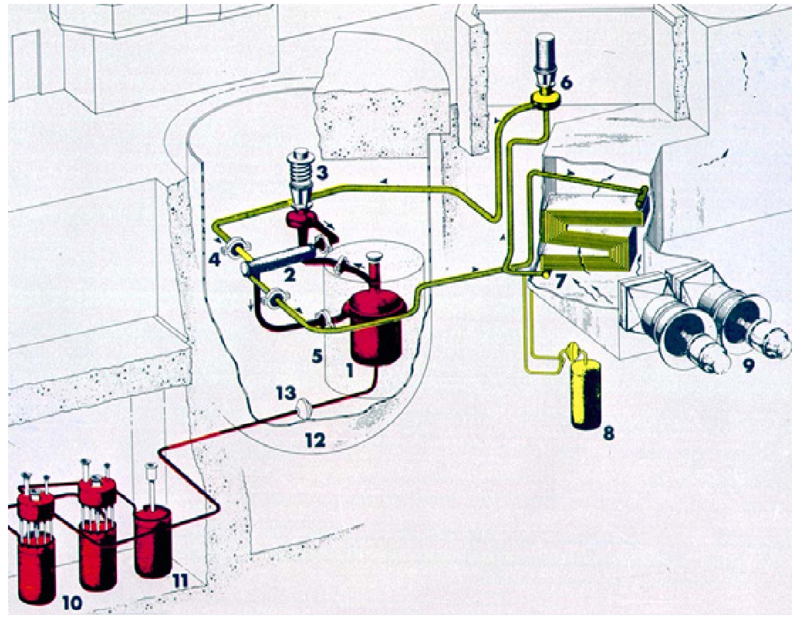


Diagram of the Molten-Salt Reactor Experiment at Oak Ridge National Laboratory, United States. (*Oak Ridge National Laboratory* / *Wikimedia Commons*)

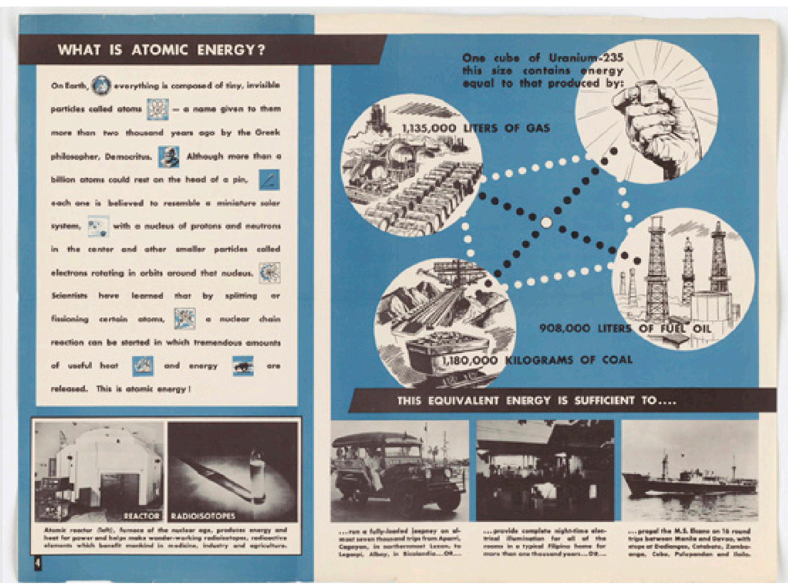
UNDERSTANDING THE ADVANCED NUCLEAR ENERGY LANDSCAPE

What is advanced nuclear energy?

Advanced nuclear energy, broadly, refers to a variety of nuclear reactors with significant design differences from today's nuclear reactors. While engineers have been developing advanced reactor concepts for decades—on paper, in laboratories, as pilot or demonstration projects, and for military applications such as nuclear submarine propulsion—recent years have seen a sharp increase in funding, research, and design for their commercial development. Advanced reactors generally use novel fuel types for power generation, higher uranium enrichment levels, and alternative coolants and neutron moderators to improve fuel efficiency, enhance safety, and produce high heat amenable to secondary industrial processes such as hydrogen production or desalination. While designs vary, advanced nuclear reactors are generally grouped into three size categories: small modular reactors (SMRs), microreactors, and large advanced reactors. SMRs are slightly smaller than conventional nuclear reactors, producing about a third of the electricity output of a conventional reactor; microreactors are even more compact than SMRs and are typically portable, producing significantly less electricity than a conventional reactor; and large advanced reactors are similar in size to conventional reactors with different design characteristics. The categories of these different types of advanced nuclear reactors can overlap and are not consistently defined among experts. For the purposes of this report, however, we use the term *advanced nuclear energy* primarily to apply to small modular reactors (SMRs) and discuss microreactors where relevant.

The promises of the advanced nuclear Industry

Advanced reactor developers promise safer designs, more efficient fuel use, less waste generation, and lower weapons proliferation risks. Particularly, SMRs and microreactors claim lower upfront construction costs and



U.S. propaganda poster from 1956 advertising the Atoms for Peace program. (*U.S. National Archives*)

shorter construction times due to their smaller size, factory-made modular parts, and on-site assembly. SMRs and microreactors are thus more attractive for countries and locations that would not be able to support a large reactor. Microreactors are designed to be compact and portable, so they are promoted as flexible for deployment to remote or isolated locations. Some SMRs are designed to provide both *baseload* power—a reliable, continuous supply of energy—as well as *peaking* power, necessary for periods of heightened electricity demand. Developers also promise that SMRs will reduce accident risks with passive safety systems that harness natural forces, such as gravity and pressure variations, to stabilize the reactor in the case of an emergency without the need for external power or human intervention. Many SMRs are designed to operate at least three years, and in some cases even decades, without refueling, reducing the circulation of nuclear material and thus the risk of nuclear weapons proliferation.

These smaller reactors are leading the next wave of nuclear innovation, promising to better match today's energy market needs due to their unique features. SMR technology could be more accessible to low- and middle-income countries because of its siting flexibility and potentially lower upfront costs. And because microreactors and some SMRs such as floating nuclear power plants do not necessarily depend on the capacity or connectivity of local grids, they could electrify remote and rural areas. Given these advertised benefits, nuclear advocates in government, media, and industry portray SMRs as indispensable tools for meeting energy demands as well as climate goals. Nuclear fission does not produce any carbon emissions and can provide a steady supply of electricity. Some countries and communities look to replace fossil fuel-fired power plants with SMRs, using existing infrastructure such as water sources for cooling and transmission lines. In the process, they hope that the SMR industry would employ local workforces and communities with experience in the energy sector. Further, with an increase in extreme weather events and power disruptions, proponents claim that SMRs could restart the power grid in a major blackout. Others argue that they are likely to be more resilient to droughts and heat waves. However, the technology is at an early stage, and it is still unclear whether the SMR industry can fulfill its promises.

Who is building advanced nuclear reactors?

Supporters of commercial advanced reactor development include long-time nuclear nations such as France, Russia, the United Kingdom, and the United States; nations that are rapidly building out nuclear energy such as China; the private sector, including large, established nuclear power companies and newcomer startups developing SMRs and microreactors; and a range of academic experts and think tanks around the world. Countries are racing to dominate the global advanced nuclear reactor market and craft strategic ties with other nations through SMR cooperation. Rosatom, the Russian state corporation for nuclear technology, currently dominates the global export market, owning half of all nuclear reactor export contracts worldwide. Unhindered by recent Western sanctions, Russia continues to expand its nuclear energy technology globally, with a growing focus on SMRs. China National Nuclear Corporation, the Chinese state-owned nuclear enterprise, recently announced the commercial operation of its first advanced reactor demonstration plant and seeks to export another SMR design to other nations soon. France has supported both state-owned utility Électricité de France and private startups in the development of novel SMR designs, seeking to develop SMRs through international partnerships.

Elsewhere, the private sector, with assistance from government programs, is playing a significant role in funding SMR and microreactor ventures. In the United Kingdom, Rolls-Royce is developing and exporting SMRs, shepherded by Great British Nuclear, the government body responsible for the United Kingdom's nuclear power expansion. The U.S. government is supporting multiple companies developing advanced reactor designs, such as TerraPower and X-Energy, buoyed by a cooperative regulatory environment and competitive funding programs such as the Department of Energy's (DOE) Advanced Reactor Demonstration Program, which has recently funded private-public partnerships. U.S. national laboratories are also supporting the research, development, and testing of microreactors and Generation IV advanced reactors. Large technology companies such as Amazon and Google and public and private utility corporations have recently signed

> Large technology companies such as Amazon and Google and public and private utility corporations have recently signed contracts with SMR developers to meet the rapidly growing energy demand from data centers powering the AI boom.

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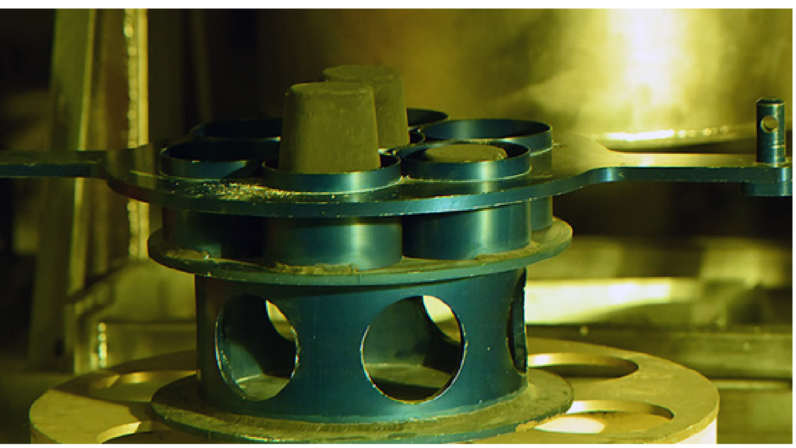
Government and industry support is not only limited to civilian applications of advanced nuclear reactors. Some nations' naval fleets have had nuclear-powered submarines and aircraft carriers for decades. Currently, some militaries are actively developing land-based small reactors to support remote operations with a reliable energy supply.

The risks and challenges of advanced nuclear energy

Despite great public interest and the rapid development of a diverse market, there are still considerable risks and uncertainties with SMRs. There is broad recognition that SMRs require a different regulatory approach than conventional nuclear reactors because they are designed and built differently, but these efforts are at an early stage. In addition, governments may need to develop new regulations to accommodate the waste from SMRs which may include new byproducts and increased levels of radioactivity. Although developers promise that the modular, factory-based, shippable approach will reduce costs, this remains speculative until a significant number of operational prototypes are built. Global financing is also a challenge. Despite the relatively lower expected manufacturing cost of SMRs, construction is still expensive, and many multilateral development banks do not fund nuclear reactor projects (though the World Bank recently reversed its longtime ban on nuclear financing). Furthermore, the export of advanced nuclear reactor technology does not eliminate fundamental concerns about weapons proliferation—with more countries adopting SMRs, transfer of nuclear knowledge and amounts of fissile material will increase. Advanced reactors also do not eliminate radioactive waste—the long-term safe management of high-level radioactive waste will always be a necessity. Finally, to achieve smaller sizes, longer operating cycles, increased efficiencies, and better fuel utilization, many SMR designs require a special type of fuel with higher uranium enrichment levels—high-assay low-enriched uranium, or HALEU. To date, the only country that produces commercial HALEU is Russia, presenting a conflict in geopolitical interests for some Western nations, which have been working to end their reliance on Russian uranium and to ensure a stable supply chain of fuel for SMRs by developing domestic HALEU production capabilities.



HALEU reguli fabricated from downblended high-enriched uranium recovered from legacy EBR-II fuel at Idaho National Laboratory. (*U.S. Department of Energy*)

THE IMPLICATIONS OF ADVANCED NUCLEAR ENERGY

Our analysis aims to expand the political debate about advanced reactors—which currently focuses on whether or not they solve the nuclear industry's waste, cost, safety, and proliferation concerns—to encompass the potential systemic implications of this emerging nuclear technology. Based on the social patterns observed in our analysis of analogous technologies in society, we anticipate that the implementation of advanced nuclear energy—particularly small modular reacors—will have significant social, environmental, ethical, equity, economic, and geopolitical impacts.

Though nations potentially receiving SMR technology hope to attain energy security and independence, SMRs are likely to become tools of geopolitical competition between powerful nations, who will use SMRs to exert their political, economic, and military influence in the name of exporting low-carbon, reliable, and affordable energy technology.

Entrenching global disparities

Though SMRs may become a vehicle for global nuclear technical cooperation, our case research indicates that SMRs will exacerbate current international power imbalances. Though nations potentially receiving SMR technology hope to attain energy security and independence, SMRs are likely to become tools of geopolitical competition between powerful nations, who will use SMRs to exert their political, economic, and military influence in the name of exporting low-carbon, reliable, and affordable energy technology.

Resources that powerful states use to gain leverage over receiving nations include nuclear-related skills and expertise, a large workforce, manufacturing capabilities, and access to infrastructure financing. Rather than securing energy autonomy, these relationships can generate ongoing economic and political dependence. SMRs and their supply chains will likely introduce or reinforce neocolonial relationships from the global level down to the local. They will create new avenues for the indirect control of low-income countries by powerful states or transnational companies through economic and political means. Promises of local benefits for these nations are unlikely to be fulfilled due to incomplete and inequitable integration of infrastructure into local context.

Privileging markets over the public good

SMR developers depict their technology as a necessary and revolutionary upgrade from the reactors in use for the past 70 years. With this framing comes the promise that these novel reactors can not just mitigate the risks and reduce public opposition but can also solve deeper social ills such as inequitable energy distribution and climate change. However, market pressures will likely prevent these promises from becoming reality and will actually increase the risks of SMRs, making them vulnerable to error and even catastrophic malfunction.

To maximize financial gains, the SMR industry will emphasize the novelty and importance of its technology in order to suppress regulatory oversight. The industry will frame SMRs as vital to fulfilling national goals like energy and infrastructure security, which will hinder governments' efforts to regulate them. At

Rössing uranium mine during IAEA Director General Yukiya Amano's official visit in December 2013, Namibia. (*Conleth Brady / IAEA*)

the same time, the industry will exploit its superior expertise in SMR technology to influence regulation in its own favor. Finally, the SMR industry will prioritize economic viability over public interests and access to public resources. This will lead to the industry undermining its promises of less profitable outcomes such as rural distribution and climate change mitigation. It will also reinforce racial inequities in pursuit of profit, exploiting racialized labor and land to support the SMR supply chain.

Overlooking local and indigenous knowledge

The "tech fix" narrative of SMRs is likely to exacerbate social alienation among marginalized communities and further devalue their knowledge in the pursuit of land and resources, including by extending settler colonialist practices. Some SMR developers and governments have expressed the importance of building public trust through democratic decision-making and deeper engagement with community experiences, responding to frustrations that the nuclear energy industry has traditionally sidelined, such as local concerns regarding reactor design, siting, and governance as well as uranium mining and milling. However, treating SMRs as a simple technological solution will obscure harm to marginalized communities while devaluing their knowledge in the process. An attitude of tech-solutionism will almost always privilege the technology over the knowledge of marginalized communities. Second, SMRs—like conventional nuclear energy—are likely to extend a legacy of settler colonialism based on resource extraction on Indigenous lands and the rejection of valuable Indigenous knowledge for sustainable land stewardship. Even though they offer key pathways to environmental sustainability, social equity, and public trust, the voices of marginalized communities are not only likely to be invalidated and ignored, but perhaps even actively and violently silenced.

Intensifying environmental injustices

SMRs will introduce and exacerbate direct and indirect environmental harms, especially on marginalized communities, that complicate the justification for using them to mitigate climate change. Though framed as a solution to the climate crisis, SMRs—even if they are successful in replacing fossil fuel plants—will enable industrial growth that is environmentally harmful. Beyond environmental concerns such as the management of high-level radioactive waste and end-of-life considerations for nuclear power infrastructure, climate-focused narratives overlook the environmental harms caused by the under-regulated industries enabled by SMRs. For example, the prospect of abundant, stable energy and the production of high process heat makes SMRs especially attractive to heavy industry. By co-locating with SMRs, these industries will introduce potential harms including local natural resource extraction, land degradation, and air and water pollution. Recent tech industry investments in SMRs to power the growing number of data centers for AI and other digital technologies will likewise exacerbate environmental impacts to land and water. The expanded development and construction of SMRs and other advanced nuclear energy technologies will also increase demand for uranium mining, an industry that is widely under-regulated and governed by inconsistent standards internationally, putting pressure on Indigenous lands already contending with a legacy of environmental and human harms from nuclear ventures.

SMRs are thus likely to exacerbate environmental risks and subsequent health burdens, either directly or indirectly. This will disproportionately affect marginalized communities, who lack the resources to prevent or manage them. Potential catastrophic accidents, while rare, will affect vulnerable populations the most. Communities with environmental and health concerns will be forced to advocate for themselves to address these risks and prevent harms. Protest or resistance to constructing uranium extraction and processing facilities, SMRs, or co-located industrial infrastructure in or near communities may be criminalized. Finally, corporate and government priorities are likely to squeeze vulnerable populations out of their local resources and limit their access to the energy benefits that SMRs could bring to the communities that need them most.

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Abandoning promises of local development and empowerment

SMR proponents argue that newly built nuclear plants, particularly in rural or low-income regions, will foster job creation that will reinvigorate local economies. Some governments and developers imagine the

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complete transformation of former coal towns, with unemployed workforces and decommissioned plants, to be a logical starting point. Yet SMR jobs require expertise that most rural communities do not possess, and coal workers will likely struggle to gain employment in the industry as a result.

Some advocates assert that SMRs could also enable greater citizen autonomy in local energy governance. Where conventional nuclear has lacked robust public participation in past planning and governance processes, SMR ownership by local cooperatives and small municipal utility companies may encourage self-governance and wider community consent. However, to realize these promises—from plentiful and accessible jobs, to economic development, to energy self-governance—proactive decision-making in technology design and policy action are needed. Additionally, disadvantaged communities are likely to be further marginalized in the process. However, achieving community governance of energy infrastructure may be possible through grassroots efforts and national-level policy. Unless the SMR industry prioritizes local consent and engagement in the same way it prioritizes cheap and efficient operations, promises of community development and empowerment will go unrealized.

Chapter 1: Introduction

Nuclear energy, a source of stable, carbon-free electricity, has long been considered essential for meeting growing global energy demands. Amid the climate crisis, geopolitical instability, energy insecurity, and growing recognition of inequitable impacts of fossil fuel extraction and use, it has recently regained attention as a key solution to these problems (Hibbs, 2022; International Energy Agency [IEA], 2022b; Kuzemko et al., 2022). Recently, major technology companies such as Amazon, Google, and Microsoft have invested in nuclear energy as a reliable, carbon-free option to power energy-intensive data centers for Artificial Intelligence (AI) and other digital technologies (Chu & Smyth, 2024; Halper, 2024; Sommer, 2024). However, nuclear power remains controversial due to its history of severe accidents, the risks of proliferation and potential use of nuclear material in weapons, challenges in managing long-lived nuclear waste, and high construction costs for nuclear power facilities (Plumer, 2024). Additionally, many nuclear power stations are increasingly facing premature shutdowns due to operating losses, maintenance costs, market conditions, and regulatory factors (Holt & Brown, 2021).

To manage these challenges, the global nuclear energy industry, in collaboration with governments, universities, and research laboratories, is developing a new generation of reactors broadly referred to as *advanced nuclear reactors.* Designed differently from today's nuclear power technologies, they have been referred to as "not your grandfather's reactors" (Gibson, 2023) and "more like airplanes and less like airports" (Karma, 2024). The United States' Nuclear Energy Innovation and Modernization Act of 2019 (NEIMA) defines them as having "significant improvements compared to [existing] commercial nuclear reactors" (Nuclear Energy Innovation and Modernization Act, 2019). The advanced nuclear reactor industry promises designs that shut down passively in case of an accident and generate less waste by burning fuel more efficiently. They may also be cheaper if they are built using factory-made modular components and more proliferation-resistant by minimizing and containing weapons-usable material (Center for Arms Control and Non-Proliferation, 2024). While engineers have been developing these advanced reactor concepts for decades (Ramana, 2015; Touran, 2020)—on paper (Nuclear Energy Research Advisory Committee, 2002), in laboratories (Stanford, 2013; Westfall, 2004), as pilot or demonstration projects (Le Renard, 2018; Tsukimori, 2016), and for military applications such as nuclear submarine propulsion (Conca, 2019)—recent years have seen a sharp increase in funding, research, and design for their commercial development (American Nuclear Society, 2024; Nuclear Innovation Alliance [NIA], 2021).

The global nuclear energy industry, in collaboration with governments, universities, and research laboratories, is developing a new generation of reactors broadly referred to as ***advanced nuclear reactors***.

While designs vary, advanced nuclear reactors broadly span three size categories:

1) Small modular reactors (SMRs): These reactors are smaller than conventional rectors and can fit into a large building or a city block, though the footprint of its industrial facility may be larger. SMRs can generate up to 300 megawatts (MW) of electricity—about a third of the power output of current large reactors, enough to power a small city (Columbus, 2023; Liou, 2023; NIA, 2024). Multiple SMR units can be assembled together for increased power generation (Hill, 2025).

2) Microreactors: Smaller and more compact than SMRs, microreactors are approximately the size of a truck and typically produce up to 20 MW of energy (U.S. Department of Energy, Office of Nuclear Energy [U.S. DOE-NE], 2021). Most are designed to be portable and flexible for deployment to remote areas, on ships and submarines, and even in outer space (Global Energy Association, 2024; Idaho National Laboratory, n.d.; U.S. DOE-NE, 2024b).

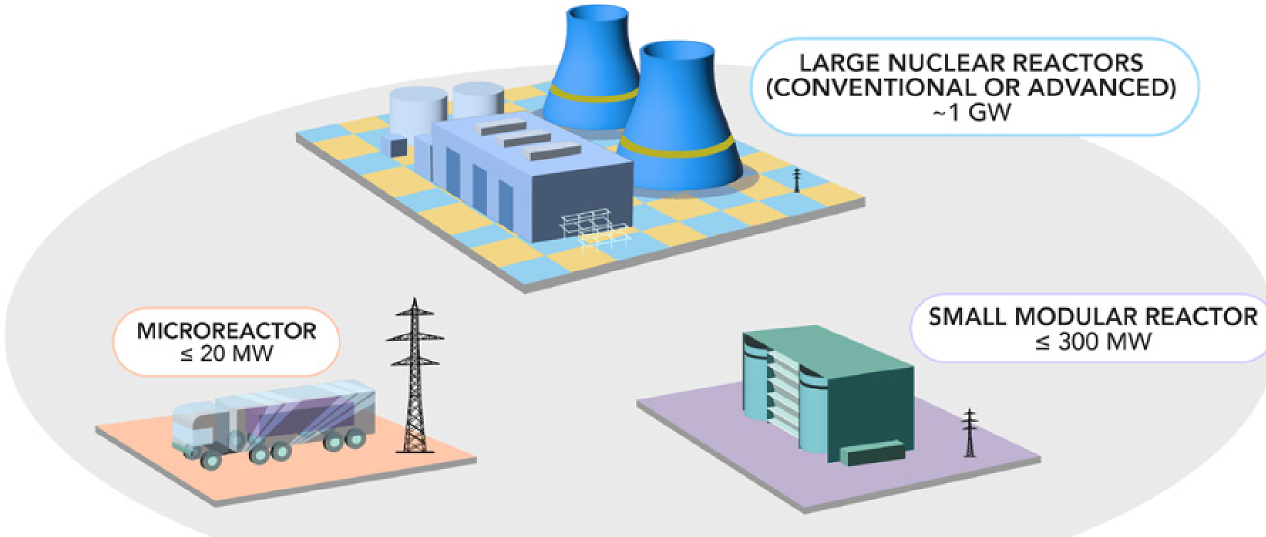
3) Large advanced reactors: Similar in size compared to current power plants, these reactors could generate about 1 GW of electricity on a power generation facility of approximately one square mile of land (U.S. DOE-NE, 2023b). Though some are simply evolutions of current reactor designs, they can also have significantly different attributes than their conventional light-water reactor (LWR) and heavy-water reactor (HWR) counterparts (Fisher, 2020; Gen IV International Forum, n.d.; S. Patel, 2012).

Advanced nuclear energy **is often used as a practical, general term for all new reactor designs currently emerging in the global nuclear industry.**

Advanced reactor concepts are primarily designed with different fuels, higher uranium enrichment levels, and alternative coolants and neutron moderators to improve fuel efficiency, enhance safety, and produce high heat amenable to secondary industrial processes such as hydrogen production or desalination (CEA, 2016; Clifford, 2023; Le Renard, 2018; Tsukimori, 2016; World Nuclear Association [WNA], 2021a). The latest iteration of advanced reactor designs are called Generation IV reactors (Gen IV International Forum, 2025). We do not discuss fusion reactor technologies in this report. For technical details about the differences between the different advanced reactor concepts, please see this report's *Appendix, Further Reading on Advanced Nuclear Reactors.*

The categories of different types of *advanced nuclear reactors* can overlap and are not consistently defined (Tennessee Valley Authority, n.d.; Touran, 2023; WNA, n.d.). For example, some SMR designs use the same LWR technology as conventional reactors and thus may not be referred to as "advanced" by all experts. Regardless, *advanced nuclear energy* is often used as a practical, general term for all new reactor designs currently emerging in the global nuclear industry (U.S. DOE-NE, n.d.-b; U.S. Nuclear Regulatory Commission [U.S. NRC], 2025). In this report, we focus primarily on small modular reactors (SMRs) and discuss microreactors where relevant.

A simplified overview of small modular reactors (SMRs), microreactors, and large advanced and conventional nuclear reactors for comparison. Due to the diversity of advanced reactor designs, some overlap exists between categories, which is not fully represented here. For more detailed information on advanced reactor designs, please see the *Appendix, Further Reading on Advanced Nuclear Energy*.



Lewis, N., Sibley, T., Stubblefield, N., Redmond, M., Kleinman, M., Parthasarathy, S., & Djokić, D. (2025). *The Reactor Around the Corner: Understanding Advanced Nuclear Energy Futures.* Technology Assessment Project, University of Michigan. https://doi.org/10.7302/25887

	Function	Physical size	Power output	Materials
Microreactors	Designed for flexible deployment in remote locations, such as military bases, ships, or even outer space.	Truck or small shipping container	Typically up to 20 MW; enough for small communities, remote areas, or industrial applications	**Fuels:** molten salt, liquid metal, TRISO, uranium oxide, or mixed oxide **Coolants:** molten salt, liquid metal, high-temperature gas, or water **Moderators:** water, graphite, metal hydrides, or no moderator
Small Modular Reactors (SMRs)	Designed for grid-scale electricity production with improved fuel efficiency and enhanced safety features. Constructed using factory-built modular components to reduce costs and construction timelines. Some designs operate at high temperatures suitable for industrial processes like hydrogen production or desalination.	Large building or a city block; industrial area may be larger	Typically up to 300 MW; enough to power a small city, though multiple units can be assembled for more power generation	
Large advanced nuclear reactors	Designed for grid-scale electricity production with improved fuel efficiency and enhanced safety features. Some designs operate at high temperatures suitable for industrial processes like hydrogen production or desalination.	Large industrial area; approximately one square mile	Typically 1 GW; enough to power a medium-sized city	
Large conventional nuclear reactors	Designed for grid-scale electricity production for residential and industrial zones.			**Fuels:** uranium oxide or mixed oxide **Coolants:** water **Moderators:** water or graphite

Instead of large and costly nuclear reactors, smaller reactors are leading the next wave of nuclear innovation, promising to better match today's energy market needs due to their unique features. SMR technology could be more accessible to low- and middle-income countries because of its siting flexibility and potentially lower upfront costs. And because microreactors and some SMRs such as floating nuclear power plants do not necessarily depend on the capacity or connectivity of local grids, they could electrify remote and rural areas (Daigle et al., 2024). Some nuclear experts claim that SMR deployment will happen alongside the continued expansion of conventional, large LWRs (Liou, 2024). The global nuclear energy industry aims to deploy the first SMRs within the next decade (EDF Group, 2022; Kozeracki et al., 2024.; Rolls-Royce, n.d.; Stanway, 2021).

Governments, media, and industry are enthusiastic about SMRs. Large technology companies have recently signed contracts with SMR developers to meet the rapidly growing energy demand from data centers powering the AI boom (Stover, 2024; Terrell, 2024; Waltz, 2024). However, commercial advanced reactor development is still in its early stages, and it is still unclear whether the SMR industry can fulfill its promises. Some early challenges to their implementation have already been identified (United States Government Accountability Office [U.S. GAO], 2015). But this creates an opportunity: there is still time to assess the impacts of SMRs comprehensively, and intervene before they perpetuate harm.

Debates about SMRs currently focus on whether they can satisfactorily address safety, cost, proliferation, and waste concerns. There is inadequate understanding of the broader social, environmental, ethical, equity, economic, and geopolitical impacts. In particular, the potential impacts of SMR development and deployment on marginalized populations remain largely unexplored, raising the risk of design and infrastructure development that reinforces inequities (Becker et al., 2020; Benjamin, 2019; Malin, 2015; Parthasarathy, 2010; Winner, 1980). A nuanced understanding of such impacts, which this report aims to provide, can guide decisions to maximize the benefits of SMRs while minimizing their systemic risks.

There is still time to assess the impacts of SMRs comprehensively, and intervene before they perpetuate harm.

HISTORY OF NUCLEAR POWER

The history of nuclear energy is inextricably intertwined with war. In the 1930s, when scientists in England, Germany, and Austria discovered nuclear fission—the splitting of uranium atoms that produces large quantities of energy—the application for military use was not far from the horizon. The Second World War triggered additional investments and research in the United States (US), the Soviet Union (USSR), and the United Kingdom (UK) (Cheban, 2015; Szasz, 1992). In 1942, scientists involved in the U.S.-based Manhattan Project built the world's first nuclear reactor, in Chicago, to test the military's ability to control nuclear fission reactions (Mally Dean, 2022). By 1945, the United States had dropped the first atomic bombs on Hiroshima and Nagasaki, Japan, killing approximately 200,000 people (Wellerstein, 2020).

After the war, governments around the world contemplated how to use atomic science and technology during peacetime. In the United States, this led to the establishment of the Atomic Energy Commission (AEC) in 1946, dedicated to fostering and controlling nuclear technology for both energy and weaponry (Hewlett & Anderson, 1962; Niehoff, 1948). But by the 1950s, there was emerging public concern about the dual-use nature of nuclear technology (Baron & Herzog, 2020). Even Albert Einstein, who had earlier written to President Franklin D. Roosevelt asking him to increase atomic research to prepare for the German threat, signed a manifesto along with other scientists and intellectuals in 1955, highlighting the danger of continued nuclear weapons development.

This soon gave rise to the "Atoms for Peace" movement, which promoted the use of nuclear power while justifying the creation of a nuclear weapons stockpile (Krige, 2006). In 1954, President Eisenhower formalized this approach by signing the Atomic Energy Act, which enabled rapid declassification of U.S. reactor technology and encouraged private sector development (Atomic Energy Act, 1954). A year later, the United Nations International Conference on the Peaceful Uses of Atomic Energy, in Geneva, also known as the "Atoms for Peace" conference, encouraged international cooperation and scientific information sharing regarding nuclear technology for civilian use, both for power generation and agricultural, medical, and industrial applications (Hamblin, 2021; International Atomic Energy Agency [IAEA] Bulletin, 1964). By the end of the decade, the United Nations (UN) had created the International Atomic Energy Agency (IAEA) as an autonomous intergovernmental organization to promote the peaceful use of nuclear energy, and it sets international standards and best practices and has the authority to monitor nuclear programs and inspect nuclear facilities to this day. In 1968, 43 countries signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) aimed to prevent the spread

Atoms For Peace Traveling Exhibit, Oak Ridge.
(*Ed Westcott* / *Department of Energy*)

of nuclear weaponry and promote peaceful uses of nuclear technology, with the ultimate goal of complete global disarmament (Treaty on the Non-Proliferation of Nuclear Weapons, 1968). The treaty is still active and now has 191 signatories, including five nations who possess nuclear weapons (the US, Russia, the UK, France, and China). However, there are some countries that have or are thought to have nuclear weapons (India, Pakistan, North Korea, and Israel) that are not currently party to the NPT (Miller & Scheinman, 2003).

In the meantime, experimentation with nuclear energy for power generation continued. In 1951, the United States generated the first electricity from nuclear energy in Arco, Idaho (Daly, 2023), and in 1954, the USSR connected its first nuclear power plant to the power grid in Obninsk (Semenov, 1983). England connected the world's first industrial-scale nuclear power station, Calder Hall, to the national grid for electricity generation in 1956 (Aldred & Stoddard, 2008). But the dual use of nuclear technology was well entrenched; Calder Hall also produced plutonium-239, a fissile isotope of plutonium used in some nuclear weapons, for Britain's newly developed nuclear weapons program.

By the 1960s, pilot-scale or demonstration reactors were operating in all major industrial nations, serving research purposes while demonstrating the technical and economic feasibility of nuclear power (IAEA, n.d.-a). Western and Eastern Europe, North America, Japan, and the Republic of Korea were particularly enthusiastic about the new technology. In the United States alone, utilities ordered more than 50 reactors by 1967, surpassing orders for new coal- and oil-fired plants. Global nuclear capacity expanded rapidly, growing from 1 gigawatt (GW) in 1960—enough to power a medium-sized city—to 100 GW in the 1970s and 300 GW by the late 1980s.

The AEC's dual role as regulator and industry promoter raised concerns about opaque risk assessment and regulatory capture (Bergen, 2016). These issues, combined with regulatory restrictions, growing environmental awareness, and concerns that the AEC was overly focused on nuclear energy alone, ultimately led to the agency's dissolution (Buck, 1983). The 1974 Energy Reorganization Act divided the Commission's developmental and regulatory functions into the newly created Energy Research and Development Administration—later reorganized into the U.S. Department of Energy (U.S. DOE)—and the U.S. Nuclear Regulatory Commission (U.S. NRC), an independent body tasked with overseeing nuclear safety (Buck, 1983; Energy Reorganization Act, 1974; McElheny, 1973). To strengthen public confidence, the NRC implemented a more rigorous reactor licensing process, adopted consensus standards, tightened engineering regulations, and introduced stricter safety requirements (U.S. NRC, 2011).

Today, the United States is the largest producer of nuclear power in the world, at 780 terawatt-hours (TWh) per year in 2023 generated by 92 commercial nuclear power reactors, providing roughly 19% of the nation's electricity (Csizmadia, 2023; Energy Information Administration [EIA], 2023; International Atomic Energy Agency Power Reactor Information System [IAEA PRIS], 2024). The vast majority of these plants were built between the 1960s and 1990s, with new site construction coming to a relative standstill by the end of the 20th century due to rising economic costs, falling fossil fuel prices, electricity liberalization, heightened regulation, and safety concerns (Khatib & Difiglio, 2016). France's share of nuclear energy on the grid, by contrast, is famously the highest in the world, at approximately 65%

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(IAEA PRIS, 2024), from 56 operating reactors. China produces approximately the same total nuclear-generated power from roughly the same number of reactors as France, though only contributing to 5% of its total national electricity generation (IAEA PRIS, 2024). While reactor construction has slowed substantially in the US and Western Europe, several Asian countries (including China) are actively planning and building new reactors (Johnson & Russo, 2024; WNA, 2024a). Other countries are also expressing interest (Cohn, 1997). The IAEA promotes domestic nuclear energy development through its Integrated Nuclear Infrastructure Reviews (INIR), an advisory and evaluating service that prepares low- and middle-income countries to build their first nuclear power plants (IAEA, n.d.-b). In 2013, the IAEA announced that 67 nuclear reactors were under construction worldwide, primarily in India and China, and from 2011 to 2019, the IAEA conducted preparatory construction INIR phases in Bangladesh, Belarus, Egypt, Jordan, Nigeria, Saudi Arabia, South Africa, Turkey, the UAE, and Vietnam (Amano, 2013; Quevenco, 2012).

Today, the IAEA and the Nuclear Energy Agency (NEA) at the Organization for Economic Co-operation and Development (OECD) provide knowledge and expertise to help countries around the world govern nuclear power. This includes guidelines on licensing processes that assess the safety of a technical design, potential environmental impacts, and the financial viability of the operation and decommissioning of a nuclear power plant or nuclear fuel cycle facility. These guidelines also suggest standards for monitoring facility operations, conducting facility safety reviews, and establishing emergency preparedness standards (IAEA, 2013; Nuclear Energy Agency [NEA], 2025; U.S. NRC, 2011). However, laws and policies still vary across nations, reflecting political and cultural differences in energy policies (IAEA, n.d.-c; WNA, 2013). In the United States, the NRC enforces stringent oversight, but it is caught between a nuclear industry that views its regulatory requirements as overly burdensome and critics who argue they are too lax (Gilinsky, 2024; Nuclear Energy Institute, 2015; Walker & Wellock, 2024). In contrast, China's state-sponsored, centralized nuclear power program faces fewer regulatory hurdles, prioritizing rapid development over extensive oversight (He et al., 2013; Wang & Chen, 2012).

The International Atomic Energy Agency headquarters, Vienna, Austria. (*Denia Djokić*)

THE RISKS OF NUCLEAR POWER

Almost since its inception, nuclear power has engendered resistance. In response to multiple small accidents in the 1960s in Michigan, Idaho, and Switzerland, citizens in California successfully challenged Pacific Gas & Electric's plan to build a reactor in Bodega Bay, on the coast north of San Francisco (SwissInfo, 2019). Soon, a global anti-nuclear movement mobilized, composed of scientists,

Protesters marching against the fast breeder sodium-cooled reactor in 1979 near Kalkar, Germany. (*Nationaal Archief*)

environmentalists, and citizens. They were motivated by Cold War anxieties as well as concerns about accidents, nuclear proliferation, terrorism, and waste disposal (Mandelbaum, 1984). The movement grew as publics paid more attention to environmental protection in the 1970s (Jasper, 1990; Nelkin, 1981). Some countries, like Australia and Austria, declined to move forward with nuclear power. Other nations persisted, but this did not stop public concern, controversy, or outright opposition.

There is also persistent worry about the dual use of nuclear technology; uranium enrichment, a process that prepares reactor fuel for energy generation, can also produce weapons-grade nuclear material (Union of Concerned Scientists, 2009). Though the levels of uranium enrichment used for most of today's reactors (roughly three to five percent) and weapons (over 90 percent) differ greatly (U.S. DOE-NE, 2023c), anxieties about the potential misuse of nuclear energy technology to covertly develop weapon arsenals have not disappeared. Some NPT signatories are not complying with its terms (Arms Control Association, 2024), and nuclear weapons states (NWS) have not shown significant progress towards total disarmament (United Nations [UN], 2024). In a concerted global effort to completely eliminate nuclear weapons, the Treaty on the Prohibition of Nuclear Weapons (TPNW) has 95 signatories to date, having entered into force in early 2021 (UN Office for Disarmament Affairs, n.d.). As noted above, some states that have or are thought to possess nuclear weapons have not signed the NPT at all, thereby operating outside of international norms (Miller & Scheinman, 2003). Furthermore, there is growing concern that non-state actors could compromise plant safety and security through sabotage, steal enriched uranium or plutonium from facilities to create weapons, or wage a targeted attack on a facility or transported material (Bunn, 2009). Over the last 50 years, there have been roughly 90 recorded incidents of terrorism at nuclear facilities or during the transportation of fissile or radiological material (De Cauwer et al., 2023; IAEA, 2024a). The IAEA safeguards regime for NPT signatories is a complex, expensive system of monitoring and reporting to verify that IAEA member states are using nuclear technology exclusively for peaceful purposes, which can present challenges with effectiveness and consistency (Blix, 1987; Goldschmidt, 2003; Goldschmidt, 2013; Pellaud, 1994). Due to the war between nuclear weapon state Russia and non-nuclear weapon state Ukraine, in addition to long-standing tensions between nuclear and non-nuclear weapon states in general (International Campaign to Abolish Nuclear Weapons, 2023; Weaver, 2023), there are renewed fears about the heightened probability of weapons use (Budjeryn, 2024). The concerns also extend to the vulnerability of nuclear facilities, such as the Zaporizhzhia Nuclear Power Plant seized by Russian forces in 2022, to political and military violence, endangering its safety and security and holding the plant and its workers hostage (Dolzikova, 2024; International Labour Organization, 2023; Kramer, 2025; Meduza, 2025; Roecker, 2023; UN, 2024).

The management and permanent disposal of nuclear waste, which can remain harmful to humans and the environment for hundreds of thousands of years, has also posed a challenge to the industry and government since the beginning of the nuclear age. Globally, there are more than one quarter million tons of high-level radioactive waste at power plants and weapons production facilities (Jacoby, 2020). The United States alone generates approximately 2,000 metric tons of high-level commercially produced spent nuclear fuel (SNF)[1] per year (U.S. DOE-NE, 2022b). A standard 1 GW nuclear power plant, which can power up to one million households (Stein, 2024), generates around 25 to 30 tons of SNF per year (Touran, 2008; WNA, 2024c). This amount is the equivalent of about the size of a brick of SNF for each person's annual electricity needs (WNA, 2021b).

Some countries, including France, India, Japan, Russia, and the UK, manage the waste by recycling—also called reprocessing—SNF (WNA, 2024h). The resulting high-level liquid waste is then immobilized in glass—a process known as vitrification—and stored in temporary storage facilities while it awaits

This low-level waste disposal site accepts waste from states participating in a regional disposal agreement. (*Wikimedia Commons*)

permanent disposal underground (Jacoby, 2020; U.S. NRC, 2023a; WNA, 2024c). However, there is significant scientific uncertainty about when and how these buried waste packages will degrade and how quickly radionuclides will leach out when the waste package comes into contact with groundwater over the course of tens, or even hundreds, of thousands of

1 Spent nuclear fuel is uranium fuel that has been used in a nuclear reactor. It is discharged from the reactor when it cannot generate electricity anymore. Spent nuclear fuel from current commercial reactors is solid in form, hot, and highly radioactive due to waste products generated from the nuclear fission reactions during reactor operation. After cooling in a pool, it can be temporarily stored in dry concrete casks, recycled and reused in a reactor, permanently disposed of in a geologic repository, or some combination of the above (U.S. DOE-NE, 2022b)

years. In the United States, a 1957 National Academy of Sciences report recommended geological disposal, while emphasizing the need for continued research (National Research Council, 1957). However, finding a site—even a demonstration site—proved difficult (Hewlett, 1978). In 1987, the United States legislature eventually chose Yucca Mountain, in Nevada, as the repository for the nation's high-level nuclear waste. But after years of controversy, the Obama administration defunded the project in 2011 (Blue Ribbon Commission, 2012; Rubin, 2021). In the absence of a permanent solution, this waste is stored above ground at power plants and processing facilities across the United States. Meanwhile, other countries, most notably Finland and Sweden, are planning and constructing deep underground repositories to store this waste; Canada also recently announced that it would build a deep geologic repository (Benke, 2023; Jones, 2024; S. Patel, 2022; S. Patel, 2024a).

Accident risk is another major concern. Since the introduction of nuclear power, there have been over two dozen nuclear accidents across the world, including three severe reactor accidents that garnered significant public attention (British Broadcasting Corporation [BBC] News, 2011; Laka Foundation, n.d.; Union of Concerned Scientists, 2013). The first, in 1979, was a partial core meltdown at the Three Mile Island nuclear power plant in western Pennsylvania, which generated significant public upset and significantly slowed reactor development in the United States (Hultman & Koomey, 2013). Seven years later, the explosion at the Chernobyl reactor in Ukraine killed multiple people immediately, and many more later through cancer, and led to the creation of a 30 km exclusion zone displacing tens of thousands (WNA, 2024b). Chernobyl remains the deadliest and costliest nuclear disaster in history and strengthened the global anti-nuclear movement (Prokip, 2020). After a public referendum in 1987, for example, Italy began to phase out its nuclear power plants (Graf von Hardenberg, 2011).

Twenty-five years later, in 2011, a powerful earthquake and tsunami off the north-eastern coast of Japan damaged both the electrical grid and the backup power sources at the Fukushima Daiichi Nuclear Power Station. The plant was unable to cool itself and released radiation into the environment, resulting in the worst nuclear power station meltdown since Chernobyl (Acton & Hibbs, 2012). As the first major nuclear disaster of the internet age, the events were widely watched around the world, increasing public concern about the technology (The Associated Press, 2022). Japan itself immediately temporarily shut down all of its operating reactors, though it has since successfully restarted many of them (McCurry, 2025). Other governments, including Germany, Belgium, and Switzerland, began to phase out reactors too; worldwide nuclear electricity production in the sector dropped 4% in 2011 and another 7% in 2012, the biggest drop in history (Paillere & Donovan, 2021; Schneider et al., 2013). Italy and Spain, which had begun to consider building new reactors, ended their efforts (Phillips, 2011). And in 2022, Austria and Germany sued the European Union for framing nuclear energy as a green investment (Frost, 2024).

Today, some of the world's most high-profile environmental organizations, including the Sierra Club and Greenpeace, continue to oppose nuclear energy. They argue that it is too

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expensive and unsafe, both in terms of accident risk and nuclear waste storage (Greenpeace, n.d.; Sierra Club, n.d.). However, some younger climate activists see these beliefs as outdated and note that nuclear power, which produces minimal carbon emissions, is cleaner than fossil fuels (Goodyear, 2023; Harder, 2019). Meanwhile, in the United States, the Union of Concerned Scientists and others claim that the NRC is too friendly with the nuclear industry to regulate it effectively (Lyman, 2024; von Hippel, 2021).

In recent years, energy analysts have also questioned the cost-effectiveness of nuclear power. Nuclear projects face enormous capital costs, with reactor construction around the world frequently delayed and the costs exceeding initial budgets (Potter, 2023). Meeting regulatory requirements further increases costs. Meanwhile, the costs of natural gas—and even solar, wind, and biofuels—have decreased, making nuclear power even less competitive (Ro, 2022).

Finally, social inequalities and injustices exacerbated by nuclear energy use is exemplified by the disparate impacts of uranium mining and processing as well as nuclear plant siting (Brugge & Goble, 2002). Nuclear power relies on uranium, which is found in low levels in minerals and rock deposits all over the world. To be used as reactor fuel, it must be mined from the Earth's crust, usually in areas with deposits of higher uranium concentrations (EIA, 2023; WNA, 2024e). It is then processed into a chemical form suitable for fuel fabrication. Both mining and processing can cause serious health effects, as they require the use of water and chemicals to extract useful uranium (from either crushed rock or underground ore). Mining uranium ore conventionally—mostly from open pits—emits radon gas, which has been associated with higher rates of lung cancer (National Research Council, 2012). It also exposes workers to radiation, which can damage cells and ultimately trigger cancers.

Uranium mine, Utah. (*Matt Affolter* / *Wikimedia Common*)

Workers might inadvertently inhale or ingest radioactive materials or absorb them through a cut in the skin. Surrounding communities are also at risk, particularly if the solvents used to extract uranium in either conventional milling or in-situ recovery (ISR) mining processes—which become radioactive and contaminated in the process—are released or leached into the groundwater (Becker et al., 2020).

Today, most of the world's uranium comes from Canada, Kazakhstan, and Australia, followed by Namibia, Niger, and Russia (Becker et al., 2020; WNA, 2024g). However, during the first few decades of the atomic age, the U.S. government procured most of its uranium from mines on or adjacent to the Navajo Nation (Richter, 2009). The mines provided stable jobs but exposed workers to dangerous conditions with insufficient protective equipment or ventilation (U.S. Department of Justice, Office of Public Affairs, 2015). Many mine workers experienced increased lung and other cancers, impaired kidney function, and shortened life expectancies (Arnold, 2014). Furthermore, in 1979, just months after the Three Mile Island accident, a dam near the United

Ranger Uranium Mine, Kakadu National Park uranium mining controlled area, Australia. (*Alberto Otero García / Wikimedia Commons*)

Nuclear Corporation's Church Rock mine and mill failed, releasing massive amounts of radioactive mill tailings—waste products from the milling process that contain radioactive decay products—into the nearby Puerco River and Navajo lands (Gilbert, 2019; Jennings, 2014). The spill caused immediate as well as long-term harm to humans and livestock, with residents continuing to report increased cancer rates and ongoing contamination levels in the water even decades later (Gilbert, 2019; Shebala, 2009).

Since then, the federal, state, and tribal governments have strengthened environmental protections and Native Americans' autonomy over their lands. This includes the National Environmental Policy Act (NEPA) which requires environmental impact assessments and the Clean Air and Clean Water Acts (Clean Air Act, 1963; Clean Water Act, 1972; National Environmental Policy Act, 1969). The U.S. Department of Energy (U.S. DOE) and the U.S. Environmental Protection Agency (U.S. EPA) are now responsible for the safe and environmentally sound disposal of radioactive waste, including the mill tailings associated with uranium processing. However, the government has provided only minimal compensation to those harmed by nuclear energy and weapons production, including those involved in uranium mining and milling (U.S. Environmental Protection Agency [U.S. EPA], n.d.; U.S. GAO, 2020; U.S. GAO, 2024b). Today, mining companies are eager to extract uranium located in the American West, including from areas near the Grand Canyon (Baker, 2024; Keith, 2023; Penn et al., 2024). Yet on tribal lands, the Indian Mineral Development Act of 1982 grants tribes the authority to develop their mineral resources in any manner (Hook & Banks, 1993; Indian Mineral Development Act, 1982; U.S. Department of the Interior, Bureau of Indian Affairs, n.d.).

Meanwhile, uranium mining continues to reflect geopolitical power asymmetries. France, known for its large generation and exportation of nuclear power, has relied heavily on past colonies in Africa, such as Niger and Gabon, to meet its uranium demand (Hecht, 2004; Hecht, 2012). The UK relies on uranium from former colonies as well, particularly Canada and Australia, where mining in Saskatchewan and Western Australia endangers First Nation and Aboriginal populations (Becker et al., 2020;

Bowen et al., 2014). Yet these dynamics are not always direct extensions of past colonial systems; neo-colonial relationships between nations have emerged, driven by interests in uranium extraction or nuclear reactor construction (Becker et al., 2020; Pibida, 2022; Rossi, 2022; U.S. Department of State, Office of the Spokesperson, 2022). Laws and regulations for worker safety and environmental protections for the extractive or energy generation sector vary by nation, for which the IAEA provides model guidelines and safety standards (IAEA, 1999; IAEA, 2002; IAEA, 2018). Furthermore, many of these countries have declared commitments to UN frameworks which require the consent of Indigenous communities and protection of tribal territories—where most global uranium deposits lie—for extractive projects (Becker et al., 2020; Indigenous and Tribal Peoples Convention, 1989; Rio Declaration on Environment and Development, 1992; Declaration on the Rights of Indigenous Peoples, 2007). Some Eurasian nations have also pledged to ensure citizens' rights to environmental protection and public participation (United Nations Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 1998). However, these frameworks are rarely exercised in practice.

UNDERSTANDING ADVANCED NUCLEAR ENERGY

Given this difficult history, advanced nuclear reactors, specifically small modular reactors, offer great promise. Supporters of SMR development include long-time nuclear nations such as France, Russia, the United Kingdom, and the United States; nations that are rapidly building out nuclear energy such as China; the private sector, including large, established nuclear power companies and newcomer startups developing SMRs; and a range of academic experts and think tanks around the world (NIA, 2021). Many SMR advocates contend that cheaper renewables like wind, solar, and hydropower require precarious environmental

Experimental Breeder Reactor-II (EBR-II), Idaho. (*Idaho National Laboratory*)

conditions to function, and the technologies to store that power (like big battery farms) are both expensive and resource-intensive. By contrast, SMRs claim to provide both *baseload* power—the reliable, continuous energy supply required throughout a day—as well as *peaking* power, necessary for periods of heightened energy demand (U.S. DOE-NE, 2020).

SMRs also promise greater efficiency, affordability, and flexibility while being adaptable to various energy needs. Unlike conventional nuclear reactors, which rely on water as a coolant and run on relatively low uranium fuel concentrations, some SMR designs use alternatives such as molten salt, high-temperature gas, and liquid metal. These advanced coolants allow for higher operation temperatures, leading to more efficient energy production (Gen IV International Forum, n.d.; WNA, 2021a). Proponents claim that SMRs are more cost-effective, as their modular components would be manufactured in factories first and then assembled on-site, reducing overall construction expenses. Their smaller size promises to further decrease costs and increase mobility (WNA, 2021a), facilitating electricity production in rural areas that may not be well-connected to the power grid or for specific energy-intensive uses like carbon capture or desalination (Fattouh et al., 2024).

Developers also promise that SMRs will reduce accident and proliferation risks. Many designs leverage passive safety systems that harness natural forces such as gravity and pressure variations to stabilize the reactor in the case of an emergency. This minimizes the need for operator action or a direct power source to prevent accidents (Giges, 2014). And, to address dangers to workers, surrounding communities, and the environment caused by highly radioactive spent fuel, many SMRs are designed to operate at least three years, and in some cases even decades, without refueling (Liou, 2023). These design changes will also reduce the risk of nuclear proliferation because there will be less need to transport fuel and reactor components which create opportunities for theft (Prasad et al., 2015). SMRs also promise to produce less waste, as most SMR are designed to burn the uranium fuel more efficiently—though the waste volume, form, and characteristics vary widely by design (Larson, 2022).

Given these promised benefits, nuclear power is promoted as being a useful tool for mitigating climate change. Nuclear fission does not produce any carbon emissions and, if functioning properly, can provide a steady supply of electricity. By contrast, for every kilowatt-hour (kWh) of energy produced, coal plants emit at least 2.3 pounds of carbon dioxide and other greenhouse gases (GHG) in addition to other pollutants (EIA, n.d.-a, EIA, n.d.-b). In the United States, fine particulate emissions from coal-fired power plants, such as sulfur dioxide and nitrous oxides, are responsible for anywhere from 7,500 to 52,000 early deaths from lung cancer and cardiopulmonary disease every year—impacts that fall more heavily on people of color (Apt, 2017; Cushing et al., 2023). Some argue that nuclear power has the lowest lifecycle carbon footprint of *any* energy source, including renewable sources (Grossi, 2024). In fact, some look to replace fossil fuel-fired power plants with SMRs, using existing nearby infrastructure, such as water sources for cooling and transmission lines. In the process, they hope that SMRs would employ local workforces and communities with experience in the energy sector (Hansen et al., 2022). TerraPower, a US-based advanced nuclear reactor developer company, is building its first SMR, the Natrium demonstration reactor, near a decommissioning coal plant in Kemmerer, Wyoming (Brulliard, 2023; Tan, 2024).

Further, with an increase in extreme weather events and power disruptions, SMRs could restart the power grid in a major blackout (Climate Central, 2022; NIA, n.d.; Sullivan, 2022). Others argue that they are likely to be more resilient to droughts and heat waves. Some countries, including China, Russia, and South Korea, are designing floating nuclear power plants for maritime cargo shipping, sea-based military operations, or bringing energy to remote regions (P. Patel, 2024; Xue & Tang, 2024). The Akademik Lomonosov, based on Russian nuclear reactors used to power icebreaker ships, provides heat and electricity to a town in the Arctic (Nilsen, 2025). Many of these ship-based small reactors are designed to withstand extreme weather events and could potentially provide power to remote mining operations or areas following natural disasters (Tiwari, 2021; World Nuclear News [WNN], 2022).

Countries are racing to dominate the global advanced nuclear reactor market and craft strategic ties with other nations through SMR cooperation.

With this potential, countries are racing to dominate the global advanced nuclear reactor market and, at the same time, reinforcing and extending their geopolitical influence (Ahn et al., 2024; Dewan et al., 2024). Rosatom, the Russian state corporation for nuclear technology, dominates the global export market, owning half of all reactor export contracts worldwide (Kobayashi, 2024; WNA, 2025b). Neither its conventional or small modular reactor orders have been significantly impacted by Western sanctions following the war in Ukraine (Jennetta & Vorotnikov, 2025; Szulecki & Overland, 2023) despite recent European Union efforts to impose sanctions on Russian nuclear exports (Gavin & Jack, 2024). Russia continues to expand its nuclear energy technology globally, with a growing focus on SMRs (Rosatom, 2023; Rosatom, 2024; WNA, 2025b). Similarly, through its national energy policy, China is investing significantly in SMR research and development (Martin, 2015; Song, 2021). China obtained IAEA approval on its first SMR, the Linglong One, in 2016 and has since started construction of the first unit in Hainan Province (Larson, 2023, Shaw, 2024; Stanway, 2021). China National Nuclear Corporation (CNNC), the state-owned nuclear enterprise, recently announced the commercial operation of the high-temperature gas-cooled reactor pebble-bed module (HTR-PM) demonstration reactor near Shidao Bay, Shandong Province (Larson, 2023). China seeks to soon export its Linglong One SMR design to strengthen its bilateral relationships across the globe, in what some call its "nuclear belt and road initiative" (Kim, 2023; Liu & Fan, 2023; Tao & Chu, 2023). Meanwhile, France's national investment plan, "France 2030," has supported both state-owned utility Électricité de France (EDF) and private startups in the development of novel SMR designs (IEA, 2022c; Pécout, 2024). Due to cost concerns and the desire to minimize financial risk, EDF has recently redrafted its designs to rely on more proven nuclear technology, and France is seeking to develop SMRs through international partnerships (Hernandez, 2024; Vidalon, 2022; Yadav, 2025).

Militaries have a great interest in developing and deploying advanced reactors, especially microreactors (Andres & Breetz, 2011). Historically, the U.S. Navy has used nuclear-powered submarines—essentially, the first microreactors—for several decades (U.S. EPA,

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2024a; WNA, 2025a). During the Cold War, a nuclear microreactor was used by the U.S. Air Force to power a remote radar station in Wyoming (Shropshire, 2023). In September of 2024, the U.S. Department of Defense broke ground on a mobile nuclear reactor, Project

Full-scale ML-1 mockup at the National Reactor Testing Station, Idaho. The actual reactor was tested nearby. (*U.S. Army* / *Office of History, HQ, U.S. Army Corps of Engineers*)

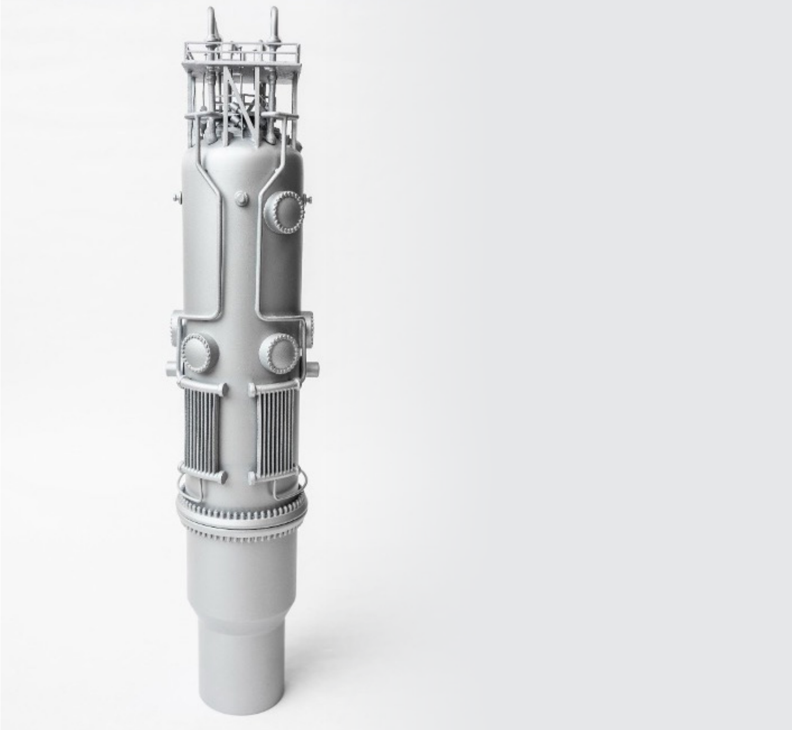
Pele, that will be used to improve the reliability and resilience of energy access for Department activities (U.S. Department of Defense, 2024).

Elsewhere, the private sector, sometimes with assistance from government programs, is playing a significant role in funding SMR ventures. In the UK, Rolls-Royce is developing and exporting SMRs, shepherded by Great British Nuclear, the government body responsible for the UK's nuclear power expansion (Rolls-Royce SMR, 2024; WNN, 2024b). The United States government is supporting multiple companies developing advanced reactor designs, buoyed by a cooperative regulatory environment and competitive funding programs such as the DOE's Advanced Reactor Demonstration Program (ARDP), which has recently funded private-public partnerships (U.S. DOE-NE, n.d.-a; U.S. NRC, 2025). U.S. national laboratories are also supporting the research, development, and testing of microreactors and Generation IV advanced reactors (U.S. DOE-NE, 2025). The advanced reactor company NuScale has received substantial financial support from the DOE for the design, licensing, and siting of its VOYGR SMR design (U.S. DOE-NE, 2023a). VOYGR's design is adapted from current LWR technology and is the first SMR to receive U.S. regulatory approval. While its technology is the most developed, the plant has not yet become operational because it has not been able to garner adequate buyer interest (Greenwald et al., 2024; Pearl, 2023). X-energy, another advanced reactor company, specializes in SMRs that use high-temperature gas as a coolant and tiny, solid, spherical balls—known as TRISO particles—as fuel (U.S. DOE-NE, 2019). It is currently building a demonstration reactor in Texas (X-energy, 2019), with more units planned in Washington State, recently funded by Amazon (De Chant, 2024). The Natrium demonstration reactor by TerraPower, founded and primarily funded by Bill Gates, started construction in June 2024 (Tan, 2024).

In the United States, nuclear and foreign policy experts argue that given the early Russian and Chinese domination of the SMR market, simply funding public-private partnerships and modernizing regulations are insufficient efforts to maintain global economic competitiveness and national security (Goodsell-SooTho & Baker, 2018). This has driven greater investment in next-generation nuclear energy, streamlined NRC review processes, and lowered licensing fees over the last five years, supported by the 2019 Nuclear Energy Innovation and Modernization Act, the 2021 Bipartisan Infrastructure Law, the 2022

Inflation Reduction Act, and the 2024 ADVANCE Act. SMR proponents are also encouraging the U.S. government to engage the International Atomic Energy Agency (IAEA) in developing global security guidelines and best practices for advanced reactors (Goodsell-SooTho & Baker, 2018; Jayarajan & Piotukh, 2023).

Despite great public interest and the rapid development of a diverse market, there are still considerable risks and uncertainties with SMRs. Although developers promise that the modular, factory-based, shippable approach will reduce costs, this remains speculative until a significant number of operational prototypes are built. Global financing is also a challenge. Despite the relatively lower expected manufacturing cost of SMRs, the cost of constructing any nuclear facility is high, and the first several SMRs will have high construction costs while the industry learns from building them. Most multilateral development banks do not fund nuclear reactor projects (IAEA, 2024e; Lovering & Halland, 2023), although the World Bank has recently lifted its longtime ban on nuclear financing (Bearak, 2025). In lieu of external financing, funding for nuclear projects must come from the state, which is particularly challenging for low- and middle-income countries who may seek contracts and loans for new nuclear energy infrastructure from banks in other places. Furthermore, the export of advanced nuclear reactor technology still raises concerns about weapons proliferation through the transfer of knowledge and spread of nuclear material. Enforcing export controls, ensuring security features, and adhering to international safeguards frameworks to minimize the risk of proliferation is complex and potentially costly, especially if not accounted for in the design stage (Cipiti et al., 2024; Kim, 2017; Trahan, 2025). Finally, to achieve smaller sizes, longer operating cycles, increased efficiencies, and better fuel utilization, many SMR designs require a special type of fuel with higher uranium enrichment levels. This high-assay low-enriched uranium, or HALEU, is only commercially produced in Russia (WNA, 2023). Since Russia's invasion of Ukraine, the United States and other Western nations have been working to develop domestic HALEU production capabilities to end their reliance on Russian uranium and ensure a stable supply chain of fuel for SMRs (Gordon, 2024; Johnson, 2025; WNN, 2024a; WNN; 2024c).

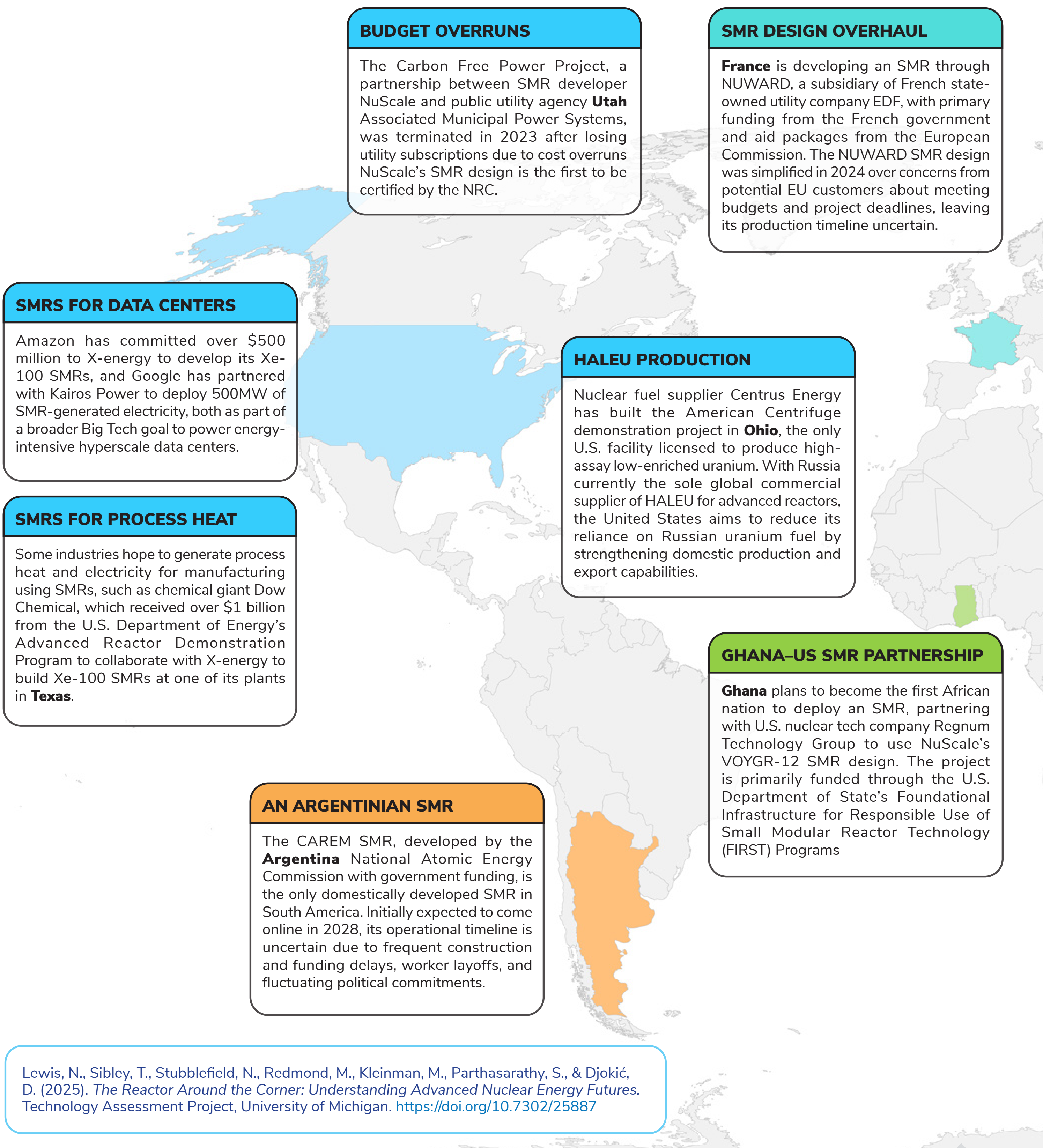


NuScale Power Module. (*NuScale Power*)

There is broad recognition that SMRs require a different regulatory approach than conventional nuclear reactors because they are designed and built differently, but these efforts are still at

A GLOBAL GLIMPSE OF ADVANCED NUCLEAR ENERGY

A partial snapshot of advanced nuclear energy projects around the world.



BUDGET OVERRUNS

The Carbon Free Power Project, a partnership between SMR developer NuScale and public utility agency **Utah** Associated Municipal Power Systems, was terminated in 2023 after losing utility subscriptions due to cost overruns NuScale's SMR design is the first to be certified by the NRC.

SMR DESIGN OVERHAUL

France is developing an SMR through NUWARD, a subsidiary of French state-owned utility company EDF, with primary funding from the French government and aid packages from the European Commission. The NUWARD SMR design was simplified in 2024 over concerns from potential EU customers about meeting budgets and project deadlines, leaving its production timeline uncertain.

SMRS FOR DATA CENTERS

Amazon has committed over $500 million to X-energy to develop its Xe-100 SMRs, and Google has partnered with Kairos Power to deploy 500MW of SMR-generated electricity, both as part of a broader Big Tech goal to power energy-intensive hyperscale data centers.

HALEU PRODUCTION

Nuclear fuel supplier Centrus Energy has built the American Centrifuge demonstration project in **Ohio**, the only U.S. facility licensed to produce high-assay low-enriched uranium. With Russia currently the sole global commercial supplier of HALEU for advanced reactors, the United States aims to reduce its reliance on Russian uranium fuel by strengthening domestic production and export capabilities.

SMRS FOR PROCESS HEAT

Some industries hope to generate process heat and electricity for manufacturing using SMRs, such as chemical giant Dow Chemical, which received over $1 billion from the U.S. Department of Energy's Advanced Reactor Demonstration Program to collaborate with X-energy to build Xe-100 SMRs at one of its plants in **Texas**.

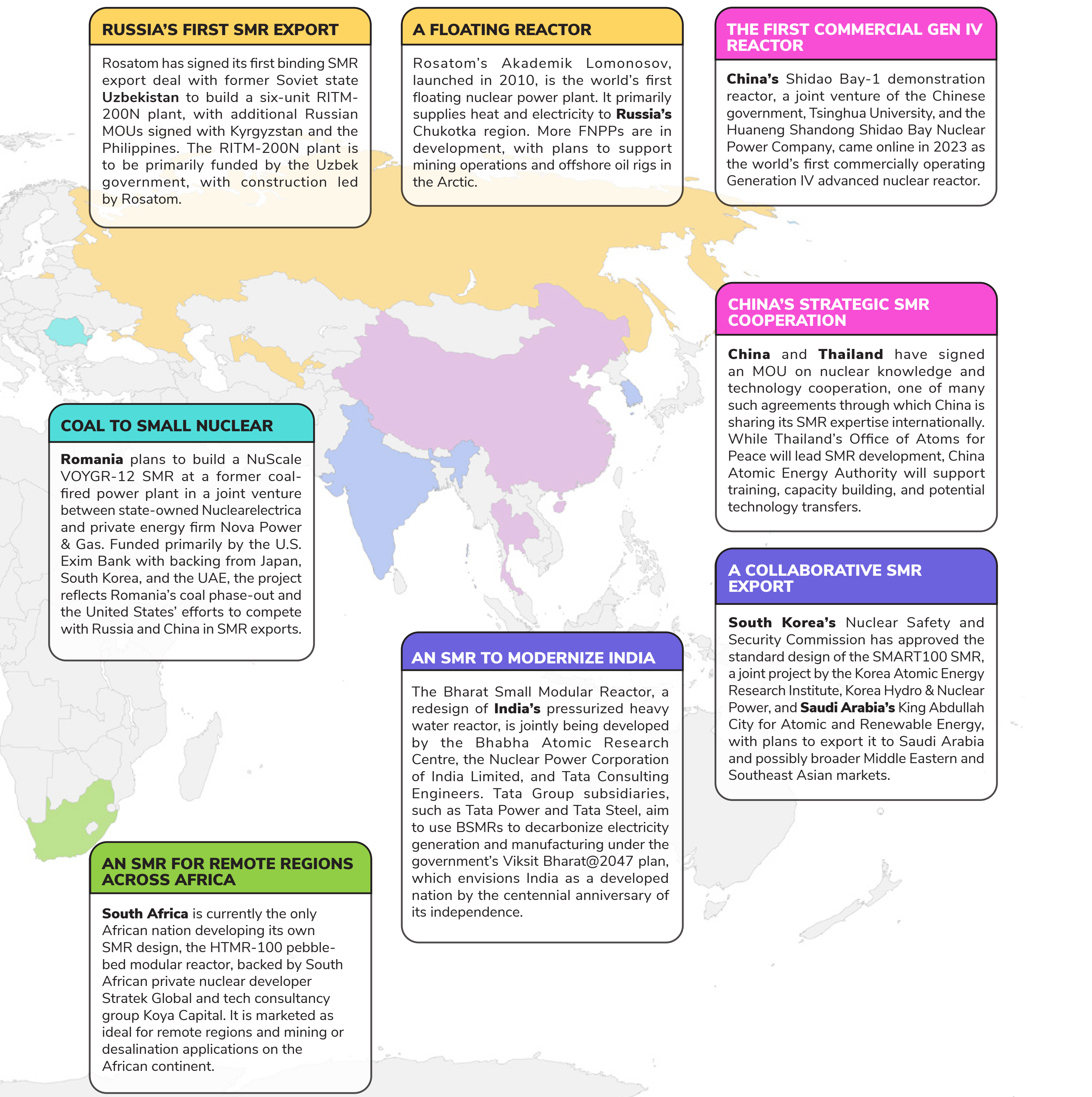
GHANA–US SMR PARTNERSHIP

Ghana plans to become the first African nation to deploy an SMR, partnering with U.S. nuclear tech company Regnum Technology Group to use NuScale's VOYGR-12 SMR design. The project is primarily funded through the U.S. Department of State's Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology (FIRST) Programs

AN ARGENTINIAN SMR

The CAREM SMR, developed by the **Argentina** National Atomic Energy Commission with government funding, is the only domestically developed SMR in South America. Initially expected to come online in 2028, its operational timeline is uncertain due to frequent construction and funding delays, worker layoffs, and fluctuating political commitments.

Lewis, N., Sibley, T., Stubblefield, N., Redmond, M., Kleinman, M., Parthasarathy, S., & Djokić, D. (2025). *The Reactor Around the Corner: Understanding Advanced Nuclear Energy Futures.* Technology Assessment Project, University of Michigan. https://doi.org/10.7302/25887



RUSSIA'S FIRST SMR EXPORT

Rosatom has signed its first binding SMR export deal with former Soviet state **Uzbekistan** to build a six-unit RITM-200N plant, with additional Russian MOUs signed with Kyrgyzstan and the Philippines. The RITM-200N plant is to be primarily funded by the Uzbek government, with construction led by Rosatom.

A FLOATING REACTOR

Rosatom's Akademik Lomonosov, launched in 2010, is the world's first floating nuclear power plant. It primarily supplies heat and electricity to **Russia's** Chukotka region. More FNPPs are in development, with plans to support mining operations and offshore oil rigs in the Arctic.

THE FIRST COMMERCIAL GEN IV REACTOR

China's Shidao Bay-1 demonstration reactor, a joint venture of the Chinese government, Tsinghua University, and the Huaneng Shandong Shidao Bay Nuclear Power Company, came online in 2023 as the world's first commercially operating Generation IV advanced nuclear reactor.

CHINA'S STRATEGIC SMR COOPERATION

China and **Thailand** have signed an MOU on nuclear knowledge and technology cooperation, one of many such agreements through which China is sharing its SMR expertise internationally. While Thailand's Office of Atoms for Peace will lead SMR development, China Atomic Energy Authority will support training, capacity building, and potential technology transfers.

COAL TO SMALL NUCLEAR

Romania plans to build a NuScale VOYGR-12 SMR at a former coal-fired power plant in a joint venture between state-owned Nuclearelectrica and private energy firm Nova Power & Gas. Funded primarily by the U.S. Exim Bank with backing from Japan, South Korea, and the UAE, the project reflects Romania's coal phase-out and the United States' efforts to compete with Russia and China in SMR exports.

AN SMR TO MODERNIZE INDIA

The Bharat Small Modular Reactor, a redesign of **India's** pressurized heavy water reactor, is jointly being developed by the Bhabha Atomic Research Centre, the Nuclear Power Corporation of India Limited, and Tata Consulting Engineers. Tata Group subsidiaries, such as Tata Power and Tata Steel, aim to use BSMRs to decarbonize electricity generation and manufacturing under the government's Viksit Bharat@2047 plan, which envisions India as a developed nation by the centennial anniversary of its independence.

A COLLABORATIVE SMR EXPORT

South Korea's Nuclear Safety and Security Commission has approved the standard design of the SMART100 SMR, a joint project by the Korea Atomic Energy Research Institute, Korea Hydro & Nuclear Power, and **Saudi Arabia's** King Abdullah City for Atomic and Renewable Energy, with plans to export it to Saudi Arabia and possibly broader Middle Eastern and Southeast Asian markets.

AN SMR FOR REMOTE REGIONS ACROSS AFRICA

South Africa is currently the only African nation developing its own SMR design, the HTMR-100 pebble-bed modular reactor, backed by South African private nuclear developer Stratek Global and tech consultancy group Koya Capital. It is marketed as ideal for remote regions and mining or desalination applications on the African continent.

an early stage (Budnitz et al., 2024; White & Lutz, 2024). The IAEA's Nuclear Harmonization and Standardization Initiative (NHSI), is trying to create common safety standards across countries to promote faster and more cost-effective deployment of advanced reactors internationally (Budnitz et al., 2024; IAEA, 2024c). However, there are national differences in regulating advanced nuclear reactors. In the United States, the NRC is developing a new rule to enable it to regulate novel designs (Nuclear Energy Innovation and Modernization Act, 2019; U.S. NRC, 2022; White & Lutz, 2024). The U.S. Department of Defense, currently building microreactors through the Army, has the option to self-regulate its nuclear infrastructure but has not (yet) applied any non-civilian safety standards (Defense Innovation Unit, 2024; U.S. Department of the Army, 2016; King et al., 2011). Meanwhile, the Canadian Nuclear Safety Commission (CNSC) and the United Kingdom's Office for Nuclear Regulation (ONR) are also developing regulations and licensing pathways for advanced reactors to accommodate the diverse technical design attributes of SMRs. China, which has fast-tracked approval and deployment of SMRs, is using demonstration projects, such as the Shidao Bay Reactor, to inform and refine its regulatory standards for high-temperature advanced reactors (Xinhua News Agency, 2021; WNN, 2023). China has fast-tracked approval and deployment of SMRs, including offshore floating nuclear power platforms under its national energy policy (Xinhua News Agency, 2021). The National Nuclear Safety Administration (NNSA) is responsible for these regulations, but some worry that it is not adequately independent from the China Atomic Energy Authority (CAEA) which promotes and funds nuclear reactor development (WNA, 2024i; IAEA, 2016). In newcomer countries, establishing the technical and regulatory infrastructure for SMRs—as with conventional nuclear power—is expected to be a long and complex process shaped by national political interests and stability, availability of relevant expertise, and global pressures.

In addition, governments may need to develop new regulations to accommodate the waste from SMRs which may include new byproducts and increased levels of radioactivity (Park & Ewing, 2023). In some cases, nuclear energy policy and radioactive waste management practices may require the reprocessing of spent nuclear fuel, which in turn would require making existing laws and regulations more adaptive and flexible to advanced nuclear fuel cycles by modernizing radioactive waste transportation safety frameworks, radioactive waste classification systems, reprocessing-related legislation, and environmental regulation (Gardner, 2020; Krikorian, 2019; U.S. NRC, 2023a). In the United States, non-nuclear functions such as enforcing environmental and transportation safety standards for radioactive waste are overseen by multiple government agencies, such as the U.S. EPA and the U.S. Department of Transportation (DOT) (U.S. NRC, 2024).

ANALOGICAL CASE STUDY APPROACH

To anticipate the potential impacts of SMRs, we use what we call the analogical case study (ACS) approach, which identifies historical case studies of technologies similar in function and impact to the emerging technology and analyzes their social, environmental, ethical, equity, economic, and geopolitical implications. On the basis of this analysis, we produce

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recommendations for policymakers and stakeholders to anticipate and minimize any potentially harmful impacts of the emerging technology (Okerlund et al., 2022).

The ACS approach to technology assessment is part of a growing suite of efforts that aim to anticipate the implications of emerging technologies in order to ensure that their development and governance are more responsible (Michelson, 2016). Some bring publics into the process, based on the idea that while they may lack subject matter expertise, they have deep knowledge about how technologies work in *society*, and particularly in the context of their own lives (Barnhill-Dilling et al., 2019; Bertrand et al., 2017; Sharma, 2020). These methods also provide citizens with a sense of civic participation and may enhance their faith in institutions, particularly at a time of eroding trust in science and technology (Kleinman et al., 2007). Ideally, they provide publics with the time and support to fully understand a technology, consider its implications, and offer nuanced recommendations (Hamlett et al., 2013; Stirling, 2008). Other methods are more expert-driven. The *midstream modulation* approach brings humanists and social scientists who study emerging technologies into the laboratory to engage subject matter experts (e.g., nuclear energy practitioners) as they do their technical work and help them critically reflect on the social, environmental, ethical, equity, economic, and geopolitical consequences of their seemingly objective choices (Fisher et al., 2006). Scenario-planning exercises deliberately bring together a diverse array of participants—subject matter experts and other scholars as well as stakeholders—to collaboratively imagine a new technology's implications (Selin, 2011). Speculative fiction workshops bring artists, writers, engineers, scientists, and lay communities together to imagine how technologies might be built and implemented to produce more desirable futures (Miller et al., 2021).

The ACS method builds on the social sciences and humanities which have demonstrated how society shapes technology and how technologies have profound social and moral implications. These relationships can be anticipated; there are patterns in how societies engage with, and are shaped by, technologies.

The ACS method builds on scholarly contributions from the social sciences and humanities, and particularly the field of science and technology studies (STS), which have demonstrated how society shapes technology, down even to the most technical details, and how technologies have profound social and moral implications (Benjamin, 2019; Bijker et al., 1987; Parthasarathy, 2007; Winner, 1980). Further, these relationships can be anticipated; there are patterns in how societies engage with, and are shaped by, technologies, which remain relatively stable over time and within a national context (Browne, 2015; Bijker et al., 1987; Parthasarathy, 2007). This includes not only how technologies affect communities and how they manage them, but also the kinds of concerns and resistance that might arise and solutions that might be feasible with emerging innovation (Nelkin, 1992). As Guston and Sarewitz (2002), who first proposed the potential utility of analogical case studies, argue:

> "...knowledge about ***who*** has responded to transforming innovation in the past, the ***types*** of responses that they have used, and the ***avenues*** selected for pursuing those responses can be applied to understand connections between emerging areas of rapidly advancing science and specific patterns of societal response that may emerge." (p. 101)

By deliberately considering the histories of analogical technologies across sectors, this project identifies relevant social patterns in how technologies develop and are implemented. It also allows us to identify successful social and policy approaches to managing technological harms and maximizing benefits.

The ACS approach goes beyond the prevailing debates to allow for a more expansive and comprehensive analysis of the potential impacts of SMRs on society.

Before taking on SMRs, we analyzed large language models (generative AI), vaccine hesitancy, and facial recognition technology in schools (Galligan et al., 2020; Okerlund et al., 2022; Wang et al., 2021). Our approach brought new dimensions into the public and policy conversations about these technologies. This includes anticipating that facial recognition technologies were likely to increase and normalize surveillance of already marginalized communities and that generative AI was likely to increase the psychological and physical risks for workers that remain as more tasks are automated. And this work has had real impact; in 2023, New York State's Office of Information Technology Services cited our work when recommending that facial recognition technology be banned in K-12 schools (New York State Office of Information and Technology Services, 2023). By the end of the year, the state legislature had passed such a ban, and the governor had signed it.

Of course, technology assessments of nuclear energy are not new (IAEA, 2013; IEA, 2019; MIT Energy Initiative, 2018). However, reports about SMRs and advanced nuclear energy mainly focus on the technical efficacy, safety, and financial viability of different designs; market readiness and technology export; security and nonproliferation issues; or technical characterizations of novel radioactive wastes. Only a few explicitly engage with the environmental justice dimensions of advanced nuclear energy (Budowle & Duba, 2024;

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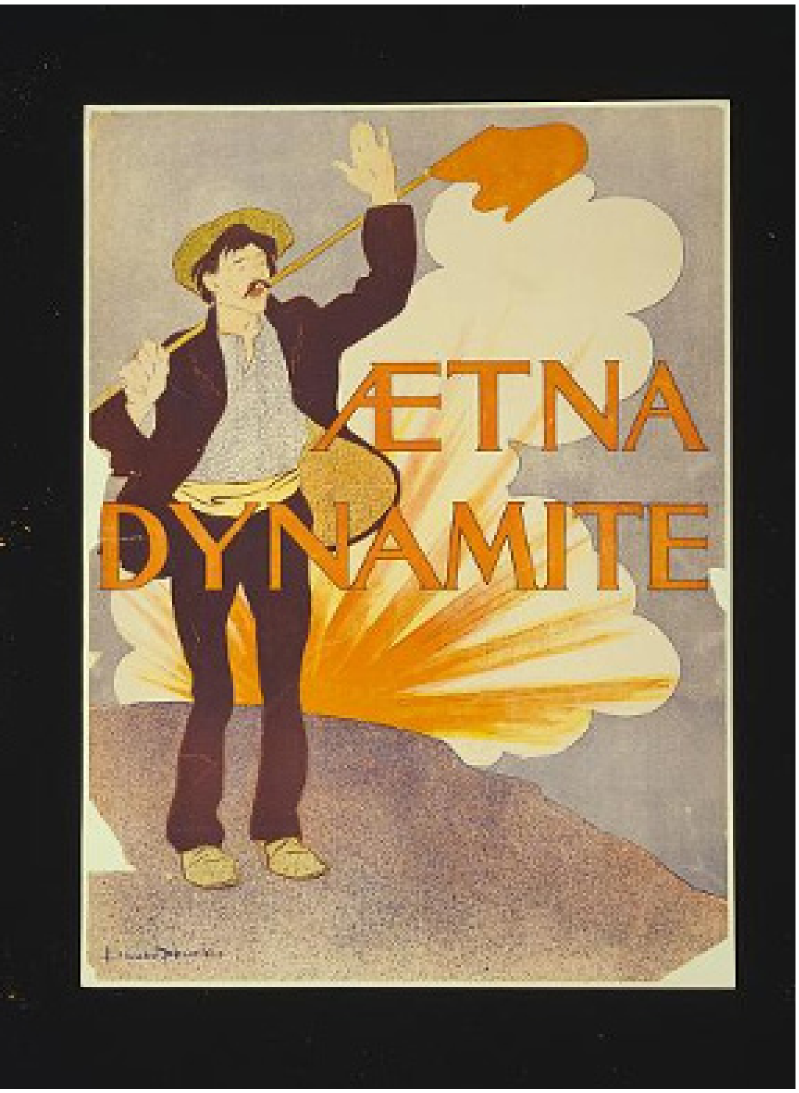
Höffken & Ramana, 2023; National Academies of Sciences, Engineering, and Medicine, 2023). Debates about the technology tend to focus on arguing whether SMRs are either too cost-prohibitive or vastly cheaper than conventional nuclear energy; either too cumbersome to build or versatile and flexibly deployable; either too risky, accident-prone, unreliable, and unproven or inherently safer by design; either generating large amounts of new types of radioactive waste or significantly reducing the volume and hazard of the waste to be managed (Abdulla et al., 2013; Ahn et al., 2024; Black et al, 2021; Budnitz et al., 2018; IAEA, 2024d; Kim et al., 2022; Krall et al., 2022; Lyman, 2024; NEA, 2025; Ramana & Mian, 2014). Such discussions are essential, though they may not always illuminate broader societal implications of the technology. The ACS approach goes beyond the prevailing debates to allow for a more expansive and comprehensive analysis of the potential impacts of SMRs on society.

> The stories that these analogical cases tell us, analyzed in the context of nuclear power's history and promises today, enable us to identify enduring social patterns that are likely to emerge in the development and deployment of advanced nuclear reactors.

THE ACS PROCESS

The ACS process begins by assembling a team composed of senior researchers and students with varied expertise. All of the senior researchers on this project have PhDs but varied technical and social science expertise. The students ranged from undergraduates to PhD candidates and represented expertise in public policy, political science, nuclear engineering, climate science, and materials science and engineering. The work began with familiarizing student researchers with the methodology and key STS ideas about the social construction of technology, responsible research and innovation, the politics of expertise, and feminist approaches to science and technology (Haraway, 1988; Haraway, 1984; Keller, 1982; Kline & Pinch, 1996; Moran-Thomas, 2020; Parthasarathy, 2010; Winner, 1980; Wynne, 1992). Students also read humanities and social science literature focused on nuclear themes, including how nuclear technology is developed and implemented in different national government structures and (geo)political regimes (Haines, 2020; Hamblin, 2021; Hecht, 1998); how reactors are designed, risk is managed, and regulatory frameworks are constructed differently in various national contexts (Hecht, 1998; Schmid, 2021); and how rhetorical and discursive tools are wielded as a reflection and reinforcement of societal values (Cohn, 1987; Endres, 2009; Hamblin, 2012). We also collectively read speculative fiction to encourage divergent, creative thinking about how advanced nuclear reactors could develop and the kinds of social worlds it might create (Chiang, 2019; Robinson, 2020). We made a deliberate effort to foster an atmosphere of open-endedness and mutual learning.

The first research task was to develop a comprehensive understanding of the national and international landscape of advanced nuclear energy, including the primary innovators and advocates, the regulatory environment, and emergent concerns, particularly given the historical controversies over nuclear power. We



Advertisement for the Aetna Dynamite Company, circa 1895. (*Edward Penfield / Library of Congress*)

relied on the research team's expertise; media articles and op-eds; scholarly publications; reports from governments, think tanks, and the private sector; our own analyses of relevant laws and policies; documentaries; and external subject-matter experts.

We then began our analogical case study analysis. As with previous projects, we identified two types of analogs. Type 1 cases are **technologies with similar functions**, while Type 2 cases are interventions **that have had similar potential impacts** to those projected for the emerging technology. Energy technologies like electric vehicles are one example of a Type 1 analog. But so too are Borlaug Wheat (developed to alleviate hunger) and vaccines (developed in response to the COVID-19 pandemic, for example), which were built in response to perceived crises—as SMRs are being built today in response to the climate and energy crisis.

For Type 2 cases, the most obvious analogs come from the history of nuclear energy, with accidents like Chernobyl, Fukushima, or Three Mile Island or waste conundrums like Yucca Mountain. But we deliberately did not begin there. Not only are these cases well tread, but we were eager to understand what the history of technology could tell us about the future of SMRs. This broad approach was also useful for developing a nuanced understanding of whether there were decision points that could have produced different outcomes and ultimately for identifying solutions to anticipated negative impacts. We began instead with Type 2 cases like the Boeing 737 Max, whose multiple catastrophic crashes resembled the potential for nuclear power plant accidents. This case taught us that industry self-regulation and multiple forms of regulatory capture in the aviation industry reoriented safety to maintain and increase company profits, which in turn minimized attention to new risks produced by the new aircraft system.

Our case studies are based primarily on secondary data. We began each by searching for published analyses of the development, implementation, and implications of the analogical technology, particularly from the historical, STS, and social science literatures. In some cases, we supplemented this work by investigating archived news sources and informally interviewing subject matter experts as appropriate.

Our process was iterative and divergent. As we worked, we identified new potential impacts and cases. For example, our early work on lithium mining, Borlaug wheat, and vaccines highlighted how technology is often a mediator in geopolitical relationships. This led us to the Nord Stream 2 gas pipeline, which exemplified the challenge of depending on Russia—a major player in the SMR industry—for access to essential resources. Studying this case taught us how war has far-reaching effects on national and regional energy policy, and perhaps less obviously, how political relationships and capture of political actors initially created this resource dependence.

In sum, the approximately 40 case studies vary across sectors and take place across the world. They include large-scale infrastructure projects, including Dutch water governance boards and the Dakota Access Pipeline, to small domestic technologies such as cookstoves. They also include both contemporary cases like carbon capture and storage, littoral combat ships, and ATMs, and historical cases like dynamite, whale oil, and railroad track gauges.

The stories that these analogical cases tell us, analyzed in the context of nuclear power's history and promises today, enable us to identify enduring social patterns that are likely to emerge in the development and deployment of advanced nuclear reactors. We have organized the report according to these patterns and anticipated implications and conclude with recommendations to steer the technology towards the public interest. Overall, our analysis aims to help policymakers, the private sector, and others interested in the promise of advanced nuclear reactors, as well as academic researchers around the world, anticipate the implications of the new technology to make informed and responsible decisions about its design and implementation.

Chapter 2: Entrenching Global Disparities

KEY TAKEAWAYS:

- Nuclear states will leverage SMR technology and infrastructure to advance their global political, economic, and military goals.
- SMR development will enable neocolonial relationships and deepen dependencies across the nuclear fuel cycle.
- States that receive SMR imports will struggle to integrate the technology into local contexts to attain significant domestic and local benefits.

Global interest in small modular reactors (SMR) is increasing as nations interested in nuclear energy evaluate their options for stable and low-carbon energy (IAEA, 2025). Although SMRs may become a vehicle for global nuclear technical cooperation, our case research indicates that SMRs will exacerbate current international power imbalances. Nations potentially receiving SMR technology hope to attain energy security and independence; however, SMRs are likely to become tools of geopolitical competition between powerful nations, who will use SMRs to exert their political, economic, and military influence in the name of exporting low-carbon, reliable, and affordable energy technology. Through international SMR contracts and agreements, states with significant nuclear-related resources—including uranium deposits, skills and expertise, a large workforce, manufacturing capabilities, and access to infrastructure financing—can generate economic and political dependencies in, secure strategic alliances with, and gain leverage over, receiving nations. Promises of local benefits for these nations are unlikely to be fulfilled due to incomplete and inequitable integration of infrastructure into local context and external control over key resources such as uranium fuel. The supply chain needed to support SMR development and operation will also contribute to perpetuating geopolitical dependencies and global inequalities. SMRs and their supply chain will become geopolitical tools for reinforcing and remaking global power through political, technological, and economic means.

As discussed in the Introduction, post-war concerns about the dual-use potential of nuclear materials and knowledge—both for military and peaceful purposes—led to a global effort of international cooperation to curb the proliferation of nuclear weapons (Rauf, 2016; Treaty on the Non-Proliferation of Nuclear

Weapons, 1970). The expansion of SMRs makes robust global governance frameworks even more essential to prevent the misuse of nuclear technology for producing weapons. However, this chapter does not address the dual-use issue—though advanced reactors do introduce new challenges for safeguardability of novel nuclear facilities (Jayarajan & Piotukh, 2023; Mayhew, 2024). We also do not explore here the use of nuclear energy technology in a military context, such as naval propulsion or military microreactors. Rather, this chapter examines the international dimensions and geopolitical implications of the development of commercial SMR infrastructure.

SMRS WILL BE USED TO ADVANCE GLOBAL POLITICAL, ECONOMIC, AND MILITARY GOALS

Nations like the United States, Russia, and China seek to export domestic SMR technology, and by extension, expand their political and economic sphere of influence (Tirone, 2023). Countries targeted for SMR imports often cannot support their own nuclear development, and will be dependent on SMR developers and countries with significant nuclear expertise if they wish to establish domestic nuclear infrastructure (Dewan et al., 2024; Igoe, 2025). Take Russian SMR exports to Turkey—despite Russia's invasion of Ukraine in 2022 and subsequent international sanctions, Turkey has remained committed to hosting a nuclear power plant that will be built, financed, and fully operated by the Russian state-owned nuclear energy corporation, Rosatom (Sebastian, 2023; Wallace et al., 2025). Several countries, including Thailand, Jordan, and Morocco, have expressed interest in Chinese SMRs (Liu & Fan, 2023). China has already exported traditional nuclear reactors as part of its "Belt and Road Initiative" to foster Chinese-led infrastructure and trade around the globe, with pending projects in places such as Argentina, and finished reactors in Pakistan (Kim, 2023). Similar to Rosatom, the China National Nuclear Corporation (CNNC) can leverage its national nuclear industrial supply chain to provide interested countries with a complete financing, construction, and operation package (Liu & Fan, 2023). The United States lags behind Russia and China in SMR exports, but has courted potential projects in Poland, Romania, Ghana, and South Africa (EXIM, 2023; Luongo, 2024). Countries that export nuclear energy technology are likely to leverage SMR technical cooperation as a means of reinforcing or expanding their geopolitical influence and bolstering nationalistic agendas.

> Countries that export nuclear energy technology are likely to leverage SMR technical cooperation as a means of reinforcing or expanding their geopolitical influence and bolstering nationalistic agendas.

Expanding the dominance of powerful nations

Our case studies show that powerful nations will leverage energy infrastructure, knowledge, and resources as geopolitical tools for international political, economic, and military objectives. Consider the construction of the Nord Stream 2 pipeline, which aimed to both deepen Europe's reliance on Russian gas and strategically weaken Ukraine (Schmitt, 2021). From 2018 to 2021, Russian state-controlled energy agency Gazprom, its subsidiary Nord Stream, and a coalition of European energy agencies financed the construction of the Nord Stream 2 pipeline, which is owned by Gazprom (Offshore Technology, 2024). The pipeline, a pair of parallel pipes, was built to ferry natural gas from Russia to Germany via a 1200 kilometer path under the Baltic Sea.

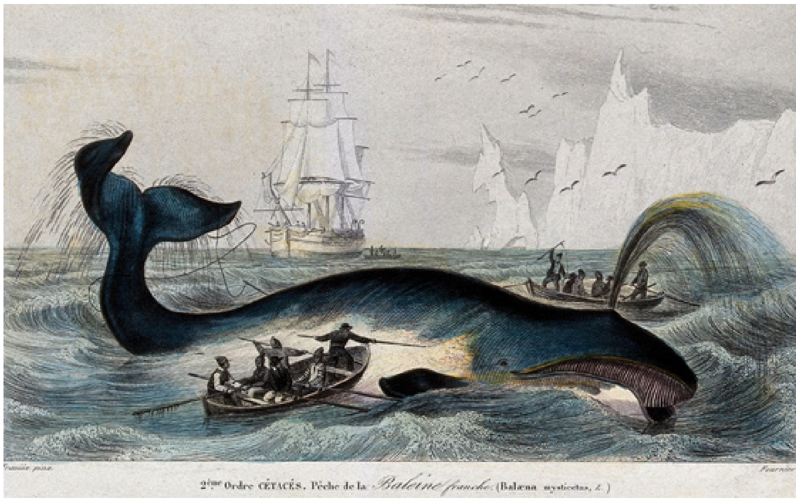
Blasting in the Culebra Cut, Panama Canal Zone.
(*Thiopene Guy* / *Flickr*)

The pipeline offered unambiguous strategic advantages for Russia. First, Nord Stream 2's annual transport capacity is 55 billion cubic meters, enough fuel to power 26 million households. Together with Nord Stream 1, another pair of offshore pipelines also owned by Gazprom, Russia could export one third of Europe's projected natural gas needs for the next two decades (Offshore Technology, 2024), entrenching Europe in long-term reliance on Russian energy exports. Russia sought to leverage the Nord Stream 2 pipeline to bypass and weaken Ukraine—a strategic interest of Russia's (Lang & Westphal, 2017). Historically, most Russian gas exports to Europe have traveled through Ukraine, providing Ukraine substantial revenue via transit fees. The combined capacity of Nord Stream 1, Nord Stream 2, and Russia's TurkStream pipeline under the Black Sea gave Russia the option to circumvent Ukraine entirely, thereby eliminating Russia's dependence on its neighbor to sell its gas on the European market (Bugayova & Kagan, 2021). Shortly after the completion of Nord Stream 2 in 2021, Russia turned its energy infrastructure into a tool of geopolitical coercion by threatening Ukraine that it would cease all gas transport through the country if it did not demonstrate "good will" by stopping military activity in the country's Donbas region, an area historically contested by pro-Russian separatists (Rettman, 2021). The following year, Russia invaded Ukraine, confirming its intentions to weaken, control, and annex its neighbor (Masters, 2023).

Powerful states are also likely to use technology to control territory and expand their regional and global influence. In doing so, they may exploit foreign workforces and expose them to risky conditions to gain geopolitical advantages. The use of dynamite to build the Panama Canal exemplifies this dynamic. When construction began in 1904, the U.S. sought to cement itself as a rising world power by gaining control of this strategic trade juncture connecting the Pacific and Atlantic Oceans (van Wagtendonk, 2014). After securing control of the Philippines, Cuba, and Puerto Rico following the Spanish-American War, the U.S. also hoped to link these Atlantic and Pacific economies more seamlessly (van Wagtendonk, 2014). At the same time, local workers suffered from brutal and deadly conditions while constructing the canal (Containerlift, 2023). To clear land for the project, workers used 61 million pounds, or almost 30 thousand tons, of dynamite, with almost half of all canal labor employed in work dealing with dynamite (EHS Today, 2001). While white personnel from the United States managed the project, most laborers were from Jamaica, Barbados, or Panama, and subject to strict racial segregation under U.S. management (Colby, n.d.; Lieffers, 2018). These laborers typically worked the most dangerous jobs, and accidents occurred frequently, such as one instance when a package of dynamite exploded prematurely, killing 26 workers and wounding 49 others (Bemis & Bagué, n.d.). Current estimates put the canal construction death toll at 5,609, though many historians believe it to be higher (Lieffers, 2018). The Panama Canal solidified the U.S. as an ambitious "international police power" in the region, a position which the U.S. used to justify military interventions and occupations in places such as the Dominican Republic, Haiti, and Nicaragua in years to come (Colby, n.d.). Dynamite was pivotal in facilitating not just canal construction, but a consolidation of global and regional power to the United States, at the cost of the safety and wellbeing of non-U.S. laborers.

Prioritizing national over collective interest

The energy industry has historically shown itself to be vulnerable to the political and economic interests of global powers. The 18th and 19th century whale oil industry reveals this dynamic well. American whalers living in Nantucket, strategically located on the coast of the Atlantic Ocean, dominated the whaling industry and possessed great whaling expertise across generations (Andreasson & Ruback, 2021). Much of the whale oil harvested by these whalers was exported to England for use in London's street lamps, which sought to limit crime at night by illuminating the city (Graham, 1935). On the eve of the American Revolution, British politicians decided to disqualify Nantucket's whalers from the Restraining Act of 1775, legislation that aimed to limit trade between the New England colonies and other countries, and initially included a clause that would prohibit colonists from carrying out any whaling activities (Graham, 1935). The politicians decided against the clause, fearing that the American oil and whaling expertise they sought would fall into the hands of France (Graham, 1935). Yet England's power calculus changed after its defeat in the American Revolutionary War. To protect its domestic whaling industry, which was framed as a resource integral to suppressing crime because of its role in lighting city streets, England decided to impose heavy tariffs on American whale oil, a move which essentially immobilized a Nantucket whaling industry already weakened by the war (Graham, 1935).



A whale being speared with harpoons by fishermen in the Arctic sea. Engraving by A. M. Fournier after E. Traviès. (*Wellcome Collection*)

The experience of the Nantucket whalers stands as a clear example of global powers wreaking havoc on energy markets for geopolitical and economic interests.

A nurse prepares a vaccine as COVID-19 vaccinations begin in Ghana under the COVAX rollout. (*World Health Organization - Blink Media - Nana Kofi Acquah / Wikimedia Commons*)

Countries may also use technologies to advance nationalistic goals, circumventing efforts for international cooperation to address global challenges. The international response to the COVID-19 pandemic in 2020 and its subsequent vaccine rollout is a telling example of states exploiting technologies—especially emerging technologies being rapidly developed in response to a global crisis—to prioritize national interests over the global collective good. International institutions attempted to implement a globally coordinated movement to suppress the spread of COVID-19. The World Health Organization (WHO), the private-public global health partnership Gavi, and the Coalition for Epidemic Preparedness (CEPI), created COVAX, a global procurement strategy designed to fund vaccine development and equitably distribute vaccines. The COVAX model relied on cooperation and buy-in from high-income countries (HIC). The model necessitated that HICs buy their vaccines through COVAX, which would first provide much-needed revenue for the non-profit organization to accomplish its mission, and second, prevent bilateral agreements between HICs and manufacturers that could disproportionately concentrate vaccine supplies in wealthy countries (Usher, 2021). However, most states did not cooperate with COVAX. Instead, over three dozen HICs, in pursuit of national and commercial interests, circumvented COVAX and made bilateral deals with manufacturers to prioritize vaccinating their populations first—a widespread display of vaccine nationalism (Bollyky & Brown, 2020; Khan, 2021; de Bengy Puyvallee & Storeng, 2022; Usher, 2021). As a result, HICs hoarded vaccine supplies within their countries, and COVAX did not have enough vaccines to distribute to low- and middle-income countries.

The above cases suggest that SMRs could be leveraged for geopolitical interests, with strategic SMR exports expanding the scope of influence for powerful nations at the expense of importing countries. SMRs will be used to prioritize national interests, increasing the wealth, political influence, and technical capabilities of powerful states, thus cementing global power imbalances. International

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cooperation to achieve collective goals, such as climate change mitigation or geopolitical stability, will be eclipsed by bilateral agreements bolstering domestic priorities or even nationalistic goals.

SMRS WILL ENABLE NEOCOLONIAL RELATIONSHIPS

SMRs will likely reinforce existing patterns of neocolonialism and create new avenues for the indirect control of low-income countries by other powerful states or transnational companies (Halperin, n.d.). This indirect control is largely enacted through economic or political means, and often makes use of past colonial relationships to continue the dependence and subjugation of former colonies (Halperin, n.d.). Global transfers of technology have played a significant role in maintaining these power structures, as wealthy global powers have better access to technologies, and thus broader control over where, when, and how they are disseminated (Lewis, 2022; Wu, 2020). Technology transfers as forms of international development reinforce technocolonialism, or the use of technology development and distribution to entrench prevailing systems of power (Hauser & Nakib, 2024; Madianou, 2025). Though advanced nuclear energy supporters claim that SMRs have the potential to expand global energy access and give states without the resources for large, traditional nuclear plants a new avenue for low-carbon energy generation, SMR research and development is currently dominated by global powers—mainly the US, China, and Russia (Dewan et al., 2024; Nakhle, 2022). By establishing relationships to export SMR technology and facilitate access to uranium resources, these powers will likely use their influence to expand their spheres of control and pursue broader political and economic objectives. Competition among these three states remains high, and each is likely to view SMRs as a valuable tool for extending systems of dependence and influence in the pursuit of global dominance.

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Deepening dependencies through international development and cooperation

Global powers will likely present SMR export initiatives as international development and cooperation, but, in doing so, they will create and reinforce dependencies. Powerful nations may also use technology transfers to gain access to another state's natural resources, expanding extractive industries and reinforcing patterns of global economic dependence. The Coca Codo Sinclair Dam in the Ecuadorian Amazon was promoted as a symbol of international cooperation and independence from Western influence. Ecuador commissioned the dam and China built and financed the project. This international partnership was aligned with Ecuador's vision of eliminating its reliance on the United States and international institutions, modernizing the country's energy infrastructure, and reducing its dependence on fossil fuels (Teijlingen & Hidalgo-Bastidas, 2022; Yu, 2023). Meanwhile, China likely sought to expand its zone of influence in Latin America's trade and investment sectors (Casey & Krauss, 2018). However, while it supported the social policy agendas of the time, the project ultimately replaced Ecuador's dependence on Western investment with reliance on a different foreign partner (Ganchev, 2020). When elected President of Ecuador in 2007, Rafael Correa moved swiftly to sever his country's ties to international financing institutions, the World Bank and the International Monetary Fund, which had dictated the country's economic policy in the 1980s and 1990s (Garzon & Castro, 2018; Teijlingen & Hidalgo-Bastidas, 2022). In their place, China became Ecuador's largest lender. Leaders of both countries promoted this new Ecuador-China relationship as a more equal "South-South cooperation" in contrast to Ecuador's former reliance on the "imperialist North" (Teijlingen & Hidalgo-Bastidas, 2022). In China, Ecuador saw the promise of equitable knowledge and technology transfer that could help its economic transition and advance its global standing. However, through multiple Chinese investments in the country, Ecuador is now reliant on Chinese goods, knowledge, and services with little ability to convert Chinese expertise into domestic capacity. Through loans from its Export-Import Bank, China funded 85% of the costs for the Coca Codo Sinclair dam, Ecuador's largest infrastructure and energy project (Teijlingen & Hidalgo-Bastidas, 2022; Radomski, 2024a). China provided its loans on the condition that Ecuador use Chinese state-owned company Sinohydro, its labor, and its supplies to construct the dam (Garzon & Castro, 2018). In essence, this was a turnkey project, where Sinohydro ran the planning, construction, and operation of the dam until the project would have been turned over to Ecuador (Teijlingen & Hidalgo-Bastidas, 2022). Yet, since the dam's inauguration in 2016, technical issues like fissures in the powerhouse pipes and malfunctioning sediment-removal equipment have prevented Sinohydro's transfer of ownership (Radomski, 2024a; Radomski, 2024b). The two nations recently negotiated an agreement which places PowerChina, the parent company of Sinohydro, in charge of operation and maintenance, raising concerns about transparency and undermining the goal of energy sovereignty by handing control of the country's largest energy infrastructure to a foreign power (Panchana, 2025; Radomski, 2024a; Radomski, 2024b; Reuters, 2025). Furthermore, most of Ecuador's debt to China is set to be repaid through direct crude oil shipments, which keeps roughly 80% of Ecuador's total oil exports across all its investment projects in the country (Casey & Krauss, 2018; Pelcastre, 2024). China also receives this oil at a discount, meaning that it could sell it for an additional profit (Casey & Krauss, 2018). The pressure to repay China through these oil loans is one factor driving petroleum drilling efforts deeper into the Ecuadorian Amazon, which has contributed to more deforestation and land degradation in the rainforest (Casey & Krauss, 2018). Rather than fostering international development and mutually beneficial cooperation, Ecuador's relationship with China has resulted in an asymmetric relationship of dependency.

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Ecuador remains reliant on not just Chinese investment and knowledge, but also its own extractive and environmentally harmful oil industry to produce domestic revenue.

As they have done for other large-scale infrastructure projects, state-owned Chinese banks have offered generous loans for the expensive up-front costs of nuclear energy projects (Kim, 2023). If countries cannot repay these loans, China may rely on "debt-for-equity swaps," in which the Chinese government will seize control of strategic assets (such as mines and ports) in return for debt cancellation (Kim, 2023). China is not the only nation to employ debt swapping, and such programs create a potential route for SMR exporters (and other global developers) to translate SMR infrastructure into political and economic leverage and neocolonial brokering (Blackwell & Nocera, 1989; Kim, 2023). Countries soliciting SMR infrastructure assistance and imports from nuclear states may find themselves in predatory loan situations that render their infrastructure and resources vulnerable to foreign exploitation and seizure.

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Reinforcing global inequities

Neocolonial relationships can also reflect global asymmetries of knowledge, positioning Western institutions as the purveyor of technical solutions and other countries as passive recipients (Hauser & Nakib, 2024). Improved cookstove (ICS) initiatives have often demonstrated an attitude of techno-saviorism—the assumption that Western technological solutions are needed to "save" other countries from complex social, political, and economic problems (Abdelnour, 2015). The Western research organizations, universities, and non-governmental organizations (NGOs) that have developed ICS initiatives frame them as crucial tools for addressing indoor air pollution, inefficient food preparation, and deforestation. ICS promoters have even claimed that better cookstoves reduce sexual violence experienced by women gathering biomass fuels for traditional stoves—an unsupported, harmful narrative that ignores the complexities of gender violence and silences the voices of the people they claim to champion (Abdelnour, 2015; Abdelnour & Saeed, 2014). Despite this view of ICS as a multi-pronged panacea for complex problems abroad, these cookstoves have rarely addressed intended problems or seen long-term uptake in target communities (Khandelwal et al., 2017). ICS technology is based on Western characterizations of other societies and their perceived issues, often failing to account for local lived experiences, cultural values, and perspectives on how problems can be best addressed on the ground (Asabere-Ameyaw et al., 2014; Khandelwal et al., 2017; Maré & M'rithaa, 2018). In India, for example, cookstove initiatives developed by UN agencies like the World Health Organization have overlooked the cultural importance of traditional Indian cookstoves and priorities of rural women—the most likely users of cookstoves—who often don't hold the same vision of a "better life" as international developers (Khandelwal et al., 2017). Context-insensitive ICS technology represents an imposition of external knowledge on recipient countries and communities, with often non-functional or even harmful effects. Meanwhile, wealthier, non-local institutions receive the majority of resources and prestige, reinforcing the dominance of Western knowledge systems (Eichhorn, 2020; Hauser & Nakib, 2024). SMR and microreactor technology transfer, often framed as saving low-income countries from energy poverty and lack of energy access, is likely to have a similar impact. As we discuss in Chapter 4, tech-solutionism will ignore local knowledge systems and silence the voices of the most affected by the complex problems that, paradoxically, technology claims to fix but that deep local knowledge is best equipped to address.

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To support energy transitions, countries and transnational companies will promote extractive economies along historical colonial relationships, as well as promote new relationships that emulate colonial power dynamics. Wealthier nations are shifting environmental and health burdens to lower-income countries in the name of a green energy transition (Bringel & Svampa, 2024). Lithium mining in Latin America for electric vehicle batteries is one such salient example. The European Union's (EU) plan to phase out internal combustion engines by 2035 necessitates an ambitious lithium extraction schedule, yet it is extremely costly and time consuming to permit mines in Europe because the social and environmental costs of mining are translated into stringent regulations (DePotter, 2023). Instead, Europe exports those burdens to low- and middle-income countries, particularly the "lithium triangle," a region covering parts of Bolivia, Argentina, and Chile that contains half of the world's lithium supply (Sanchez-Lopez, 2023; Giglio, 2021; Pacheco, 2024). Europe is not alone; other countries with growing electric vehicle markets, like China and the United States, wield influence over these global supply chains and concentrate resource extraction in the triangle (Bringel & Svampa, 2024). Some of these lithium-rich countries have forged relationships with nations who wish to expand their lithium ion battery and electric vehicle production, seeking to form joint ventures with transnational mining companies (Ahmad, 2020). Mining corporations benefit greatly from these relationships, reaping a large share of the profits of lithium extraction. Some triangle country leaders have expressed hope to translate domestic lithium ownership and mining into industrial benefits at home, but how raw materials will provide equal or similar benefits as processed industrial products such as EVs remains unclear, even as mining risks and environmental burdens are profoundly impacting rural and Indigenous groups—populations who do not have access to electric vehicles (Barandiarán, 2019; Giglio, 2021; Jerez et al., 2021). In 2023, Chile announced it would nationalize its lithium industry to boost its economy, protect its environment, and redistribute wealth (Villegas & Scheyder, 2023). In most cases, however, wealthy mining corporations keep most of the financial rewards of lithium mining, while Indigenous populations receive few benefits and bear the majority of the industry's environmental risks (Aylwin, 2025). Mining also poses great environmental and health risks for local and Indigenous populations, who have faced widespread droughts resulting from water-intensive lithium mining, negatively impacting local agriculture and quality of life (Greenfield, 2022). As foreign states and multinational corporations transform these national economies, they uphold harmful extractive industries and fail to distribute technological benefits to triangle countries, reinforcing global inequities and neocolonial dependencies, establishing hierarchical relationships whereby one society is made to work for another (Andreucci et al., 2023).

The nuclear industry has historically mined uranium through traditional colonial dependencies. During World War II, the United States secured uranium for its Manhattan Project from the Belgian Congo and former Dutch colony South Africa (Atomic Heritage Foundation, 2018; Winde et al, 2017). Between 1942 and 1980, most uranium for French, British, and American reactors came from both former and current Western colonies (Hecht, 2004). And by 1980, Africa had become the largest uranium supplier due to the legacy of colonial relationships: the UK's Commonwealth, France's African colonies, and South Africa's control in Namibia (Hecht, 2004; Hecht, 2012; Winde et al., 2017). Though these states have since achieved independence, former colonizing powers are still using them to supply their uranium through neocolonial control. While much of the world's uranium is found in Canada, Russia, Central Asia, and Australia, uranium extraction has been shifting increasingly to Africa. Nuclear states generally have more regulatory and bureaucratic hurdles

Energy efficient stove (Berkeley Darfur Stove) being used with both charcoal and firewood in Lobule Refugee Settlement, West Nile Uganda. (*Laura Toledano* / Wikimedia Commons) at home than exist in many African countries (Conde & Kallis, 2012). Malawi, Mozambique, and South Africa all provide uranium to Russia. China sources uranium from Zimbabwe and Namibia, France from its former colony Niger, and the UK from Namibia and South Africa (Becker et al., 2020; Nylander, 2020). With expanding SMR development, global powers will likely seek to increasingly rely on these colonial pasts and cultivate new extractive relationships.

Encouraging waste colonialism

Additionally, high-income countries (HICs) will exploit neocolonial dependencies to shift the risks and waste of a technology elsewhere, with significant environmental impacts, as discussed in Chapter 5. During the COVID-19 pandemic, high-income countries such as the United States, the United Kingdom, and Canada had the resources to make direct bilateral agreements with vaccine manufacturers, ensuring a stable and excess supply of vaccines (Gonsalves & Yamey, 2021; Hassan et al., 2021). Many of these countries purchased huge surpluses, emptying manufacturers' stockpiles and precluding a coordinated international effort to equitably distribute vaccine supplies (Usher, 2021). Without the availability of supplies or the financial means to outbid HICs, low-income countries had to rely on vaccine donations. These donations came from HIC hoarded stockpiles of vaccines so big that many doses went unused past their shelf life. Beneficiary countries turned down 15 million expired vaccine donations from the EU in October and November 2021, and the United Nations Children's Fund, an intermediary that distributed donations, received over 100 million of nearly-expired vaccines at the end of 2021 (Cavince, 2022). This vaccine donation stream created a significant problem for countries in Africa. In October 2021, Nigeria accepted 2.6 million vaccine donations, yet nearly half were almost expired and thus unusable (Barnéoud, 2022). Nigeria, with no other options, had to dispose of other states' vaccine waste. Over one million doses were bulldozed into a large pit and buried just outside of the capital, Abuja, posing a risk of soil and groundwater contamination (Barnéoud, 2022). Affected African countries had to invest limited resources into vaccine waste treatment plants instead of focusing on vaccine acquisition (Cavince, 2022).

The case mirrors the growing electronic waste, or e-waste, problem in Malaysia—an example of the growing phenomenon of "waste colonialism" (Michaelson, 2021; Sangaralingam, 2024). The country has become the dumping ground for a multi-billion dollar illegal e-waste ring, which uses the waste from electronics to collect valuable metals such as copper and gold and resell them (Priyashantha et al., 2022). As mentioned in Chapter 5, much of these illegal imports of e-waste come from Western countries, particularly from ports in Los Angeles, and have become a major burden for Malaysia (Palansamy, 2025). E-waste can release toxic substances and heavy metals into soil and drinking water if not disposed of properly (Palansamy, 2025). The large amounts of waste shipped to Malaysia from other countries has made waste management untenable, and forced municipalities to divert many taxpayer dollars toward environmental clean-up efforts (Palansamy, 2025). Global electronic consumption continues to increase with each passing year, and countries like Malaysia pay the price of this technological waste, struggling with public health and

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environmental crises as a result (Priyashantha et al., 2022).

While international nuclear technology transfers generally expect receiving countries to articulate a plan for managing radioactive wastes, they are not required to have all the necessary infrastructure or national policy in place (IAEA, 2024b). Additionally, novel waste types generated by advanced reactors introduce new technical and regulatory challenges (Cothron & Koshgarian, 2024). Thus, nations without adequate frameworks for safe spent fuel storage and disposal or uranium mining waste management could introduce risks of negative health and environmental consequences, often impacting the most vulnerable, as discussed in Chapter 5. International frameworks that promote safe radioactive waste management, like the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management or bilateral spent fuel takeback clauses in reactor export agreements (Bunn, 2001; IAEA, 2024b), are important commitments for responsible waste handling. However, they do not guarantee that nations will adhere to those frameworks or that countries and communities will not be shouldered with waste burdens they did not consent to (France-Presse, 2015; International Panel on Fissile Materials, 2011). The implementation of safe spent fuel and mining waste management strategies varies globally, and long-term stewardship challenges remain.

Our cases demonstrate that SMRs will both enable neocolonial relationships under the banner of global cooperation and technological development. Leveraging the reliance on foreign expertise, funding, and infrastructure, new or existing avenues of geopolitical control will be created or reinforced. Nations with uranium resources needed to fuel SMRs will also be vulnerable to neocolonial dependencies, as powerful nuclear nations pursue expanded pathways for uranium extraction, threatening environments and labor protections instead of guaranteeing safety and economic benefits. Spent nuclear fuel and uranium mining waste could disproportionately impact nations lacking adequate waste management infrastructure, reinforcing the inequitable distribution of the risks of SMRs for the benefit of powerful nations or corporations.

SMR TECHNOLOGY TRANSFER WILL BE INCOMPLETE AND INEQUITABLE

Like with many emerging technologies, nations and companies developing SMRs promise a slew of technical, political, and economic benefits

> Given the large size and complex manufacturing supply chains of conventional nuclear reactors, countries see the potential scalability, lower upfront costs, and siting flexibility of SMRs as factors that will make adoption possible in areas that would otherwise have difficulties supporting traditional, large reactors.

to adopting countries. However, despite the promises of prosperity from SMRs, non-nuclear energy states will struggle to translate SMR technology into local benefits. Rising demands for reliable, low-carbon energy have ignited a new global interest in nuclear power, including among nations that do not currently have nuclear energy (Dewan et al., 2024). Given the large size and complex manufacturing supply chains of conventional nuclear reactors, countries see the potential scalability, lower upfront costs, and siting flexibility of SMRs as factors that will make adoption possible in areas that would otherwise have difficulties supporting traditional, large reactors (Daigle et al., 2024; Murakami & Anbumozhi, 2022). In essence, SMR technology promises to create more accessible pathways for domestic nuclear reactor development because it does not necessarily depend on the capacity or existence of local grids—one limiting factor for adding new power generation—and could electrify remote and rural areas. SMRs are also attractive for their potential to fill energy demands in local industries, expand energy options for reducing carbon emissions (especially if supplemented with renewable energy), and reach economies of scale to lower costs (Daigle et al., 2024).

Depending on unreliable funding and politics

Precarious international funding sources and decisionmaking can undermine domestic energy transitions. The role of international organizations in Romania's attempts to shift away from historical coal dependency illustrates this well. After the fall of the Iron Curtain in the 1990s, the World Bank imposed a decision on the Romanian government to close down national coal mines due to economic inefficiency (Bucată, 2020; Kozak, 2013). But the country lacked an industrial substitute to replace coal infrastructure, and this internationally-driven decision exacerbated social inequities, abandoned communities, and massive job loss in the coal sector (Catună, 2022; LaBelle et al., 2021; Nicola & Schmitz, 2022). In 2019, as part of its Green Deal to reach net-zero emissions by 2050, the EU identified Jiu Valley as a candidate for transition assistance away from its dying coal industry (European Commission, 2019). That same year, the Romanian government partnered with a domestic wind power corporation to fund a wind power workforce retraining program to address the hardships faced by Jiu Valley's coal miners (LaBelle et al., 2021). While the program aimed to use funds from both the EU and Romanian government to train around 8,000 new workers, EU funding support was never secured for the project, and the collapse of Romania's ruling coalition government halted any national funding (LaBelle et al., 2021). As a result of these unstable funding pathways, the program lacked resources and proved a failure, training only one worker for a career in wind power (LaBelle et al., 2021). Under the EU's "Just Transition Fund," an initiative created to support EU member states in green energy transitions, Jiu Valley may be eligible for more concrete assistance in the future, yet the funds for the platform have fallen from €40 billion in 2019 to less than €20 billion today, eroding trust in the reliability of these resources for stewarding Romania's energy transition (Bucată, 2020; European Commission, n.d.). In the meantime, Romania's dependence on foreign funding has caused it to lag behind other EU states in its transition away from coal. Jiu Valley miners continue to face economic and social costs of the transition without viable job alternatives, and the burning of coal remains a considerable health risk across the country (Ciobanu & Stoica, 2018).

Implementing technology without local considerations

The modularity and small scale of SMRs have made them an attractive electricity option for remote and rural areas worldwide. Yet often when technology is transferred internationally, it prioritizes Western knowledge and ignores national contexts, leading to failed technological uptake—or worse, outward harm (Khandelwal et al., 2017; Pandey et al., 2021). Improved Cookstove (ICS) initiatives, for example, attempt to bring more efficient, safe, and environmentally friendly stoves to areas in Africa, Asia, and Latin America which often rely on biomass fuels for cooking that cause indoor air pollution and health harms (Urmee & Gyamfi, 2014). UN agencies and NGOs have provided funding and development support for many of these initiatives, placing immense pressure on nations to find technical solutions to their perceived cookstove problems (Khandelwal et al., 2017). While some areas have embraced incorporating modular stove types, many of these internationally-developed programs have failed to consider important contextual questions, such as local cooking preferences, fuel access, and willingness to pay for the technology (Gadgil & Booker, 2011). Poor information sharing between researchers, program leadership, and communities has also resulted in stove technology that is incompatible with social expectations and local needs (Gadgil & Booker, 2011; Urmee & Gyamfi, 2014). As a result, international stove technology initiatives such as ICS have struggled to consistently minimize health harms in target regions, leaving these populations at greater risk of respiratory and cardiovascular illnesses than their electric and gas stove-using counterparts (Fullerton et al., 2008). Communal ovens in neighborhoods across Morocco—an integral part of society for centuries—present a different picture. There, the cultural preference for communal cooking spaces plays a vital role in shaping quality of life, often more so than technological improvements in private cooking appliances (Belarte et al., 2024; Steiner, 2006).

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Historical technology transfers have also taught us that without supportive, congruous infrastructure and a strong research capacity, countries will be unable to translate regional SMR deployment into lasting domestic benefits. Consider the Green Revolution, the period from the 1950s to 1980s that saw an increase in global food production through the distribution of agricultural technology such as high-yield crops (Wu & Butz, 2004). During the international agricultural technology transfers of this time, countries without substantial domestic research capabilities experienced few benefits (Pray, 1981). States with robust agricultural research programs were more likely to invest and participate in exchanges of high-yielding variety (HYV) strains of wheat, and even develop their own varieties to fit domestic climate and agricultural conditions (Pray, 1981). The Indian Agricultural Research Institute, for example, was an established organization that successfully pushed the Indian government to import HYVs in the 1960s, whereas in countries like Bangladesh, which lacked this same research foundation as India, the first HYV uptake occurred almost a decade later (Pray, 1981). Thus, global disparities in food security arose with this delayed—or in some cases, non-existent—uptake, and agricultural tech transfers proved largely dependent on domestic research capabilities and effective international information sharing.

Exacerbating local inequities

Beyond perpetuating global inequities, SMRs are also likely to reinforce disparities at national and local levels. In recipient countries, political and industry elites are likely to oversee SMR imports and expanded domestic uranium mining, forging close ties with counterparts from exporting nations. As a result, these domestic elites will likely reap the primary benefits of these operations and act as stewards of the interests of wealthier nations within their own country. Meanwhile, domestic workers and local communities will bear most of the environmental impacts associated with SMRs discussed in Chapter 5, yet experience few social, political, or economic benefits.

Domestic elites will likely reap the primary benefits of these operations and act as stewards of the interests of wealthier nations within their own country. Meanwhile, domestic workers and local communities will bear most of the environmental impacts associated with SMRs, yet experience few social, political, or economic benefits.

Geopolitically motivated transfers of technology may enrich a beneficiary country's elites at the expense of other populations in the receiving nation. During the Green Revolution, technology was primarily exchanged between the United States government, U.S.-funded research and philanthropic organizations, and nations dealing with hunger crises, with the US hoping to use these transfers to quell the global spread of communism (Kumar et al., 2017; R. Patel, 2012; Perkins, 1998). Politicians and philanthropists worried that famines in India in particular would spur the country along the same communist direction as China, where hunger had led to political unrest and helped prompt a communist revolution (Kumar et al., 2017; Perkins, 1998; Saha, 2013). U.S. efforts thus focused on developing high-yield crops that would rapidly increase food production

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to deal with hunger, rather than targeting the more fundamental issues of inequitable food and resource distribution in India (Perkins, 1998; Baranski, 2015). Scientists targeted wealthy, landowning farmers in India to try out these new high-yield crops, as they were better able to take on the risks of potential crop failure, and also shoulder the costs of expensive fertilizers and large sums of water required to sustain these crops (Aga, 2021; Public Broadcasting Service, 2020a; Saha, 2013). Yet as a result, local farmers could not afford to grow these capital-intensive crops. While food production increased substantially, high-yield crops degraded soil quality, lowered water tables, and minimized biodiversity with disastrous effects for local farmers (Aga, 2021). By prioritizing its geopolitical aims in the transfer of agricultural technology, the US failed to distribute technological benefits across Indian society, benefiting the country's elites while harming local communities.

Developers and government officials emphasized that the Coca Codo Sinclair Hydroelectric Power Plant in Ecuador would foster national prosperity through job creation and increased energy supplies, but in practice the dam's construction has had mixed impacts. Developers promised that the project would source 70% of its workforce locally, yet actual local employment only reached 40%, and the majority of these jobs were in temporary construction (Teräväinen, 2019). When construction finished, unemployment in the region rose when locals could not easily return to their old jobs or find new work (Vallejo et al., 2018). Workers from outside the local community, primarily from China or elsewhere in Ecuador—most of the Ecuadorian workers were engineers from Quito (Nathanson, 2017)—took on the dam's long-term and higher-paying technical roles because they possessed the expertise and education that locals did not (Teräväinen, 2019; Vallejo et al., 2018). The turnkey nature of the project also played a role in preventing Ecuador from gaining significant technological or knowledge transfer, while leaving the country with costly, defective energy infrastructure and new environmental risks—the dam is riddled with cracks and faulty technology, and its proximity to an active volcano and eroding river beds threatens its integrity further (Casey & Krauss, 2018). Additionally, the dam has changed the ecology of fish habitation in the region, reducing a primary food source for local Indigenous populations (Palma, 2017). While the dam has succeeded in covering a significant part of Ecuador's electricity demand, the country continues to grapple with

Norman Borlaug teaches a group of wheat scientists at one of the International Maize and Wheat Improvement Center's experimental fields in Mexico. (*International Maize and Wheat Improvement Center* / *Flickr*)

widespread energy shortages due to energy infrastructure neglect, droughts, and alleged corruption under new leadership (Turkewitz & León Cabrera, 2024; Yauri, 2024). Promises of affordable and dependable energy access have remained elusive, especially among low-income local populations during the recent and ongoing energy crisis, who still struggle to pay high energy costs and often cannot afford a generator for their homes (Turkewitz & León Cabrera, 2024).

In Mexico, political and industry elites profit from a Coca-Cola bottling plant in the state of Chiapas, while local Indigenous communities face public health harms and water shortages. Since the 1950s, Coca-Cola, a major transnational corporation headquartered in the United States, has remained not just a cultural symbol and staple in many Mexican diets, but also a major contributor to Mexico's economy (Gómez, 2019). At times, the line between Coca-Cola's corporate leadership and the country's political leadership have been blurred, such as when Vicente Fox, the former head of Coca-Cola in Latin America, became Mexico's president in 2000 (Gómez, 2019; Lopez & Jacobs, 2018). The brand relies on numerous bottling plants like its facility in Chiapas to maintain this level of economic and cultural dominance. In exchange, Chiapas residents struggle with widespread diabetes, as clean water is hard to come by and Coca-Cola provides a cheap and accessible alternative (Lopez & Jacobs, 2018). Residents point to the large (and government-subsidized) water intake of the bottling plant as another strain on the region's already dwindling water supply (Lopez & Jacobs, 2018). Local Mayan farmers struggle to make a living given these droughts, and also tend to be at higher risk of diabetes than Mexicans of European descent (Domínguez-Cruz et al., 2020; Leroy et al., 2022). The Chiapas plant thus helps uphold Coca-Cola's global corporate dominance and the concentration of wealth to the national elite by extracting resources from the local population and contributing to serious public health crises.

Our case studies indicate that the benefits of SMRs will likely concentrate among national actors who already possess power and access to international networks. Technology access often requires connections and resources, and whether these are leaders of transnational corporations, as in the Coca-Cola case, or wealthy landowners, as in the case of the Green Revolution, the conditions around international SMR contracts are vulnerable to these same power dynamics. Beyond technological distribution, global SMR developers will need to strengthen paths for resource extraction and land use to remain competitive. As a result of these asymmetrical domestic benefits of international partnerships, local inequities will be reinforced.

Our case studies indicate that the benefits of SMRs will likely concentrate among national actors who already possess power and access to international networks.

Global powers will shift the risks of SMRs onto less powerful countries through physical infrastructure and resource extraction pathways, reinforcing global inequities. As the cookstoves and Green Revolution cases show, for countries without the domestic capacity to support SMR research, development, and integration, exported technology is not likely to consider the full complexity of local conditions. Russia's nuclear reactor export packages—Rosatom's "Build, Own, Operate" model—are an example of this, with the state not only being responsible for building the plants, but also promising training for local workforces and helping with construction services, funding, long-term maintenance contracts, and sometimes even uranium fuel supply pathways (de Carbonnel, 2013; Foltynova, 2022). Russian loans, subsidized by the government, are often used to make these projects attractive, sometimes covering over 80% of construction costs for importing states (Foltynova, 2022). Yet, as the Coca Codo Sinclair Dam case makes clear, these models of funding and construction often seek to reinforce dependencies of low- and middle-income countries on foreign investment, rather than prioritizing the distribution of economic benefits and sustainable transfer of knowledge to receiving states. The Jiu Valley and whale oil cases also reveal how technology or industries are vulnerable to fluctuations in international funding, political priorities, and even war. This dependency and destabilization, paired with intensive resource extraction, will also saddle low- and middle-income countries with environmental and public health harms, as seen in the case of lithium mining in South America.

In sum, despite SMR proponents promising that SMRs will provide energy security, foster international cooperation, and be easily transferable into a variety of international contexts, the technology will be difficult to integrate into local environments and likely extend global power imbalances. These power imbalances will deepen global and local inequities, limiting the benefits of SMRs to corporate leaders, politicians, and wealthy citizens. Furthermore, the vulnerability of energy markets and technology to geopolitical aims can be used by global powers to destabilize or control other countries. Technology transfers motivated by geopolitical and nationalistic goals instead of local and collective interests are ineffective or even harmful for recipients, not addressing the root of complex social and political problems. As nuclear energy competition between the US, Russia, and China continues to build, these powers will look to expand their networks of influence and foster relationships with more countries, including those that are vulnerable to the geopolitical interests of more powerful nations. These countries are unlikely to reap the potential technological benefits of SMRs. This disparate difference between costs and benefits will reinforce or create neocolonial relationships across the nuclear fuel cycle, further entrenching the dominance of powerful nations and transnational corporations.

The Coca Codo Sinclair hydroelectric power station during construction, circa 2016. (Ecuadorian Ministry of Tourism / Wikimedia Commons)

Chapter 3: Privileging Markets over the Public Good

KEY TAKEAWAYS

- The SMR industry will prioritize profit over public interests, resources, and safety.
- Profit considerations will undermine industry promises of rural distribution and climate change mitigation.
- The SMR market will likely reinforce and exacerbate racial inequity and racial capitalism.
- Promoting SMRs as crucial for national goals will enable the industry to evade regulatory oversight, increasing the risks of SMRs.
- Financial pressures will force the SMR industry to take risky shortcuts.
- The SMR industry will leverage its expertise to influence regulation.

Small modular reactor (SMR) developers depict their technology as a necessary and revolutionary upgrade from the reactors in use for the past 70 years. With this framing comes the promise that these novel reactors can not just mitigate the risks and reduce public opposition but can also solve deeper social ills such as inequitable energy distribution and climate change. However, market pressures will likely prevent these promises from becoming reality and will actually increase the risks of SMRs, making them vulnerable to error and even catastrophic malfunction.

Industry prioritizes profit. To maximize financial gains, the SMR industry will emphasize the novelty of its technology to suppress regulatory oversight. It will frame SMRs as vital to fulfilling national goals like energy and infrastructure security, which will limit governments' efforts to regulate the technology. And, the industry will exploit its superior expertise on SMR technology to influence regulation. Finally, the SMR industry will prioritize economic viability over public interests and access to public resources. This includes reinforcing racial inequities in pursuit of profit, exploiting racialized labor and land to support the SMR supply chain.

THE SMR INDUSTRY WILL ESCAPE STRINGENT REGULATORY OVERSIGHT

Like other industries and as discussed in other chapters, SMR developers will frame the technology in terms of national objectives, including innovation and economic competitiveness, energy security, and the mitigation of climate change. In addition, they may lack the technical knowledge to regulate the industry forcefully. Ultimately, this will produce industry-friendly governance, with regulators unlikely to evaluate the technology critically or slow it down.

The power of public interest framing

American industry has long framed its work in emotional, and even nationalistic, terms to avoid government oversight. After the invention of the telephone in 1876, the American Telephone and Telegraph company (AT&T) had a monopoly over telephone service. This dominance enabled it to construct a nationwide long-distance telephone network (Langdale, 1978). But at the turn of the 20th century, the rapid emergence of smaller, independent telephone service providers disrupted this monopoly, and the refusal of companies to overlap their telephone lines with competitors led to fragmented and isolated service options for subscribers (Mueller, 1997). AT&T hoped to consolidate the independents into its system, but the US government fought to protect smaller providers from what it interpreted as a clear violation of the Sherman Antitrust Act, a law that prohibits monopolies and promotes competition (History of Computer Communications, n.d.). In 1907, AT&T's new president Theodore Vail responded with a massive publicity campaign to convince the government and public that his company's exclusive control over a long-distance network served the country's greater goals of national unity, self-reliance, and democracy (Long, 1937; MacDougall, 2006). Vail coined the phrase "one system, one policy, universal service," and launched national magazine advertisements to sway public opinion towards his cause (Griese, 1977). The framing worked, and the U.S. government decided that competition would harm the industry, and by extension, the public (Yale Law Journal, 1975). In 1921, the U.S. Congress passed the Willis-Graham, Act,

Sergius P. Grace, Vice-President of the Bell Telephone Laboratories, shows the old and the new in telephones. (*U.S. Library of Congress*)

which exempted telephone companies from antitrust laws so that they could merge with competitors (Mueller, 1997). By 1932, AT&T had become a "natural monopoly," controlling 80% of the national telecommunications network (Lasar, 2011; Mueller, 1997). This natural monopoly greatly minimized the public's power to challenge high rate increases and reductions in quality of service. This problem continues today, with an oligopoly of mobile telephone providers (Garcia, 2005; NTCA – The Rural Broadband Association, n.d.).

Similarly, the recent history of climate change solutions is littered with language of innovation fixes, which depress attempts at regulatory oversight while hiding risks.

Smokestacks at a coal-fired power plant, Arizona. (*Nick Humphries* / *Creative Commons*)

For example, fossil fuel companies promote carbon capture technologies as solutions to the climate impacts of their industry. There are two types of carbon capture approaches: (a) carbon capture and storage (CCS), or point-source capture discussed further below, which collects carbon dioxide (CO2) at its emission source, such as the smokestack of a coal-fired power station, and (b) carbon dioxide removal, such as direct air capture (DAC), which extracts CO2 from the ambient air (Center for Environmental International Law, n.d.). Both capture and compress CO2 into a fluid, which is then transported to storage sites, typically deep underground in geological formations (Mahjour & Faroughi, 2023; National Energy Technology Laboratory, n.d.). Proponents frame CCS and DAC as effective methods to tackle the climate crisis while maintaining the vast energy infrastructure that powers the world (Carbon Capture Coalition, n.d.; Center for Climate and Energy Solutions, n.d.). However, this framing omits the social and environmental risks and lack of regulatory oversight (Asayama & Ishii, 2017; Gunderson et al., 2020). This includes the leakage problem. Experts estimate CCS storage infrastructure could leak upwards of 25 gigatons of CO2, which undermines claims of containment and could contribute to warming temperatures by 0.01–0.02 degrees (Vinca et al., 2018). In addition, injecting liquidized carbon into the ground can induce seismic activity, increasing the possibility of earthquakes at storage sites (White & Foxall, 2016). Nevertheless, global investment in carbon capture, transport, and storage is quickly growing, valued at USD $9–11 billion in 2024 (Casey, 2024; Global Market Insights, 2024). Regulations to manage these environmental risks are still insufficient (Environmental Integrity Project, 2023; Huron River Watershed Council, 2024).

Security framings are also extraordinarily powerful, even suppressing considerations of cost and effectiveness. In 2003, the United States Navy committed $15 billion to the Littoral Combat Ship (LCS) program, a large fleet of small, modular, technologically advanced ships conceived by Deputy Defense Secretary Robert Work to perform a variety of unspecified combat roles (Morgan, 2003; Sapien, 2023). Secretary Work advertised LCS as the revolutionary technology needed to advance the U.S. naval fleet into the future and confront emerging national security threats (McLeary, 2022; Axe, 2011). Even though there was limited planning and little to suggest that the "advanced" designs were feasible, Congress appropriated funding (Axe, 2011; McLeary, 2022). The Defense Department used the funds to add weapons, features, and purposes to the emerging LCS systems to the point of absurdity (Axe, 2011). This further obscured the program's actual purpose and burdened taxpayers with exorbitant costs, while the ships failed (Work, 2013; Axe 2011). Some Navy officials petitioned to permanently retire the costly program, but defense companies—who have lucrative maintenance contracts—have successfully slowed decommissioning efforts (Lipton, 2023; McLeary, 2022).

These analogical cases suggest that the SMR industry will frame the technologies as advancing national interests, but industry needs will overtake other public interest concerns. This framing will also make it harder to regulate SMRs, as such oversight will be viewed as harming innovation, not to mention achieving the goals of climate change and national security. When coupled with existing financial and expertise pressures that regulators face, this will reduce the technology's safety and increase the likelihood of accidents.

Pressures to compromise safety

Developers claim that the same design features that make SMRs more efficient and easier to operate make them safer. They require fewer components, which reduces maintenance needs and opportunities for malfunction; use smaller reactor cores, which physically limit the amount of nuclear material; and employ passive safety systems that do not require human intervention (U.S. DOE-NE, n.d.-c). These technical promises, however, obscure the economic pressures that the SMR industry is likely to face. Ultimately, despite extensive safety regulations and redundancies in reactor design, our analogical cases suggest that the SMR industry will prioritize economically feasible (profit-maximizing) reactors in ways that undermine safety culture and practices.

Littoral combat ship USS Independence (LCS 2) arrives at Joint Base Pearl Harbor-Hickam. (*Defense Visual Information Distribution Service*)

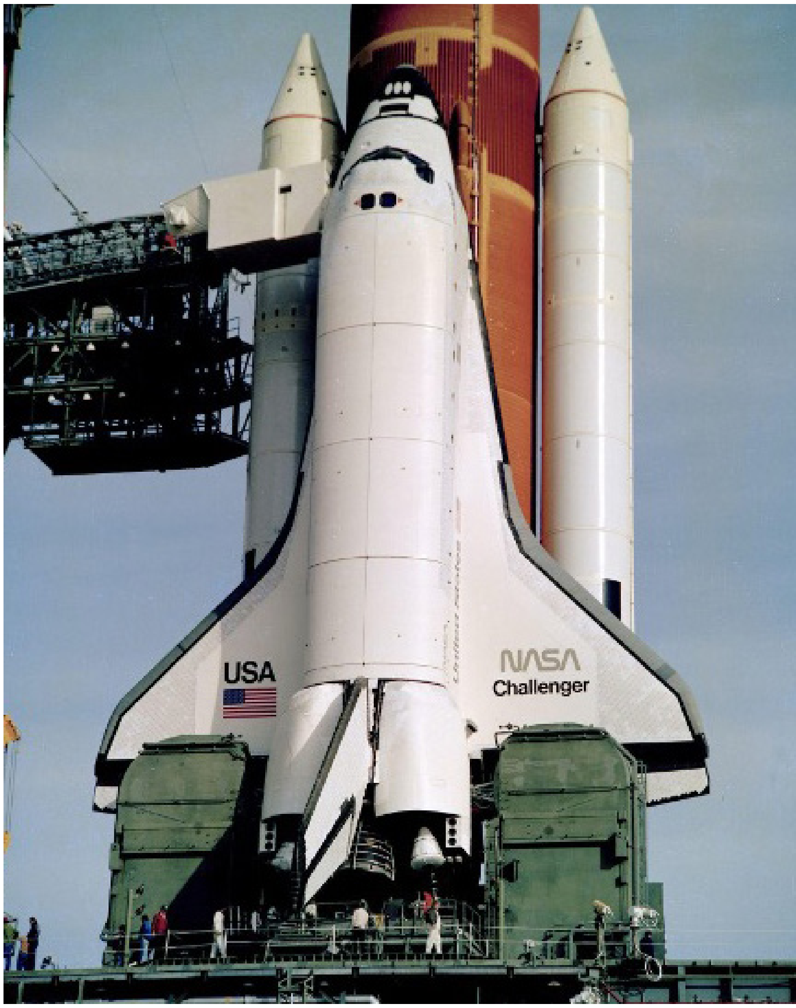
When Boeing merged with competing aircraft manufacturer McDonnell Douglas in 1996, it traded its venerated innovation and safety culture for an approach that worshipped cost-cutting procedures to increase stock prices and shareholder value (Tkacik, 2019; Wendel, 2023). Safety practices eroded across the new company, but the most notorious impact was on its new aircraft, the 737 Max, which crashed twice, in 2018 and 2019, killing hundreds of people (The Associated Press, 2024). Boeing conceived the aircraft in a very competitive market environment. In 2010, Airbus, its primary competitor, had released the fuel efficient, single-aisle A320NEO. Boeing's customers liked the A320NEO and threatened to switch suppliers. So, the company rushed into production for a competing model: the 737 Max (Clark, 2011; Seattle Times Business Staff, 2019). Its leaders indicated that the plane was necessary for the company's survival, suggesting that all decisions—including those related to safety—be made in service of a competitive, punctually delivered product. Boeing responded to this pressure by cutting engineering and regulatory corners, which increased risk to the flying public (Schacter, 2021).

Instead of innovating an entirely new plane design, Boeing modified its previous "Next Generation" model with two larger, more fuel efficient engines. The company hoped this would shorten production time, simplify the Federal Aviation Administration (FAA) certification process, and save costs (MacArthur, 2020; Turman, 2021). However, the new engines and their placement on the wings created a tendency for the Max to pitch up in flight, threatening to stall the plane in mid-air. Engineers remedied this problem by tailoring their Maneuvering Characteristics Augmentation Systems (MCAS) software to pitch the plane's nose back down. The company intentionally concealed these new features of the software and its impact on flight simulations from regulators. Had FAA officials known about this, they would have required pilots to take lengthy training courses before flying the Max. Such training requirements would lower the plane's market value, so Boeing misrepresented the change as a continuation of familiar, regulated software rather than a novel system: a deadly and profit-motivated decision (U.S. Department of Transportation OIG, 2020). In addition, managers pushed engineers to complete designs at twice the usual pace, resulting in incomplete, sloppy technical specifications (Gelles et al., 2019). Boeing also outsourced most of the Max's software development to underpaid, inexperienced coders to circumvent union requirements (Tkacik, 2019). Throughout the development process, Boeing leaders worked hard to remove any barriers to meeting the production timeline (The House Committee on Transportation & Infrastructure, 2020).

But the Max's failures are only symptoms of a broader phenomenon. In the years following the crashes, Boeing's 777 model experienced multiple problems, including plane engines breaking in mid-flight and raining down debris (Zweifel, 2021). In 2024, an emergency door flew off a 737 Max 9 in the middle of a flight. Subsequent investigations discovered systemic maintenance and equipment issues, including misdrilled holes on fuselages, missing bolts, and engines that went up in flames (Saric, 2024). A 2024 FAA report found Boeing lacked a systematic way of capturing and resolving safety concerns and that its employees were unaware of the company's efforts to establish an enterprise-wide safety culture (Organization Designation Authorization Expert Review Panel, 2024).

The Boeing 737 Max story is one of many examples of how pressure to meet deadlines minimizes concerns about error, leading to disaster and death. Similar financial and time pressures emerge even in state-run enterprises, with the same risky outcomes. While explanations for the 1986 Space Shuttle Challenger explosion that killed seven astronauts cite a variety of organizational problems, they all recognize that NASA managers shut down conversations about error and concerns from engineers because they had a timeline to maintain (Gouran et al., 1986; Heimann, 1993; Vaughan, 1996). NASA had already postponed the Challenger launch three times. And after a series of failures that were met with increased press scrutiny, the agency was at risk of tarnishing its reputation (Gouran et al., 1986; Higginbotham, 2024). On January 27th, the day before the planned launch, a group of engineers at Thiokol, the private contractor in charge of the shuttle's booster rockets, petitioned their supervisors to stop it. In an impromptu meeting between Thiokol and NASA management, they presented data that cast doubt on the shuttle's ability to fly in the cold temperatures expected the next day. However, NASA officials vehemently opposed the engineers' recommendation, with one NASA official exclaiming, "My God, Thiokol, when do you want me to launch, next April?" (Presidential Commission on the Space Shuttle Challenger Accident, 1986). Initially, some of the Thiokol managers sided with the engineers, but they all ultimately agreed with the NASA officials to proceed with the launch (Gouran et al., 1986; Higginbotham, 2024). After the following day's disaster, some of the Thiokol managers and engineers reported that they felt pressure from NASA staff to reverse their decisions because of the perceived desire to launch (Gouran et al., 1986). They felt this pressure changed the burden of proof to proving to NASA leadership that the launch was unsafe, rather than taking the typical risk mitigation approach of presuming the system was unsafe until proven otherwise (Gouran et al., 1986).

Economic pressures also influence the preparation and management of disasters. In 1990, BP and other big oil companies jointly founded the Marine Spill Response Corp (MSRC), a non-profit organization that specialized in oil spill cleanup. They calculated that participating in MSRC would be cheaper than reforming drilling operations to proactively prevent spills, while reducing both the costs of disaster management and liability for damages incurred during cleanup (National Commission on the BP Deepwater Horizon Oil Spill and Offshore



The Space Shuttle Challenger waits on Launch Complex 39A at Kennedy Space Center before its first mission, STS-6, launched on April 4, 1983. (*NASA* / *Flickr*)

Drilling, 2011; Stephens & Flaherty, 2010). However, MSRC proved an inadequate solution for BP's risky deepwater drilling operations. It lacked the resources, equipment, and personnel to comprehensively address major oil spills, which BP knew, but discounted (Stephens & Flaherty, 2010). In 2010, a combination of engineering failures, regulatory errors, and corporate negligence culminated in the catastrophic explosion of BP's Deepwater Horizon drilling rig, sending oil gushing into the Gulf of Mexico for 87 days, releasing an estimated 134 million gallons of oil (Bratspies, 2011; Krauss & Fountain, 2011; Marine Mammal Commission, 2015; Robertson & Krauss, 2014). After the Deepwater Horizon spill, BP monitored the air quality of communities, not for the purpose of ensuring their health, but to defend against future litigation. The company also refused government requests to monitor the blood, urine, or skin of cleanup workers, as results likely would have revealed the presence of carcinogens and opened BP to liability and serious litigation (Sneath & Laughland, 2023).

IAEA experts depart Unit 4 of TEPCO's Fukushima Daiichi Nuclear Power Station on April 17, 2013 as part of a mission to review Japan's plans to decommission the facility. (*Greg Webb (IAEA)* / *Wikimedia Commons*)

We see a similar pattern with the 2011 Fukushima Dai-ichi nuclear accident. Experiencing market pressures, the Tokyo Electric Power Company, which operated the nuclear plant, neglected crucial safety upgrades (Weitzdörfer & Djokić, 2021). And while Japan's Nuclear and Industrial Safety Agency was required to provide regulatory oversight, its location within the Ministry of Economy, Trade, and Industry—tasked with promoting nuclear power—limited its influence (Ferguson & Jansson, 2013; Kurokawa & Meshkati, 2021). The accident and its aftermath forced evacuation of about 170,000 residents and caused more than 2,000 deaths (Hasegawa et al., 2015; World Nuclear Association, 2024).

Overall, the Boeing 737 Max, NASA's Space Shuttle Challenger, BP Deepwater Horizon, and Fukushima disasters showcase how economic pressures—even on government institutions—undermine the promises of safety, leading to catastrophic failures of complex technological systems. These disasters show us that profit-maximizing pressures on the SMR industry are likely to lead to risky shortcuts in the interest of rapid development and deployment. Some SMR proponents may dismiss these cases as low-probability events, but taken together they demonstrate a clear pattern that must be taken seriously.

The expertise deficit

Even when regulators step in, it can be difficult for them to develop and maintain the necessary expertise to provide appropriate technology oversight. For the past 60 years, light water reactors (LWRs) have dominated commercial nuclear electricity generation, and the agencies tasked with overseeing this industry have

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developed safety standards and assembled expertise based on these designs. SMR designs introduce new reactor technologies and systems such as non-conventional cooling methods, different reactor materials, higher operating temperatures, and passive safety systems; regulators do not have as thorough a knowledge and understanding of these technologies as the developers (Jayarajan & Piotukh, 2024; Sam et al., 2023). Regulators also face financial constraints in hiring new employees (U.S. GAO, 2023). As a result, they turn to the private sector for this expertise, but this ultimately creates a conflict of interest (Jayarajan & Piotukh, 2024).

This problem, where industry controls the knowledge used in government decision-making, could be considered a different, epistemological form of regulatory capture (Borges, 2017). This is more likely in countries that prioritize limited government or in sectors with significant technological innovation. Consider the regulation of the aircraft industry in the United States. The Federal Aviation Administration (FAA) certifies all new commercial aircraft according to safety standards. Citing limited resources, in 1958, the FAA created the Designee Program, which permits the agency to appoint private industry employees and organizations to perform this evaluation (Federal Aviation Administration [FAA], n.d.-a; FAA, n.d.-b). These "designees" perform nearly all certification duties related to aircraft safety and personnel competency (U.S. GAO, 2004). FAA program offices supervise the performance of designees, coordinate with them, and evaluate the data they collect, though the agency's oversight and engagement is inconsistent (U.S. GAO, 2004; FAA, n.d.-c). The agency continuously defends these practices by pointing to the superior labor and technical capabilities that the private sector provides (FAA, n.d.-b).

This oversight approach had profound impacts on the Boeing 737 Max's recent failures. When Boeing began to develop the new plane in 2011, the company's first since 1993, it appointed its own designees to report on safety evaluations and compliance with regulatory standards to the FAA (Kitroeff et al., 2019). This enabled the company to hide information about MCAS (Gates, 2019). Customarily, new systems are subject to additional regulatory scrutiny. But company designees presented the software as a modification rather than a new feature (U.S. Department of Transportation OIG, n.d.). Boeing understood that any changes to MCAS would compel FAA action, which would delay timelines and increase costs. So, during a closed-door meeting in 2013, its leaders decided to never discuss MCAS outside of internal communications (Krisher, 2020). As a result, alterations to and problems with MCAS never reached the FAA. During flight testing,

Boeing 737-9 MAX first flight. (Jeff Hichcock / *Wikimedia Commons*)

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designees did not report the problem when a test pilot took ten seconds (a response time the pilot called "catastrophic") to identify and respond to activated MCAS software (The House Committee on Transportation & Infrastructure, 2020). And in 2016, they chose to conceal changes to MCAS in the Flight Standardization Board Report (FSB), a document detailing important information to include in the airplane manual and pilot training materials. Consequently, the published Max manuals and pilot training materials contained no information about the MCAS (Krisher, 2020; U.S. Department of Justice, Office of Public Affairs, 2021).

Platform supply vessels battle the blazing remnants of the off-shore oil rig Deepwater Horizon. (*U.S. Coast Guard* / *Wikimedia Commons*)

Similarly, through the late 20th century, the U.S. deepwater drilling industry leveraged its superior technical knowledge to circumvent government oversight, manipulate regulation standards, and rewrite safety mandates in its own interest. The government established the Mineral Management Service (MMS) in 1982 to manage the country's offshore energy and mineral resources, including policing offshore drilling sites by subjecting mining operations to formal, regulatory approval processes and conducting frequent, unannounced on-site inspections (Hogue, 2010; Natl. Comm. on the BP Deepwater Horizon Oil Spill & Offshore Drilling, 2011). However, MMS lacked the resources, technical knowledge, and personnel to sustain this work, particularly as offshore drilling activity increased dramatically, and drilling technology became more complex (Neal et al., 2007). Unannounced inspections, and the agency's capacity to exert direct oversight and update regulations, plummeted (Natl. Comm. on the BP Deepwater Horizon Oil Spill & Offshore Drilling, 2011). Further, MMS began deferring to industry assurances of safety rather than updating drilling safety requirements. For example, MMS mandated frequent tests for blowout preventer stacks (BOPs), the specialized valves meant to seal drilling wells, control their pressure, and prevent catastrophic releases of oil and gas (Wollff, 2023). But when the industry challenged the regulation and claimed their BOPs were safer than MMS standards, the regulator halved the number of mandated tests (Natl. Comm. on the BP Deepwater Horizon Oil Spill & Offshore Drilling, 2011). This lack of regulatory oversight enabled the deployment of defective and dangerous technologies, producing catastrophic technical failures. A failed BOP caused BP's Deepwater Horizon disaster, an oil rig explosion that killed 11 workers and created the worst unintentional oil spill in history, causing both humans and the ecosystem serious harm (Perrons, 2013; Shultz et al., 2015).

Some might argue that regulators are simply not doing their jobs, but a recent FAA survey suggests that the problem is cultural. On two occasions, in 2018 and 2019, MCAS software malfunctioned and pushed the plane's nose

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down shortly after takeoff. The pilots, unaware of MCAS, were unable to respond, and both planes crashed, killing a total of 346 people (Seattle Times Business Staff, 2019). In the wake of the 737 Max crashes, the FAA sought to understand and improve its safety culture. Employees reported that their industry counterparts complained regularly about the financial stress caused by overbearing regulatory standards and expected them to find industry-friendly solutions (Koenig, 2020). This pressure led to policy choices and interpretations that prioritized business-oriented outcomes, with FAA senior leadership sometimes even taking Boeing's side over its own safety engineers (Kitroeff et al., 2019; Koenig, 2020; Krisher 2020).

We expect similar compromises to safety culture in the SMR regulatory environment. Improving regulatory efficiency for SMRs will depend heavily on industry expertise, thus making oversight and safety vulnerable to economic pressures. While some worry about over-regulation, these concerns rarely consider the knowledge deficit experienced by overburdened regulators.

THE SMR INDUSTRY WILL PRIORITIZE ECONOMIC OVER PUBLIC INTEREST

The need to generate revenue will also cause SMR developers to seek out markets that rarely, if ever, align with the industry's professed goals of climate change mitigation and increased energy access. As we also discuss in other chapters, these markets will likely be industrial, and they may be extractive, polluting, and otherwise harmful to the environment. This reality may undermine citizens' legal protections and rights to informed consent and self-determination. And, local natural resources could be diverted from communities to serve powerful private companies at the expense of taxpayers.

Carbon capture and storage (CCS), which captures carbon from an emission source to reduce the total amount in the atmosphere and ultimately mitigate climate change, is a particularly perverse analog. Revenue pressures have driven the CCS industry towards business models that directly counteract its green promises. At its current level of development, the technology is costly and therefore unattractive to energy facilities seeking to reduce their carbon footprint (IEA, 2022). Across the United States and Europe, it is cheaper to pay taxes on emissions than to capture and store the carbon (Bright, 2022; Butterworth, 2023; Tollefson, 2018). So, the CCS industry has created a secondary market: selling its captured carbon for enhanced oil recovery (EOR). The fossil fuel industry uses EOR to remove oil that is difficult to extract, typically from mature oil fields that have dropped in productivity. The process works by converting carbon dioxide into a highly compressed fluid that is then injected underground to bring the oil closer to the surface (National Energy Technology Laboratory, n.d.; U.S. DOE, Office of Resource Sustainability, n.d.). Of the 400 million barrels of previously unreachable oil in the United States, about half can be extracted via EOR (National Energy Technology Laboratory, n.d). Thus, as we discuss further in Chapter 5, CCS ultimately enables the fossil fuel industry and its carbon emissions infrastructure (Roberts, 2019).

Similarly, during the COVID-19 pandemic, manufacturers prioritized their own economic interests above the public health needs of low- and middle- income countries despite the World Health Organization's efforts at equitable distribution (World Health Organization [WHO], 2021). This left economically disadvantaged and otherwise vulnerable global communities lacking vaccines. Pfizer and Moderna, among others, shunned global distribution models in favor of opaque yet lucrative bilateral funding arrangements that granted a few wealthy countries primary access to critical vaccine supplies. Once manufacturers made vaccines available, the United States, the United Kingdom, and Canada—despite initially proclaiming vaccines as a global public good and necessity (Boulet et al., 2021)—stockpiled supplies, severely limiting the global availability of vaccines. Canada bought enough vaccines to dose its population 5 times over (Hassan et al., 2021), and Britain stockpiled enough supplies to vaccinate its population 8 times over (Gonsalves & Yamey, 2021). These stockpiles ensured that only wealthy countries had meaningful access to vaccine supplies. Near the end of 2021, when the United States and United Kingdom had already vaccinated over 60% of their respective populations, the world's 50 least wealthy nations, together containing 20% of the world population, only had 2% of all existing vaccine doses (Hassan et al., 2021).

New York & Pennsylvania Railroad train, circa 1900. (*Wikimedia Commons*)

Developers will even undermine legal protections to maximize profitability. During the mid-18th century, railroad development was largely a local pursuit, with the technology mainly used to support local transport needs (Puffert, 2000). In many cases, developers laid different gauges—the distance between the two rails of a track—which then required passengers and cargo to change trains when the railroads met. This design feature created significant economic opportunities for nexus cities; Erie, Pennsylvania, for example, built an economy feeding, transporting, and housing layover passengers. So pivotal was this Erie nexus to regional commerce, that the Pennsylvania state legislature passed the Pennsylvania Gauge Law to halt any changes in track gauge size in 1852. But national railroad companies disliked the financial and logistical burden posed by Erie's gauge switch (Kent, 1973). They bribed lawmakers, and legislators repealed the law in 1853. Erie officials retaliated by passing a local ordinance prohibiting gauge changes within city limits (Grinde, 1974). The railroad companies attempted to coax the city into an agreement, offering to build an engine house and repair shop (Grinde, 1974). But Erie officials refused. Ultimately, the railroad companies simply ignored the ordinance and laid new track despite the local opposition.

Economic interests also drive governments to favor industrial over public needs. On the outskirts of the Mexican city of San Cristóbal de las Casas, in the state of Chiapas, a Coca-Cola bottling plant receives not just generous government subsidies but also permits to drill deep wells to extract water, despite an ongoing water crisis in the state (Lewek, 2024; Lopez & Jacobs, 2018). Though Chiapas is one of Mexico's rainiest regions, climate change has diminished rainfall, and poor water management has made reliable water access difficult, particularly for the large Indigenous population (Lopez & Jacobs, 2018). FEMSA, the food and beverage giant that controls Coca-Cola bottling in Mexico and much of Latin America, has enormous economic and political power; the former head of Coca-Cola FEMSA in Latin America, Vicente Fox, became Mexico's president in 2000, and many argue that his administration's lax regulation of the soft drink industry was an extension of this corporate past (Gómez, 2019; Lopez & Jacobs, 2018).

In addition to subsidizing water costs for FEMSA plant operations, the Mexican government has issued the company permits to drill wells that enable it to extract almost 500 million liters of water per year (Lopez & Jacobs, 2018; Pskowski, 2017). But, it will not provide permits to citizens who have been begging for similar wells for decades. Instead, communities must rely on shallow wells, where the water is often contaminated. Citizens have challenged the government through complaints, signed petitions, and organized protests, to no avail (EJ Atlas, 2022). Instead, FEMSA's priority access to the highest-quality water in the region accelerates the water shortages for the community (Pskowski, 2017; Yeung, 2025). In 2017, a UN Special Rapporteur on the Human Right to Safe Drinking Water and Sanitation appealed to the Mexican government to act urgently on its constitutional commitment to provide all of its citizens access to water and sanitation (UN Office of the High Commissioner for Human Rights, 2017). Meanwhile, Coca-Cola's famous sugary drinks are often more accessible than clean water, and as a result, Chiapas has seen the highest annual increase in its diabetes mortality rate of any Mexican state since 1990 (Gutiérrez-León et al., 2022; Lopez & Jacobs, 2018).

A Coca-Cola truck, Mexico. (Josh Withers / *Pexels*)

We see a similar pattern with the recent development of data centers. In the U.S. state of Arizona, energy regulation reflects a growing sensitivity to tech industry interests, and the government is actively pursuing data center development while actively suppressing equitable energy access (Obando, 2024; Verma, 2024). Hundreds of households in the Navajo Nation, for example, go without electricity

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Protest of President Trump's executive order directing the Army Corps of Engineers to expedite the approval of the last permit needed for the Dakota Access Pipeline, St. Paul, Minnesota. (*Fibonacci Blue / Wikimedia Commons*)

each year, forcing people to rely on wood- and coal-burning appliances that release dangerous particulates that can harm their health (Verma, 2024). Despite this, Arizona's utility board rejected a power company's proposal to raise rates to expand the grid to these homes, arguing that customers should not bear the burden (Verma, 2024). Meanwhile, the utility board approved a significant rate increase to better meet the rising electricity demands of data centers (New Mexico Political Report, 2024; Verma, 2024). Further, the state will increasingly rely on fossil fuels to accommodate data center demands, as seen in the historically Black town of Randolph, where officials recently approved the expansion of a large natural gas plant (Verma, 2024). The particulate matter released by the plant causes widespread asthma and lung cancer, which will only increase with expanded facilities (Verma, 2024).

These analogs suggest that the SMR industry will not just jeopardize the safety of its reactors but also devalue public needs—even those it claims to serve, like climate change—as it vies for efficiency and profitability. Further, governments will defer to the needs of the SMR industry in the name of economic progress at the expense of its citizens. Ultimately, this will do the greatest damage to communities or nations that are strained for resources and who are least able to advocate for themselves.

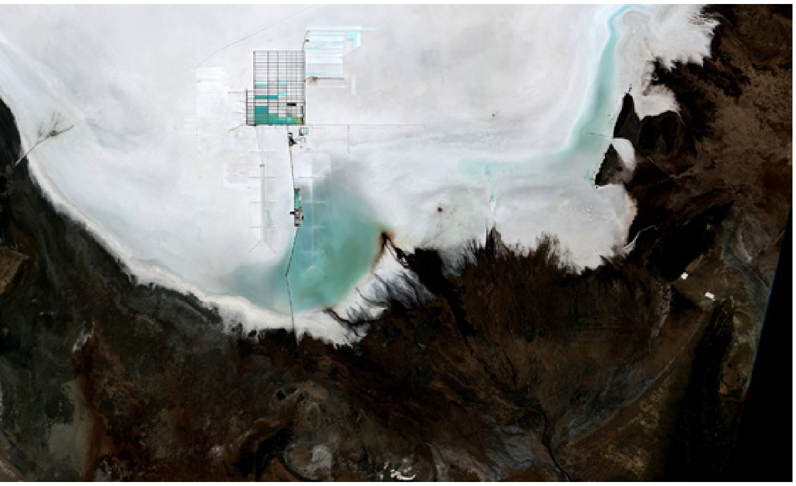
SMRS WILL REINFORCE RACIAL CAPITALISM

As it does with other extractive industries, racial capitalism, or the process of deriving economic and social value at the expense of marginalized racial identities, will also shape the emerging SMR industry (Leong, 2013). Racial capitalism divides racial identities and makes them distinct, namely by separating who does the work, who benefits from it, and who governs societal infrastructure, all ultimately in service of capital accumulation and preserving prevailing systems of power (Gilmore, 2002; Melamed, 2015). We expect that SMRs will continue to create and maintain racial inequities for the purpose of accumulating capital (Melamed, 2015).

Infrastructure projects often bolster profits at the expense of racial equity. Crossing the Dakotas and Illinois, the Dakota Access Pipeline (DAPL) in the midwestern United States travels beneath a Missouri River reservoir that the Standing Rock and Cheyenne River Sioux reservations use for drinking water (Hu, 2024). In 2016, the tribes protested against the pipeline, noting the dangers to this resource and other sacred land. Law enforcement brutally suppressed these efforts, and the pipeline was ultimately built on this path (Hu, 2024). But the pipeline's original route had not always put Indigenous lives at risk. Early proposals routed the DAPL over a stretch of river just north of Bismarck, North Dakota, an overwhelmingly white city and state capital (Mathewson et al., 2016). That community did not need to organize protests or attend town hall meetings to protect their local drinking water supplies; the U.S. Army Corps of Engineers rejected permits for the route based on an environmental assessment before Bismarck residents ever got involved (ABC News, 2016; Mathewson et al., 2016). In choosing to reroute the pipeline from a white community to an Indigenous one, developers shifted its risks to already disenfranchised Indigenous populations and revealed disparate, racialized valuations of these groups.

Developers may also harness corporate funding and influence to reinforce racial inequities, as seen in the Cop City case. Since the earliest days of modern law enforcement, Black communities in Atlanta have faced disproportionate policing, violence, and death at the hands of police (Legal Defense Fund, n.d.; Watts, 1973). Atlanta's South River Forest was once home to a prison farm known for abusing Black prisoners, sometimes even to death (Agbebiyi et al., 2023). After the site was abandoned in the 1990s due to human rights violations, it became a de facto landfill and shooting range for the Atlanta Police Department (APD) (Spalding, 2022). Then, the Atlanta Police Foundation (APF), a wealthy non-profit that funds and supports the APD, developed plans for Cop City, a sprawling police training compound equipped with a mock city, explosive testing sites, and military-style helicopters (Wendling, 2023). The APF receives millions in private equity and corporate funding from Bank of America, Coca-Cola, and Delta Airlines, with numerous CEOs sitting on its boards and committees (American Friends Service Committee, 2023). The CEO of Cox Enterprises, an Atlanta-based media conglomerate that owns the *Atlanta Journal-Constitution*, leads its fundraising (American Friends Service Committee, 2023). This web of funding and corporate partnerships, ranging from financial institutions to media powerhouses, has made Cop City (and its aims to expand the reach and capabilities of law enforcement) a reality. APF will shoulder $60 million of Cop City's $90 million price tag, which made the project more politically feasible for Atlanta city council members when they approved it in 2021 (American Friends Service Committee, 2023). However, many Atlanta residents, particularly the city's Black communities, have condemned the project as a means of militarizing the APD and inflicting further harm on overpoliced Black populations (Huynh, 2021). Not only does Cop City extend the site's legacy of racist policing and

Buildings and debris at the Old Atlanta Prison Farm, Atlanta, Georgia. (*RJ* / *Wikimedia Commons*)



Lithium mine at the Uyuni Salt Flat, Bolivia.
(*Coordenação-Geral de Observação da Terra* / *Flickr*)

incarceration, but it also extends the racialized power structures that drive inequity.

In pursuing profits, infrastructure developers can also diminish traditions and ways of life in marginalized communities. To construct the Moses-Saunders Dam and a commercial seaway in the 1950s, the U.S. and Canadian governments flooded the land of the Indigenous Akwesasne people, straddling present-day Ontario, Québec, and New York State (Johnson-Zafiris, 2024). These projects ensured that the St. Lawrence River was one of largest trade arteries in North America and encouraged trade between the two countries (U.S. Department of Transportation, n.d.). But the Akwesasne community paid the price. The dam and seaway displaced many and disrupted local, river-based livelihoods (Clamen & Macfarlane, 2018). The concurrent influx of ships and polluting industries to the region has ravaged the local ecosystem and public health ever since, harming fishing, farming, and spiritual traditions tied to the St. Lawrence's waters (Johnson-Zafiris, 2024). Meanwhile, both U.S. and Canadian industrial, manufacturing, and natural resource sectors have reaped huge profits from the seaway, increasing the global competitiveness and prosperity of these North American economies (Transport Canada et al., 2007). The hydroelectric power generated by the Moses-Saunders dam has also supported manufacturing and technology development in the region, such as numerous cryptocurrency mining facilities (McGeehan, 2018).

These commercial and technical benefits were accrued through the dismantling of Indigenous ways of life, driven by the view that Indigenous interests are subordinate to profits and national infrastructure growth. We see a similar picture in the case of lithium mining and electric vehicles, which we describe throughout the report; the largely Indigenous communities who live near lithium mines in South America and Australia cannot afford the new technologies but experience harms from pollution generated by the industry—harms that will only grow due to the global popularity of EVs (Frankel & Whoriskey; 2016; Mazzieri & Montanari, 2024; Morelli & Danielson, 2023).

Meanwhile, the extraordinary interest in SMRs as a solution to the uninterrupted, low-carbon energy needs of data centers, and by extension, artificial intelligence (AI) and other digital technologies (IEA, 2024), suggests that there are likely to be great incentives for both the industry and governments to quickly build SMRs. In 2024, Google signed a Master Plant Development Agreement with Kairos Power to develop a 500 MW fleet of molten salt nuclear reactors to power its data centers (Martucci, 2024). Google anticipates its first reactor going online by 2030, and it plans more reactors by 2035 (Patel, 2024b). Amazon has invested USD $500 million in Dominion Energy to explore small modular reactor development for its own data centers (Olick, 2024). The Silicon Valley-based advanced nuclear startup Oklo, whose board chair is OpenAI founder Sam Altman, has entered into an agreement with data center developer Switch to supply 12 GW of electricity from its Aurora microreactor by 2044 (Camacho, 2024; Patel, 2024c). In effect, large technology companies are offering lucrative lifelines to yet unproven SMR technology. Developers hope to take advantage of this excitement to prove their viability, but doing so is likely to require maintaining timelines and budgets that have so far proven unfeasible (Cho, 2023; Day, 2023). And while the SMR industry often promises community consent and self-governance—which we discuss in further detail in Chapter 6—it is likely to bypass these efforts to enable quick infrastructure development to meet data center demands.

> The emerging SMR industry is likely to encourage developers to prioritize profit while undercutting its promises of safety, climate change mitigation, equity in energy distribution, and community-based governance.

As we describe throughout this report, SMRs depend on the land and labor of marginalized communities for uranium supplies. Without proactive government attention, as SMRs become more popular, the market for uranium mining and milling will increase, and the inequitable wages and working conditions will continue or worsen. Furthermore, the worst impacts of SMRs—whether the reactor itself, uranium extraction infrastructure, or other fuel cycle facilities—are likely to be felt the most by historically disadvantaged communities of color. When we compare DAPL and Cop City, we see that white communities are likely to be protected from potentially risky infrastructure developments. Furthermore, the concerns of communities of color are less likely to be taken seriously. These dynamics will enable SMR developers to build infrastructure and reap financial gain, while racial and ethnic minorities continue to be disempowered.

Overall, the emerging SMR industry is likely to encourage developers to prioritize profit while undercutting its promises of safety, climate change mitigation, equity in energy distribution, and community-based governance. The SMR industry will seek out markets that maximize financial returns. Its profit motivations will promote asymmetric and inequitable distribution of energy resources, exacerbating resource inequities in marginalized communities and enabling wealth concentration in SMR industry executives. These markets could also be extractive, polluting, and otherwise harmful to the environment and people—especially people of color. Yet at the same time, regulators are likely to defer to industry needs in the name of the public interest, and because they lack the financial resources and expertise to provide much scrutiny.

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Chapter 4: Overlooking Local and Indigenous Knowledge

KEY TAKEAWAYS:

- Tech-solutionism—the idea that a single technology, such as SMRs, can solve a "wicked" problem—will exacerbate social alienation among marginalized communities.
- However, this social alienation and related harms will be hidden.
- When the knowledge of marginalized communities conflicts with tech-solutionism, the technology will win.
- SMR expansion will extend settler colonialism through its hunger for uranium mining and milling.
- SMR developers are likely to devalue Indigenous knowledge, even though it offers important pathways to environmental sustainability.
- Proactive measures can help SMR developers respect local and Indigenous knowledge.

Governments, the private sector, and technical experts share great excitement about the potential of small modular reactors (SMR) to produce large amounts of energy with little harm to the climate, while resolving the problems—including accidents, waste, cost, public opposition, and weapons proliferation—that have plagued its conventional counterpart. In other words, they view it as a technological solution to a multi-faceted "wicked" problem. This is quite attractive. After all, it seems that simply investing in SMRs can produce social, economic, technological, and environmental progress. Throughout this report, we describe how the consequences of SMRs are likely to be far more complex and explore the geopolitical, economic, and environmental impacts. In this chapter, we focus on how the "tech fix" narrative regarding SMRs is likely to further devalue marginalized communities and their knowledge, including by extending settler colonialist practices.

TECH-SOLUTIONISM WILL ALIENATE MARGINALIZED COMMUNITIES

Our analogical case studies suggest that when societies view technologies like SMRs as seemingly straightforward technological solutions, they tend to ignore or dismiss harms that the technology poses to marginalized communities. As a result, these communities become further marginalized—without much public attention or outcry. Consider large language models (LLMs), the subject of our 2022 Technology Assessment Project report (Okerlund et al., 2022). LLMs are a type of machine learning used to summarize, translate, predict, and generate human language using large text-based datasets. Since we wrote the report, LLMs have been introduced to the global market; taken up in an array of fields, including education, criminal justice, science, and medicine; and are increasingly used to replace human decisionmaking (Altamimi, 2024; Biswas, 2023; Dement & Inglis, 2024). Technologists view LLMs as a convenient and accurate way to access and interpret information and complete tasks (Hardy, 2023; Shone, 2024). In other words, like SMRs, LLMs have been framed as a "tech fix" for problems of inefficiency and inaccuracy (Dexian, 2024). Interestingly, they are also being proposed for use in the nuclear industry (Azhar, 2024; Fleet, 2024; IAEA, 2022a).

Yet, as our 2022 report predicted, LLMs draw from existing texts—primarily in English—that often contain inaccurate and biased information and remake these biases with each new application and output (Hofmann et al., 2024; Turk, 2023). Marginalized communities, for example, are mis- or unrepresented in these texts. Users know very little, if anything, about how an LLM produces its output, so these biases are invariably hidden. This has triggered multiple studies trying to understand and fix LLM bias (Gallegos, 2024; Raj et al., 2024; Yogarajan et al., 2025) as well as efforts to try to balance the proliferation of English-language LLMs with counterparts based in other languages (Dave, 2023; Sharma, 2023). But these efforts are ad hoc, and there is virtually no regulatory oversight anywhere in the world. As a result, it will likely be up to these communities themselves to raise concerns, but their concerns may not be taken seriously because of their less-privileged social position (Charette, 2018; Pierson, 2023; Roose, 2024; Wells, 2023). Furthermore, developers may respond that this is an acceptable error associated with the better overall future tied to the new technology solution.

Cochlear implants (CIs) also illustrate how "tech fixes" can erode support for marginalized communities and further alienate them. CIs are an implanted neuroprosthetic that interprets electrical signals as sound, including speech,

Cochlear ear implant with accessories, 1999.
(*Wellcome Collection* / *Wikimedia Commons*)

President Dwight D. Eisenhower at a ribbon cutting ceremony marking the opening of a new extension of the George Washington Memorial Parkway. (*White House Albums*)

for deaf users (Macherey & Carlyon, 2014). Yet despite popular assumptions, CIs do not give users the same aural capacities as those with natural hearing, and patients spend months and even years learning to navigate and interpret signals (Tyler & Summerfield, 1996). Deaf organizations and schools are thus important support systems for the deaf community. However, treating CIs as the solution to deafness has threatened funding for other deaf-focused entities and access to resources including translators, language learning programs, and even schools (Tucker, 1998). It also limits the support available for deaf individuals who cannot or do not choose to use CIs, further marginalizing these groups (Cooper, 2019). Promoting CIs as a cure for deafness is not only inaccurate but also has a cascade of negative implications for the deaf community, who value and need other resources beyond this "miracle" technology.

In the form of built infrastructure, tech-solutionism can literally divide already disenfranchised communities. The Federal-Aid Highway Act of 1956 led to the construction of over 41,000 miles of highway across the United States (Weingroff, 1996). The federal government aimed to connect growing American communities and modernize the nation's commerce, travel, and national security (Weingroff, 1996). But low-income and predominantly-Black neighborhoods were treated as acceptable collateral damage, as building the highways prompted the demolition of homes, businesses, and gathering places and fragmented communities (Coombs, 2022). Today, these residents still face immense social and cultural losses, economic disenfranchisement, and increased chronic illnesses tied to highway development and related air pollution (Coombs, 2022). The government framed highways as a necessary tool for American post-war prosperity, but in reality the new highways benefitted white, wealthy car owners and suburbanites while making it impossible for marginalized people to maintain their own communities (Mahajan, 2024).

Taken together, the LLM, CI, and highway cases demonstrate how enticing technological solutions invariably have a hidden dark side for marginalized communities. While this garners minimal attention, particularly in the face of enormous hype, it has lasting consequences.

SMR DEVELOPMENT WILL DEVALUE KNOWLEDGE OF MARGINALIZED COMMUNITIES

The harms described above often occur because those promoting technological solutions reject knowledge that is rooted in communities' lived or occupational experience. Consider Borlaug wheat, developed by American agronomist Norman Borlaug in the 1960s to solve the Indian famine (Public Broadcasting Service, 2020b). Funded by the Rockefeller Foundation and the Mexican government, Borlaug designed the strain to be more pest- and disease- resistant and to produce higher crop yields (Nature India, 2009). Borlaug also promoted expensive fertilizers, and his new wheat crops were water intensive (Center for Food Safety, 2014). In 1966, India imported 18,000 tons of his wheat seeds, and the traditional story is that, along with the increased use of fertilizers, it bolstered crop production and helped feed millions who might have otherwise gone hungry (Nature India, 2009). However, these new technologies pushed Indian farmers away from traditional practices including crop rotation and field fallowing, which help soil regenerate nutrients to avoid degradation (Mohan et al., 1973). Further, while high crop yields enabled India to become a food exporter by the 1970s, its new focus on exportation reduced crop diversity and therefore led the country away from natural methods of pest and disease resilience (Abel, 1970). This has led to a regular decline in crop yields and quality, even today (Eliazer Nelson et al., 2019). To many, Borlaug wheat is the spark that ignited the Green Revolution, the 20th century agricultural movement that increased global food production and reduced hunger (Spanne, 2021). Yet in retrospect, its good intentions have created a reliance on harmful agricultural chemicals and reduced biodiversity and the use of local farming techniques (John & Babu, 2021; Stone, 2022). Because Borlaug wheat was deemed a life-saving "tech-fix" for hunger by Western scientists, similar strains of high-yield crops sprung up around the world without community input and with similar ecological harms (Vidal, 2014).

Half a century later and half a world away, the controversy over the Dakota Access Pipeline (DAPL) shows how community knowledge is devalued even when it appears to be seriously considered. Announced to the public in 2014, DAPL was designed by developer Energy Transfer Partners (ETP) to transport crude oil over 1,000 miles across the midwestern United States. In the process, it would cross the Standing Rock and Cheyenne River Sioux Native American reservations. In a 2014 meeting with ETP's vice president, Standing Rock representatives made clear that they steadfastly opposed the project, arguing that its route beneath a nearby reservoir would threaten their drinking water supply and disturb culturally-significant and sacred land (Hersher, 2017; Thoet, 2016). But ETP continued its effort, claiming the pipeline would be one of the safest and most technologically advanced pipelines in the world (Dakota Access Pipeline, n.d.; National Museum of the American Indian, n.d.). Before permitting construction, the U.S. Army Corps of Engineers conducted several rounds of environmental and cultural assessments and held consultations with local communities and tribes to address concerns (Lowenstein, 2017). However, the Standing Rock Sioux Tribe argued that the government had

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structured its assessment to define culturally significant land narrowly, minimizing their spiritual and historical connection to it and excluding serious consideration of health and environmental impacts, including water quality (Hersher, 2017; Lowenstein, 2017; Ravitz, 2016; Thoet, 2016). The pipeline became operational in 2017 after the Trump administration canceled a more comprehensive environmental impact assessment to expedite construction. Ultimately, the Army Corps of Engineers' limited impact evaluations were treated as

Protesters marching in Minneapolis remember Manuel Esteban Paez Terán (Tortuguita), who was shot and killed by officers at a prolonged protest in an Atlanta forest. (*Wikimedia Commons*)

sufficient measures of risk because of the Corps' technical expertise, but the assessments have had profound impacts on local health and safety. The pipeline has leaked at least five times, and the largest of these spills required the remediation of contaminated soil near the pipeline's endpoint in Pakota, Illinois (Brown, 2018; Guha, 2023).

Ignoring community knowledge doesn't just trigger adverse environmental outcomes. It also produces public distrust and political instability. Atlanta officials disregarded local communities' experiences of environmental and racial inequity in ceding green space to create the Atlanta Public Safety Training Center, or "Cop City." Locals have long petitioned for the land in Atlanta's South River Forest to become a park (Center for Civic Innovation, 2023; Huynh, 2021). Access to green spaces is highly segregated across Atlanta, and Black residents are disproportionately exposed to the health impacts of extreme heat, flooding, and air pollution (Agbebiyi et al., 2023; Van Dam & Brink, 2021). Predominantly Black communities living around the proposed Cop City site—which has transformed from a notoriously abusive prison farm to a landfill in recent years—have sought to remediate it to increase access to green space and its health benefits since the 1990s (Agbebiyi et al., 2023; Van Dam & Brink, 2021). Atlanta's Black residents have also endured a long history of police brutality and racialized violence, and many called attention to the role that Cop City would play in exacerbating these harms by further militarizing local law enforcement (Rojas, 2023; Shahshahani, 2023; Slotkin, 2020). Despite repeated efforts to bring this knowledge to the attention of decisionmakers, city officials approved the project in 2017 in the name of community betterment (Thigpen, 2023). The Atlanta Police Foundation, the non-profit organization that funds much of Cop City, has stated that the initiative will emphasize community knowledge, cultural awareness, and environmental stewardship (Atlanta Police Foundation, n.d.; Moving Atlanta Forward, n.d.). But given how their experiences have already been dismissed, residents are deeply skeptical (Dixon & Wheatley, 2023).

Technical projects that center on community knowledge are more resilient. For decades, communities in the southwest Indian state of Maharashtra faced droughts and inequitable water distribution, with political elites controlling irrigation systems to benefit lucrative cash crop industries (Morrison, 2010). In response, a political organization called the Mukti Sangharsh Chalval (MSC or Struggle for Liberation Movement) mobilized for regional water redistribution and organized the Baliraja community dam project in 1984 (Rout, 2009). Seeking to place community knowledge of water needs and environmental conditions at the forefront of the dam's design, MSC surveyed local families about water conditions before creating a citizen council of village representatives on drought eradication (Phadke, 2002). The council enlisted a Mumbai-based engineering firm to construct the dam and lead local environmental remediation efforts, including reforestation to curb riverbed erosion, based on their vision—rather than the specifications of technical experts and politicians (Phadke, 2002). Here, technical assistance was governed by community knowledge. Instead of favoring the water-intensive but profitable cash crop industry, the Baliraja Dam's developers created infrastructure that gave priority to local water needs and environmental conditions (Phadke, 2002). As a result of the Baliraja's community-centered design and governance, local water access in the region remains resilient to droughts and responsive to changes in local needs.

Similarly, the history of HIV and AIDS activism shows how both institutional legitimacy and marginalized groups can benefit from the incorporation of grassroots knowledge. Throughout the 1980s, the number of HIV/AIDS cases and deaths rose rapidly across the United States, with the disease disproportionately affecting gay men and women of color (Greene, 2007; Tillerson, 2008). But even as epidemiologists recognized the severity of the new epidemic, political leaders and research agencies did little in response (Lopez, 2015; McCarthy, 2019). In addition, the Food and Drug Administration (FDA), which had more stringent pharmaceutical regulations than most other countries at the time, became a barrier to treatment as it insisted on rigorous testing and

1970s AIDS activist lapel badge. (*Michael James Papers / Hall-Carpenter Archives*)

"gold standard" clinical trials (Epstein, 1998; Rodraza, 1993). Grassroots activists, many of whom belonged to the queer community and suffered from AIDS themselves or lost friends and family to the disease, formed the AIDS Coalition to Unleash Power (ACT UP) to protest the government's inaction and intransigence (Schulman & Ciesemier, 2023). They argued that these rigid clinical trial guidelines prevented dying patients from getting the help they needed and demanded that the FDA shorten drug approval processes, stop giving suffering patients placebo drugs in studies, and make clinical trials more representative of the diverse populations impacted by AIDS (Crimp, 2011). By 1987, the FDA had created new accelerated approval regulations for life-saving drugs including AIDS treatments, giving sick patients access to promising experimental drugs outside clinical trials and demonstrating deference to community knowledge and concerns in the testing of new drugs (Food and Drug Administration, 2019). These changes saved thousands of lives during the AIDS epidemic and also demonstrated that the FDA could be responsive to public needs.

The Cop City and DAPL cases show that when developers disregard community knowledge and values, not only does political instability and unrest follow, but the decisions are also less informed, and communities face further harm. However, the AIDS and Baliraja Dam cases demonstrate that bottom-up efforts can succeed, producing better and more responsible decisions, more engaged communities, and more respected institutions.

While citizens may lack the technical expertise of SMR developers or reactor operators, they have deep local knowledge of technologies, like nuclear power, that affect their health, safety, and autonomy (Lovering & Baker, 2021). However, the nuclear industry has historically treated community opposition as ignorance and responds by emphasizing the low likelihood of accidents, recent strides in plant safety, and nuclear's low-carbon energy production (Lovering & Baker, 2021; U.S. DOE-NE, 2022a; WNA, 2024). This approach fails to address why communities might mistrust nuclear technology and leads to projects that diminish local insights instead of incorporating them into planning and governance. Although SMR developers promise to engage communities more expansively and respectfully, our analogical case studies suggest that this will be difficult to accomplish, especially when community knowledge and decisions conflict with scientific risk assessments and tech-solutionist rhetoric. However, to create technology that truly benefits local communities and addresses past harms, they cannot just rely on technical expertise. Nor can they create a narrow scope for community consent. Instead, they must ground design, siting, and governance in community knowledge, developing true partnerships to create multi-faceted energy futures.

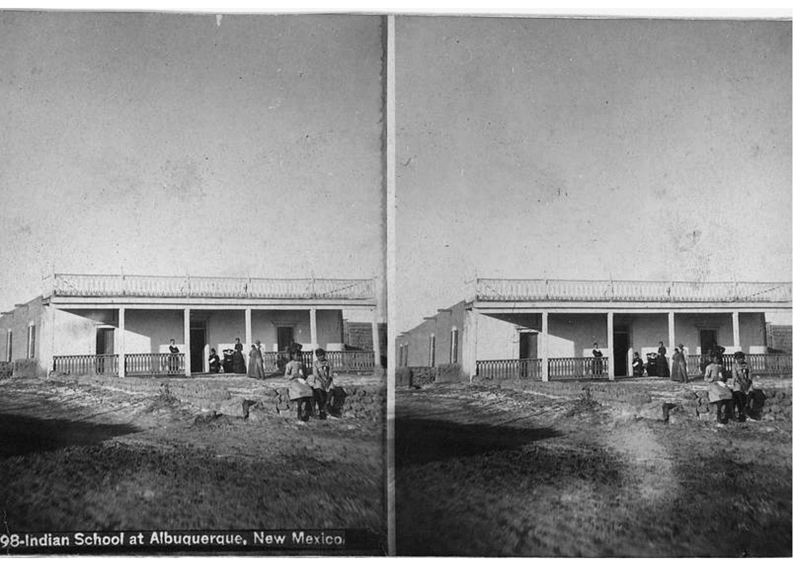
To create technology that truly benefits local communities and addresses past harms, SMR developers cannot just rely on technical expertise. They must ground design, siting, and governance in community knowledge, developing true partnerships to create multi-faceted energy futures.

SMRS WILL REINFORCE SETTLER COLONIALISM

This devaluation of local, and particularly Indigenous, knowledge is part of the legacy of settler colonialism, the extension of power by taking over Indigenous lands for the purpose of resource extraction and settlement. For centuries, countries around the world have forced Indigenous (including Native American, First Nations, and Aboriginal) populations to leave their land in the name of modernization and national prosperity (Larkin, 2013; Son, 2018). Colonists destroyed Indigenous peoples' knowledge of and relationship with the land, viewing it as useless—even dangerous—in comparison to technical knowledge that enabled colonists' accumulation of power and wealth. Early settlers in the United States decimated forests that Indigenous populations used for food, shelter, and spiritual practices in order to build homes, civil infrastructure, and clear land for slave plantations that supported the colonial economy (Anderson, 2022). In Australia, settlers displaced (and often murdered) Aboriginal populations and seized their land to create a mining economy that enabled rapid growth of the white population (Howlett & Lawrence, 2019). Legal frameworks empowered these activities, authorizing, even encouraging, settlers to live, build on, and extract resources from Indigenous territories while giving Indigenous populations little to no land rights (Howlett & Lawrence, 2019). These practices continue today, significantly harming Indigenous communities, as they have long, spiritual connections to their lands that are integrated into their daily lives. They must begin again in a new location or manage with degraded lands that puts their lives at risk. Indigenous populations thus become "acceptable" collateral damage for progress, a harmful dynamic which has persisted historically under the belief that Indigenous populations are inferior and in need of "civilization" from controlling colonial powers (Mignolo, 2006).

Train, Salar de Ascotán, Chile (2016). (*Diego Delso* / *Wikimedia Commons*)

As we have noted throughout the report, much of today's "green" infrastructure depends on lithium mining on Indigenous lands in Australia and South America's Atacama Plateau. Electric vehicles (EVs) are powered by lithium ion batteries and celebrated by technologists and policymakers as a key component of many national decarbonization plans (IEA, n.d.). They are framed as an innovative tool for the transportation sectors of Europe and North America, a technology that will make these societies more resilient to climate change (Wingender et al., 2024; World Resources Institute, 2024). But by encouraging EV development, technical and political leaders, inadvertently, perhaps, reinforce the decimation of Indigenous land and resources for the benefit of colonial societies. In South America's Atacama Plateau, lithium mined from the plateau's salt flats has drained the region of water, displaced Indigenous communities, and reduced biodiversity (Greenfield, 2022). In Australia, lithium mining on Indigenous land requires crushing and heating rocks, a practice which produces tailings that can contaminate nearby water systems and soil if not properly disposed of (Gabay, 2024; Kurmelovs, 2022). Meanwhile, Indigenous populations often cannot afford EVs themselves, resulting in a failure to distribute technological benefits of harmful resource extraction to affected communities (Greenfield, 2022). These



The Indian School of Albuquerque was established in 1881 to provide off-reservation training to Native American students from the American Southwest, Duranes, New Mexico. (*National Archives and Records Administration*)

harms are integral to EV development and largely obscured in EVs' positioning as crucial infrastructure for wealthy societies and world powers.

Developers and governments justify the continued subjugation of communities by labeling them as "blighted," even when settler colonial states purposefully foster poor living conditions. Indigenous boarding schools, used largely in the U.S., Canada, and Australia in the 19th and 20th centuries, built on the settler-driven murder and land theft enabled by previous colonial policies to frame indigeneity as backwards, dangerously ignorant, and needing an external savior to civilize them (Jacobs, 2006; Woolford, 2015). This justified hundreds of government-funded and often church-run boarding schools to forcibly remove Indigenous children from their homes and send them to distant schools where they were punished for speaking Indigenous languages, barred from wearing Indigenous clothing and hairstyles, and taught to practice Christianity and speak English (The National Native American Boarding School Healing Coalition, 2020; Smith, 2009). In some cases, Indigenous families elected to send their children to boarding schools voluntarily under the belief that they provided stability and opportunity not available on reservations, but parents were often forced to give up custody of their children in exchange (Levitt et al., 2023). In reality, these schools barely provided education, instead training Indigenous children in domestic work and manual labor for white households and farms (Jacobs, 2006; Smith, 2009). Disease and emotional, physical, and sexual abuse ran rampant, leading to the deaths of thousands of children. But these horrors received little attention from administrators and government officials who viewed them as "civilizing" institutions (Equal Justice Initiative, 2024; Kavi, 2024; Smith, 2004). Boarding schools fragmented communities in order to extend Indigenous land, resource,

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and labor exploitation, a cycle which has led to disenfranchisement and poverty among Indigenous populations (Cooper, 2024; Cornell, 2008; Hedgpeth & Horwitz, 2024). These schools left many children with greater instances of mental health disorders, substance abuse, and suicide in adulthood, exacerbating already high levels of these negative outcomes in Indigenous communities (Sebwenna-Painter et al., 2023; Smith, 2004).

Settler colonial violence is also extended when developers and governments shut down protests against risky infrastructure on Indigenous lands. The U.S. government has a long history of violating land treaties with Native American nations, a strategy that has sustained the growth of colonial settlements and use of Indigenous land (Pruitt, 2020). The Standing Rock and Cheyenne River Sioux Tribes argue that the DAPL crude oil pipeline violates Article II of the Fort Laramie Treaty of 1868, which guarantees the Indigenous right to undisturbed use and occupation of reservation land (Guha, 2023; Treaty of Fort Laramie, 1868). The tribes mobilized a youth relay run and march from Standing Rock to Washington, D.C., horseback rides, and an encampment on the Standing Rock Reservation to call attention to the issue (National Museum of the American Indian, n.d.). But the government responded violently to tribes who asserted their rights and argued that DAPL threatened their drinking water supplies and sacred lands. Local law enforcement and private security forces used water cannons, attack dogs, rubber bullets, tear gas, and drones against crowds protesting on their own land (Hu, 2024; Parrish & Levin, 2018). Developers and federal officials said these protests obstructed national security and energy needs, rhetoric consistently used by settler colonial governments historically to quell dissent, justify violence, and build infrastructure (American Social History Project, n.d.; National Museum of the American Indian, n.d.).

Stand With Standing Rock protest, November 2016, San Francisco. (*Pax Ahimsa Gethen* / *Flickr*)

SMRs will likely reinforce this history of settler colonialism, particularly as the hunger for uranium grows. Approximately 70% of global uranium deposits are located on Native land, and the uranium mining industry has disproportionately sickened Indigenous communities and ecosystems as a result (Gould, 2022; Graetz, 2015). This has increased the rates of asthma, cancer, and kidney damage, as well as soil erosion and landslides (Banu et al., 2022; Gould, 2022). Further, uranium mining has done little to create lasting wealth and enhanced quality of life for these communities (Gould, 2022; Leyton-Flor et al., 2024; Robbins, 2024). To meet SMR demands, the nuclear industry is

Native women clean salmon, Alaska, circa 1905. (*University of Washington: Special Collections*)

likely to infringe further on Indigenous land and violate land treaties to support its growth. Further, as described in the lithium mining case, framing SMR as a necessary technology for more resilient and prosperous societies will obscure harms felt by Indigenous communities. This framing will also open these communities up to violent suppression, as the DAPL case exemplifies, particularly when Indigenous interests are viewed as contradictory to broader national interests. SMR developers vow to remediate past harms and rebuild trust with Indigenous populations, but the growth of SMR is dependent on gaining access to more uranium and by extension, more Indigenous land (NO RUSSIA Act of 2022; Yousif, 2024). Both the DAPL and boarding school cases show how past policies of Indigenous land degradation and theft are used to justify today's injustices. Today, these communities are seen as blighted and in greater need of the mining industry's alleged jobs and economic stability, which is used as justification for their exposure to greater risk in the form of uranium mining. However, these cases also show that the promised benefits may not be realized and will likely extend structural inequality.

SMRS WILL DEVALUE INDIGENOUS KNOWLEDGE

By destroying Indigenous sovereignty and lands, settler colonialism also weakens the power of Indigenous knowledge. Over generations, Indigenous peoples have developed shared traditions, experiences, beliefs, and understandings of the land that have enabled, for example, deep understanding of the environment and its patterns and how to use natural resources to sustain life while replenishing it to maintain balanced and healthy ecosystems (Avalos, 2020; Global Climate and Health Alliance, 2023). They view the land as alive, sacred, and connected to the human spirit (Beltran & Uchoa, 2024; Martin, 2012). Settler colonialism has not just decimated Indigenous culture, but ecosystems have suffered as a result (Jessen et al., 2021). After all, this sense of mutual nourishment and spirituality is antithetical to settler-colonial and capitalistic relationships to land, which rely on resource extraction to maximize profits and expand spheres of influence (Curley, 2021; Son, 2018). We expect that as SMRs extend settler colonialism, they will also continue to harm Indigenous communities by devaluing their knowledge.

Consider the case of salmon fishing in the Pacific Northwest and present-day Alaska, where Indigenous peoples have sustainably harvested salmon for thousands of years. They tend to focus on smaller salmon harvests along rivers rather than fishing in the ocean, which helps minimize "bycatch"—the incidental capture of non-target organisms—and therefore maintain aquatic biodiversity

(Atlas et al., 2021). Based on their knowledge of the land and sea, they have also developed special fishing technologies that easily release non-target species and account for local migration patterns and tides (Atlas et al., 2021). Salmon populations and fishing traditions feed Indigenous communities, but they also maintain local cultural identities and creation stories (Atlas et al., 2021). However, despite this tradition of sustainable fishing, Indigenous Yup'ik and Athabascan villages along the Yukon and Kuskokwim Rivers of present-day Alaska have seen declining salmon harvests in recent years because of industrial fishing techniques (Carothers, 2023). To achieve efficiency, these fisheries use large nets that catch and dispose of over 600,000 chum salmon and other bycatch each year, which greatly limits not just salmon populations but biodiversity overall in connected rivers (Carothers, 2023). These commercial overfishing practices, combined with no federal bycatch limits on chum salmon, undermine thousands of years of Indigenous knowledge that emphasizes respect for ecological balance. As a result, Indigenous communities struggle to uphold their fishing traditions and maintain food sovereignty, and broader ecosystems are sicker (Carothers, 2023).

Similarly, Indigenous peoples around the world have developed fire management traditions that are extremely effective. This includes prescribed burns (small and strategically-placed forest fires) to combat large uncontrolled fires and promote new plant growth (Buono, 2020). Local knowledge about biodiversity, crop management, and wind patterns inform these burns, which are embedded in the cultural traditions of practicing tribes. For example, the Yurok Tribe, based in present-day Northern California, uses fire to strengthen and straighten hazel branches which are then woven into traditional baby baskets (Buono, 2020). However, settler fire management policies in the United States have historically embraced the suppression of all types of fires, a practice that increased natural fuel accumulation and made wildfires more severe (Buono, 2020; Krieder et al., 2024). In fact, Indigenous burning practices were criminalized in the United States, with one 1850 California state law making it legal to shoot Indigenous peoples for practicing prescribed burns until the 1930s (Attebery, 2024). Yet as global temperatures rise and wildfires become more frequent, the U.S. Forest Service and Department of the Interior (the government agencies responsible for the country's fire management services) have begun to recognize the invaluable role of Indigenous burning practices in curbing wildfires (Buono, 2020; National Park Service, n.d.). They have provided funding support to the Indigenous Peoples Burning Network (IPBN), an Indigenous-led organization that seeks to revitalize traditional burning techniques and foster more resilient fire management throughout the United States (Indigenous Peoples Burning Network, n.d.). Through workshops and other forms of outreach, IPBN trains Indigenous communities in burning traditions across the United States. The U.S. government has expressed its intent to integrate these indigenous fire management traditions into its policies, representing a rare case of Indigenous knowledge becoming steadily integrated into federal policies after many years of repression (Buono, 2020).

Without similar deliberate efforts from developers and governments, we expect SMRs to continue the most extractive aspects of settler colonialism. While developers argue that the new technology will be an opportunity to repair relations with Indigenous communities, this will be extremely difficult as demand for uranium mining, which takes places primarily on Indigenous lands in the United States, Canada, and Australia, increases (Graetz, 2015). Sustainable fishing and prescribed burn practices illustrate how maintaining Indigenous knowledge is important not only as a demonstration of respect for autonomy but also because it can have enormous environmental benefits. In order to achieve such benefits, developers will need to unlearn dominant extractive resource practices, support the creation of organizations like the IPBN and heed their recommendations, and also be willing to stop expansion (including uranium mining and milling) when it conflicts with Indigenous knowledge.

Treating SMRs as a simple technological solution will obscure harms to marginalized communities, while devaluing their knowledge in the process.

SMR developers argue that their new technology is well-positioned to solve not just the world's growing energy needs but also the problems that plague conventional nuclear reactors. At the same time, some have expressed the importance of building public trust through democratic decisionmaking and deeper engagement with community experiences, responding to frustrations that the nuclear energy industry has traditionally sidelined, such as local concerns regarding reactor design, siting, and governance as well as uranium mining and milling (Lovering & Baker, 2021). Throughout this chapter, we have argued that achieving these goals will require developers and governments to contend with at least two challenges. First, treating SMRs as a simple technological solution will obscure harms to marginalized communities, while devaluing their knowledge in the process. Second, SMRs—like conventional nuclear—are likely to extend a legacy of settler colonialism based on resource extraction on Indigenous lands and rejecting valuable Indigenous knowledge. To address these challenges, both governments and developers must develop frameworks to ensure that the voices of marginalized communities are heard and respected throughout the nuclear fuel cycle. In the long run, these measures will improve environmental sustainability, social equity, and public trust.

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Chapter 5: Intensifying Environmental Injustices

KEY TAKEAWAYS:

- SMRs will paradoxically exacerbate environmental damage in the name of mitigating the effects of climate change.
- The co-location of SMRs and industry will disproportionately harm the land and health of marginalized communities.
- Communities in proximity to extractive industrial activities along the nuclear fuel cycle will experience greater resource exploitation and related environmental risks.
- In the event of catastrophe, vulnerable populations will be affected the most.
- Marginalized communities will have few protections against environmental harms and be left to advocate for their own health needs.
- Dissent or resistance against nuclear energy may be criminalized.
- Despite promises of energy abundance, marginalized communities are likely to lack energy access.

Advanced nuclear reactors such as small modular reactors (SMR) promise to be an ideal alternative to fossil fuels and conventional nuclear energy, offering a flexible and reliable source of low-carbon electricity. However, SMRs, like many technologies marketed as solutions to complex societal, environmental, and political crises, will produce downstream consequences. SMRs will introduce and exacerbate direct and indirect environmental harms that complicate the justification for using them to mitigate climate change.

Some environmental challenges are not unique to advanced nuclear energy. For example, as with conventional nuclear power, many SMRs rely on uranium fuel. Despite relatively improved mining methods and claims of more

> SMRs will introduce and exacerbate direct and indirect environmental harms that complicate the justification for using them to mitigate climate change.

efficient fuel utilization in SMRs, the continued or even expanded mining and processing of uranium will pose ongoing environmental risks associated with uranium extraction (Becker et al., 2020). This is similarly the case for water use and thermal pollution (Sustainability Directory, 2025). Even waste storage and disposal, despite being highly regulated, pose environmental justice challenges and environmental risks if the waste is not safely managed and isolated (Höffken & Ramana, 2024). To complicate the picture, advanced nuclear reactors introduce unique forms of high-level radioactive waste and end-of-life considerations, creating new technical and regulatory dimensions for waste management and decommissioning (Corkhill et al., 2025; Cothron & Koshgarian, 2024; Liou, 2023), even if these are not expected to fundamentally alter existing waste management challenges (Blue Ribbon Commission on America's Nuclear Future, 2012). And environmental implications extend beyond the nuclear sector—the prospect of abundant, stable energy and the production of high process heat makes SMRs especially attractive to heavy industry, in turn driving additional potential harms including local natural resource extraction, land degradation, and air and water pollution (Ludwig, 2024). The tech industry is recently increasingly investing in SMRs to power its growing number of data centers for Artificial Intelligence (AI) and other digital technologies, thus exacerbating environmental impacts to land and water (Amazon, 2024; Google, 2024; Rogin et al., 2025).

As with other infrastructure developments, these impacts are likely to be unevenly distributed, disproportionately impacting low-income, minoritized, and Indigenous groups across the world.

Aerial view of Google data center, Council Bluffs, Iowa. (*Wikimedia Commons*)

As with other infrastructure developments, these impacts are likely to be unevenly distributed, disproportionately impacting low-income, minoritized, and Indigenous groups across the world. Efforts to transition former coal towns into nuclear communities introduce unique environmental risks, as these regions are already burdened by ecological damage caused by coal extraction and processing (U.S. DOE-NE, 2024a; Donovan, 2023). The hunger for uranium will likely increase, putting pressure on Indigenous lands already contending with a legacy of environmental and human harms from nuclear ventures (Gould, 2024; Graetz, 2015). Acknowledging and proactively addressing these consequences

> The hunger for uranium will likely increase, putting pressure on Indigenous lands already contending with a legacy of environmental and human harms from nuclear ventures.

are key to ensuring that SMRs can effectively contribute to carbon reduction goals while not compromising environmental sustainability and disproportionately burdening already marginalized populations.

SMRS WILL EXACERBATE ENVIRONMENTAL HARMS WHILE CLAIMING TO MITIGATE CLIMATE CHANGE

Proponents usually describe SMRs as environmentally friendly because of their potential to reduce greenhouse gas emissions (Government of Canada, 2024; Holtec International, 2024; Sahlman et al., 2012). Beyond back-end concerns of the nuclear fuel cycle such as the management of spent nuclear fuel, climate-focused narratives overlook the environmental harms caused by the under-regulated industries enabled by SMRs. For instance, nuclear reactor developer X-Energy has agreed to deploy a reactor at Dow Chemical's Texas SeaDrift plant (Dow Chemical, 2023). However, Dow Chemical is the biggest source of toxic pollution in Texas's Brazos Watershed, and the Seadrift plant in particular has a record of violating discharge permits by letting plastic pellets and other waste seep into a nearby canal (Erdensanaa, 2023; Venable, 2020). Meanwhile, SMR developer NuScale describes its SMRs as not just producing electricity, but also generating steam for use in high-temperature industrial processes. Although these processes can be used for hydrogen production and desalination of seawater, they can also enable carbon-intensive industries such as oil refining, dissolving heavy oil to produce gasoline additives, and plastic production (NuScale, 2023)—all processes that perpetuate the fossil fuel industry and, ultimately, exacerbate climate change. They also pose additional environmental hazards; oil refineries cause air pollution from toxic chemicals and particulate matter, water contamination from wastewater discharges, and soil pollution from spills and waste byproducts (Prioleau, 2003). Plastic production is similarly harmful, exposing people and environments to microplastics and plastic waste that damage cells and increase the likelihood of serious illness in humans and animals (Jiao et al., 2024).

SMRs are also poised to provide substantial energy resources for data centers and chemical manufacturing, which will likely increase environmental harms—including water depletion and intensified mining—deepening the rift between purported climate solutions and responsible environmental stewardship. Tech giants like Microsoft, Amazon, and Google are already investing heavily in nuclear infrastructure to address the escalating carbon footprint of their AI operations (Plumer, 2024; Stover, 2024). Celebrated by these companies as a step toward a carbon-free future (Amazon, 2024; Dow Chemical, 2023; Google, 2024), nuclear energy itself may not produce onsite carbon emissions, but it will not prevent environmental harms. Data centers pollute the air (Danelski, 2024) and are highly resource-intensive, with a single large data center consuming hundreds of thousands to several million gallons of water per day (Google, 2022; Yañez-Barnuevo, 2025). In addition, poor recycling practices for electronic materials such as servers, routers, and cables lead to increased amounts of toxic e-waste containing hazardous substances. Particularly affected are low-income countries where many countries often send their excess e-waste, contaminating soil and water and harming human, animal, and plant health (Andrews et al., 2021; Jain et al., 2023; United Nations Environment Programme, 2025).

1920 advertisement for a Corona range. (*Ingenium*)

SMRs will enable unsustainable industrial growth

Driven by the promise of carbon-free, reliable energy, the practice of heavy industry clustering around SMRs is likely to increase. This parallels the industrial nexus that developed around the Moses-Saunders Dam at the US-Canada border. Built without consent on Akwesasne land, the Moses-Saunders Dam has been celebrated as a reliable, green hydropower energy source by the United States and Canadian governments (Stocks, 2024). However, the dam's cheap and reliable hydropower has encouraged industrial development, including a General Motors foundry and a Reynolds aluminum plant. Their activities polluted the surrounding water, air, and soil with fluoride ash and polychlorinated biphenyls (PCBs), a type of toxic chemical once widely used in manufacturing, resulting in decades of ecological destruction and human and animal illness (Clamen & Macfarlane, 2018; Fitzgerald et al., 2005; Johnson-Zafiris, 2024; Krook & Maylin, 1979). The dam has also attracted a continuously operating cryptocurrency mining facility. Such large-scale data facilities providing high amounts of computing power generate significant electronic waste that pollutes water, air, and soil if not properly recycled, particularly in low-income countries where wealthier nations often illegally ship e-waste (McGeehan, 2018; Wiwoho et al., 2024; United Nations Environment Programme, 2025). While hydropower is itself a low-carbon energy source, it attracts industries that cause enormous—and rarely responsibly managed—damage such as environmental pollution, waste, health harms, and habitat destruction.

While SMRs have the potential to replace fossil fuel-powered energy generation, they are paradoxically likely to enable the growth of the fossil fuel industry, thus not necessarily reducing overall carbon emissions. For example, carbon capture and storage (CCS) technology demonstrates how carbon reduction strategies can paradoxically empower polluting, carbon-emitting industries. CCS collects climate-warming carbon dioxide (CO2) before it leaves an emission source—usually a large industrial facility, like a petrochemical factory or coal or gas power plant—which reduces onsite carbon emissions. For example, retrofitting coal plants with CCS can capture up to 90% of smokestack carbon (Wang et al., 2017). However, this comes at a cost—energy penalties, or the additional energy needed to power CCS equipment, can reach up to 40% of the total fuel used (House et al., 2009). This increases coal mining and its downstream effects, including land degradation, air and water pollution, and species loss (Gopinathan et al., 2023). Furthermore, 70-95% of captured CO2 is injected into oil fields to support enhanced oil recovery, the practice of extracting crude oil that cannot be otherwise captured (Roberts, 2019). Ultimately, this practice supports the fossil fuel industry while posing environmental risks from leaking pipelines (Radtke, 2025). However, in some places, products from CCS-equipped petrochemical plants carry a "green" or "clean" label, obscuring these environmental harms (a practice known as "greenwashing") (Radtke, 2023).

While SMRs have the potential to replace fossil fuel-powered energy generation, they are paradoxically likely to enable the growth of the fossil fuel industry, thus not necessarily reducing overall carbon emissions.

Similarly, highways have triggered unsustainable industrial development. The U.S. Federal Aid Highway Act of 1956, which allocated $25 billion toward the construction of 41,000 miles of interstate highways, exemplifies how infrastructure can induce cyclical resource demand (Weingroff, 2017). The federal government has repeatedly expanded highway capacity to alleviate congestion (Weber, 2012). However, each expansion encouraged more road usage, resulting in cyclical growth triggered by induced demand (Mann, 2014). This spiraling growth has profound environmental consequences, including higher carbon emissions from cars, greater gas consumption, and massive demand for asphalt production. Asphalt production releases volatile organic compounds that cause skin irritation, chronic headache, respiratory illness, and ozone depletion (Harvey et al., 2016), indicating caution regarding the downstream environmental impacts of infrastructural expansion. The normalization of expanding infrastructure can directly and indirectly increase energy and resource demand, leading to environmentally unsustainable growth.

The history of stove technology development has also shown us that technological improvements do not always lead to socially desirable outcomes. While open hearths and cooking fires were difficult to manage and produced heightened indoor air pollution, closed system stoves developed in the 19th century enabled

1915 Baker Electrics Coupe. (*Alden Jewell* / *Flickr*)

safer and more efficient use of energy in the home, as well as a new milieu of unpaid labor (Lopes Ramos, n.d.; National High Magnetic Field Laboratory, n.d.). With industrialization, men shifted away from traditional tasks such as gathering and chopping wood for fires to take on factory jobs, while women were expected to handle the housework, now fostering a greater scope of consumption for their families enabled by the efficient stove (Cowan, 1983). Today, domestic tasks are still largely taken on by women in heterosexual households, even with the entrance of more women into education and employment sectors (Chamie, 2018; Ferrant et al., 2014). Thus, technology like stoves help make gendered divisions of labor even more distinct, not only increasing the scale of household energy and resource use, but also the amount of work that can realistically be done by women in the home each day, despite seemingly simplifying domestic workloads (Cowan, 1983). This case shows that an increase in efficiency of a technology does not necessarily reduce the total amount of consumption, but instead may increase the very burden it is supposed to alleviate.

By enabling energy consumption, and with it resource extraction and environmental degradation, SMRs will simply become a substitute for fossil fuels, rather than reimagining energy-environment relationships. This is similar to the California Air Resources Board's decision to promote electric vehicles (EVs) rather than improved public transportation as a solution to smog (Bedsworth & Taylor, 2007). Similarly, the 2021 Bipartisan Infrastructure Law in the United States earmarked $7.5 billion to single-passenger-focused EV charging infrastructure and only $1 billion for bus electrification and $3 billion for projects that address neighborhood equity, safety, and affordable transportation

An increase in efficiency of a technology does not necessarily reduce the total amount of consumption, but instead may increase the very burden it is supposed to alleviate.

SMRs will similarly enable current consumption patterns without forcing societies to grapple with the true complexities of environmental harms and the ways that some climate solutions put broader environmental sustainability out of reach.

(The White House, 2021). As in the EV case, SMRs will similarly enable current consumption patterns without forcing societies to grapple with the true complexities of environmental harms and the ways that some climate solutions put broader environmental sustainability out of reach. From our case studies, we expect that adding more SMRs to our energy system will lead to a "boomerang effect", where a reduction in carbon intensity leads to increased energy consumption overall (Zehner, 2012). Thus, SMRs will increase, not mitigate, energy consumption and other industrial growth, negating the promised positive effects on carbon emissions from SMRs (Bell et al., 2020).

SMRs will increase, not mitigate, energy consumption and other industrial growth, negating the promised positive effects on carbon emissions from SMRs.

SMRs will exacerbate burdens along the supply chain

Meanwhile, the demand for advanced reactors like SMRs will necessitate the expansion of uranium mining and processing infrastructure, particularly for high-assay low-enriched uranium (HALEU) (Mining.com, 2025). In the United States, the Inflation Reduction Act allocated $500 million to increase domestic HALEU production (Gardner, 2024).[2] Increased uranium mining, in turn, will place additional environmental stress on Indigenous lands—the primary location for these extractive activities in countries such as the United States, Australia, and Canada (Gould, 2024; Graetz, 2015; Lovejoy & Anderson, 2024). Approximately 70% of the world's uranium deposits are situated on or near these lands, and uranium mining, milling, and transportation has already disproportionately harmed these communities and their ecosystems (Gould, 2024; Graetz, 2015). As discussed in the Introduction and Chapter 6, these processes generate radioactive dust that contaminate the air, water, and workers' bodies. The nuclear industry has acknowledged the legacy of environmental and cultural harms associated with uranium mining and expressed intentions to reform practices (IAEA, 2010; NEA, 2014). However, the urgent demand for uranium driven by increasing energy consumption has often resulted in unfulfilled commitments, particularly to Indigenous communities. Despite a 2024 uranium mine ban around the Grand Canyon to protect local Navajo/Diné and Havasupai communities from further health, cultural, and environmental

2 Under the Biden Administration, the U.S. DOE performed an environmental risk assessment for HALEU processing sites. The environmental impacts of domestic HALEU production in the United States were categorized as "small", "moderate", and "large" (Lovejoy & Anderson, 2024). These narrow measures of harm took a resource-centric approach and did not necessarily reflect or incorporate cultural values—such as ancestral or spiritual—when assessing impact.

harms, the Pinyon Plain mine was exempted and recently reopened for uranium mining to bolster domestic uranium supply (Nowell, 2024; Singh, 2024).

Comparably, decarbonization proponents view the environmental and social harms associated with lithium mining—used to produce the batteries for electrification—as a necessary price to pay to reach a carbon-neutral economy by 2050 (European Commission, n.d.; Paris Agreement, 2015). In recent years, the United States government has increased funding for domestic mining while creating new incentives for electric vehicles (EVs) that use lithium-ion batteries (U.S. DOE, 2021; Ewing, 2022). But this is ecologically harmful; the mining process can contaminate water, air, soil, flora, and fauna, and its intensive water use can deplete groundwater, causing droughts (Kaunda, 2020; Greenfield, 2022). And in the United States, more than 65% of lithium, copper, and nickel reserves and resources—all used in batteries and posing similar environmental risks when mined—are within 35 miles of Native American Reservations (Block, 2021). Further, over half of the thousands of currently operating global resource extraction projects of so-called energy transition metals such as cobalt and nickel—materials demanded by the switch to low-carbon energy systems—are located on or near Indigenous peoples' lands (Owen et al., 2023). The EV industry has generated trillions of dollars in regions such as North America, Western Europe, and China, with marginalized, often Indigenous communities bearing the largest environmental consequences of lithium mining (IEA, 2024b). These governments have taken little to no steps to ensure implementation of high sustainability standards (Bandura & Hardman, 2023). Furthermore, not many scientific studies of the ecological consequences of widespread lithium extraction techniques, notably brine pool evaporation, exist (Barandiarán, 2019). Similarly for the uranium mining industry, where the environmental impacts of not only open-pit mining but even in-situ recovery (ISR)—an extraction method using liquid solvents pumped underground with minimal surface disturbance—are not comprehensively evaluated (Mudd, 2001), we expect environmental harms to continue, underlining the importance of environmental justice protections for vulnerable communities and land.

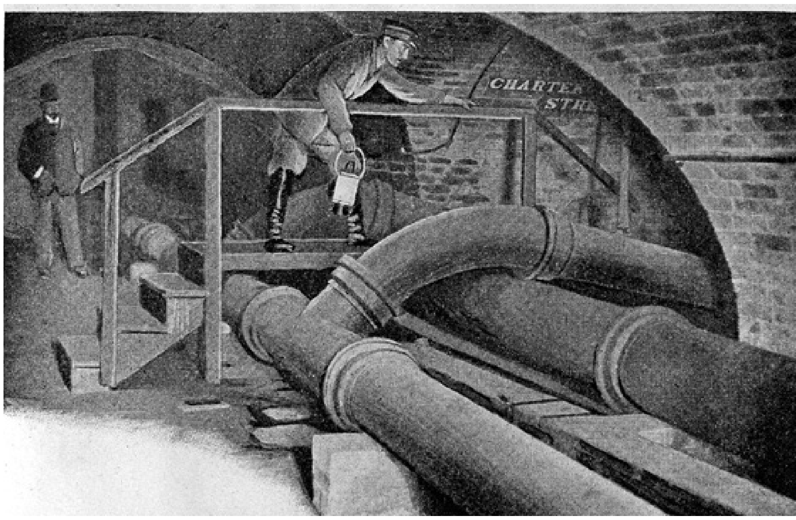
If SMR projects fail to equitably distribute the technology's benefits, communities along the nuclear fuel cycle will be vulnerable to the very problems of pollution and energy supply that proponents claim to address.

Proponents argue that SMRs are a crucial tool for responding to the climate crisis, with the potential to provide stable, carbon-free power to communities and boost resilience in the face of extreme weather and energy shortages. Yet if SMR projects fall short of these aims and fail to equitably distribute the technology's benefits, communities along the nuclear fuel cycle will be vulnerable to the very problems of pollution and energy supply that proponents claim to address. Modern sewer systems are a similarly crisis-driven technology, developed in response to rapid population growth, urbanization, and public health crises (Collinson, 2019). Until the mid-19th century, London relied on "cesspits" or underground chambers that stored human waste and were manually emptied—these containers frequently leaked, contaminated groundwater supplies, and fueled deadly cholera outbreaks (Jackson, 2014). Poor neighborhoods saw more infrequent cesspit cleaning than their wealthy counterparts, leading to higher instances of disease transfer and lower quality of life in these communities (Science Museum, 2021). When the city first switched to centralized sewers in 1848, systems were integrated into poor neighborhoods last—if at all—and routed raw waste directly into the Thames River (Science Museum, 2021). Not only did these communities have little escape from the overpowering smell of sewage they encountered living and working along the Thames, but the persistent cholera outbreaks in their communities threw the whole city into frequent public health crises (Collinson, 2019). Paradoxically, the infrastructure built to solve London's waste problem created further public health challenges because of its inequitable distribution and secondary environmental impacts. British civil engineer Joseph Bazalgette was chosen to rework early sewer designs in the 1860s, and his new models proved more centralized, expansive, and environmentally-sound, diverting waste away from the Thames and helping to close class-based gaps in waste disposal services (Collinson, 2019). The modern sewer effectively eliminated the spread of cholera and vastly improved the quality of life, not just for London's poorest populations, but for the city as whole. With this more equitable spread of infrastructure and attention to environmental consequences, London was

Our analogical case study analysis indicates that SMRs will contribute to a climate-environment paradox.

able to weather population growth and curtail public health crises more effectively.

As described in this section and in other parts of this report, governments, industry, and researchers imagine SMRs as a solution to the climate crisis (Hafner, 2024; Teplinsky et al., 2022; U.S. Department of Defense, 2024). But our analogical case study analysis indicates that SMRs will contribute to a climate-environment paradox. Beyond standard concerns about radioactive waste management and environmental remediation of decommissioning power plant sites (Chatzis, 2016), SMRs will intensify other kinds of environmental harms. As the technology and heavy industries seek out SMR-generated power and heat, these reactors may be co-located with existing facilities or attract new



Sewage pipes under London, 19th century. (*Wellcome Collection / Wikimedia Commons*) industrial development, thereby concentrating and exacerbating local environmental harms and facilitating the expansion of other polluting sectors. Moreover, the spread of SMRs and advanced reactor technologies will intensify extractive activities to supply the fuel needed by these reactors, leading to further localized environmental burdens in the name of solving the climate crisis.

MARGINALIZED COMMUNITIES WILL EXPERIENCE DISPROPORTIONATELY HIGHER ENVIRONMENTAL AND HEALTH BURDENS

The direct and indirect environmental risks of the SMR fuel cycle—including radiological contamination from mining and milling, pollution from co-located industries, or thermal pollution of water from the power plants—will affect the health of nearby communities both physically and psychologically. In addition to disproportionate impacts on marginalized communities from uranium extraction and other fuel cycle activities, industries co-located with SMRs will bring myriad risks, as described in the previous section. Oil refineries cause air pollution from toxic chemicals and particulate matter, resulting in respiratory illness and skin problems (Khatatbeh et al., 2020; Prioleau, 2003). Plastic production exposes people and environments to microplastics, which may be neurotoxic and carcinogenic (Lee et al., 2023). And data centers cause both air and sound pollution, which can increase stress (Han et al., 2024; Gonzalez Monserrate, 2022). This complex risk picture is familiar in marginalized communities, including former coal towns and areas with heavy industry that lack access to resources like good health care and the ability to pay for it (Woolley et al., 2015). Our analogical cases suggest that governments and industries often ignore these risks because it is difficult to measure adverse effects on humans and the environment and to prove causality in a way that aligns with legal and regulatory standards. While marginalized communities disproportionately take on the health burdens caused by these industries, they receive limited benefits and are left to self-advocate for attention, protection, and action.

Sacrificing vulnerable communities

Despite being framed as a solution to the climate crisis, which will globally affect vulnerable populations most severely (World Health Organization, 2023), the industrial growth and local environmental harms exacerbated by SMRs will also disproportionately impact marginalized groups, including communities of color and low-income communities. Our analogical case study analysis illustrates that areas where communities of color and low-income groups live are often seen as dispensable, making them vulnerable to the most harmful impacts of industrial infrastructure projects.

While marginalized communities disproportionately take on the health burdens caused by these industries, they receive limited benefits and are left to self-advocate for attention, protection, and action.

Developers—including governments—often portray these projects as crucial to the national interest, thereby justifying concentrated environmental harm to people and ecosystems for what they perceive as broader societal benefits (Juskus, 2023; Lerner, 2010). Using Native land as a sacrifice zone for nuclear development is not new: former Secretary of Energy Spencer Abraham stated in 2002 that the “national interest” of high-level nuclear waste disposal at Yucca Mountain outweighed the cultural significance for Native people (Endres, 2012).

Consider the history of highway construction in the United States. The Federal-Aid Highway Act of 1956 allocated $25 billion for the construction of 41,000 miles of the Interstate Highway System, described by the U.S. government as a path towards national connectivity, enhanced trade, and modernization (Weingroff, 1996). However, to make way for these highways, Black and low-income neighborhoods were fragmented and bulldozed (Karas, 2015; Mohl, 2000). Highway development also reshaped urban landscapes; asphalt absorbs substantial heat, contributing to urban heat islands and increased air pollution (Tong et al., 2021). Its low permeability also increases stormwater runoff contaminated with pollutants, raising the risk of flooding (Kriech & Osborn, 2022). These environmental burdens are concentrated in marginalized communities because of intentional siting decisions; the U.S. government explicitly saw highway development as an evolutionary natural selection process, whereby blighted land would be replaced with socially beneficial infrastructure (Eno Center for Transportation, 2015; Mohl, 2008). Furthermore, the same Act—also known as the National Interstate

Four-level interchange Fort Worth at Intersection of IH 20 (US 80) and IH 35 (U.S. 81), Texas. (*National Archives Catalog*)

and Defense Highways Act—displaced Black and low-income communities in pursuit of Cold War preparedness, justifying the sacrifice of displacing communities for military movement and evacuation routes (Lewis, 2022), creating aforementioned long-standing health and environmental inequities. Today, the U.S. military’s push for advanced nuclear technologies, supported by National Defense Authorization Act amendments directing the DOE to expand domestic uranium supply and HALEU production, mirrors this precedent. We expect that the military’s pursuit of advanced nuclear technologies—particularly microreactors—is likely to exacerbate inequitable land use in the name of defense and national security. The current development of military-use advanced nuclear prototypes as "resilient" energy infrastructure (U.S. Department of Defense, 2024; Eielson Air Force Lab, 2024) reflects the defense and climate crisis rhetoric that has historically been used to legitimize resource and land exploitation for militaristic pursuits.

When the government takes steps to develop these "sacrifice zones" (Lerner, 2010)—areas that have experienced severe environmental damage and tend to be located in areas where marginalized populations live—social inequities are often reproduced. Consider the Atlanta Public Safety Training Center, dubbed "Cop City" by activists, an 85-acre, city-sanctioned police training compound slated for construction in Atlanta's predominately African American South River Forest region. In Chapter 6, we describe how the siting process for this facility has been profoundly undemocratic. It is also environmentally harmful. The South River Forest and watershed are a vital ecological resource, offering rare green space for both residents and wildlife. It is considered one of four "city lungs," providing a natural retreat that is an important emotional, social, and communal asset (City of Atlanta Department of City Planning, 2017). But the South River Forest has experienced decades of environmental degradation; it has functioned as an unofficial dumping ground since the 1990s, is located near a landfill, is the site of a former prison, and faces ongoing pollution from failing water treatment and sewage systems in DeKalb County (U.S. EPA [U.S. Environmental Protection Agency], 2020). It still functions as a natural barrier protecting Atlanta from storm flooding, the city's most pressing natural disaster risk, which is expected to worsen with climate change (Agbebiyi et al., n.d.). Razing Atlanta's South River Forest to build Cop City will increase the climate vulnerability of the entire city—especially that of nearby marginalized communities. Environmental activists and local residents have voiced powerful objections to this decision, pointing to the environmental damage the compound is likely to cause in addition to existing longstanding harms (Hassan & Keenan, 2023). Instead of trying to remediate the site, the government has prioritized the needs of law enforcement (Alcorn, 2023). Former mayor Keisha Bottoms' assertion that the city "didn't have anything else to choose from" (Huynh, 2021) underscores the municipal government's perception of these lands as disposable and the lives of people who depend on it as less valuable than others. The decision to locate Cop City in Atlanta's South Forest region, depleting green space and climate resilience in the process, illustrates how

When the government takes steps to develop "sacrifice zones"—areas that have experienced severe environmental damage and tend to be located in areas where marginalized populations live—social inequities are often reproduced.

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governments reinforce patterns of harm and neglect, and even violence, in environmentally compromised areas disproportionately located in marginalized communities.

The exploitation of land and ecosystems of marginalized communities does not only lead to immediate impacts for local populations, but also creates long-term social and environmental harms. Decades before the construction of the Coca Codo Sinclair Dam, a Chinese-built hydropower project in the Ecuadorian Amazon, engineers warned that plans to site the dam in a valley prone to natural disasters could endanger surrounding communities and the environment (Casey & Krauss, 2018). Yet the dam project continued, reflecting the nation's energy shift away from fossil fuels at a politically complex moment, and environmental impact assessment studies were approved within a week by the Ecuadorian national electricity entity (Teräväinen, 2019). Built to supply 30% of the country's electricity, it started operating in 2016. To generate hydropower, the dam's reservoirs periodically collect and release water, but this disruption to natural water flow has altered fish migration patterns and led to erosion and increased sedimentation around the dam (Aguilera, 2023; Millard & Kueffner, 2025; Palma, 2017). As erosion accelerates, the Amazonian Kichwa communities living close to the dam grow more vulnerable to deadly sinkholes and flash floods (Palma, 2017; Paz Cardona, 2020b). The San Rafael waterfall, located on the Coca River and once Ecuador's tallest waterfall, collapsed in 2020 due to regressive erosion in the river and has since triggered sedimentation build-up that harms clean water and fish supplies that Kichwa communities depend on (Paz Cordona, 2020a; Velastegui-Montoya et al., 2024). Dwindling yields of fish in Coca River tributaries threaten traditional Kichwa fishing practices, food sources, and livelihoods (Palma, 2017). Additionally, Ecuador must repay the majority of Chinese loans for infrastructure projects in crude oil exports (Casey & Krauss, 2018). The extraction of crude oil contaminates air, soil, and water in the Amazon, and leads to higher rates of cancer in local Indigenous

Catastrophic erosion of the Río Coca bed following the 2020 collapse of the San Rafael waterfall, Ecuador. (*U.S. Geological Survey*)

populations (Coronel Vargas et al., 2020). Despite these harms, officials dispute the claims that the dam has negatively impacted surrounding ecosystems and public health, making future remediation and compensation efforts for Indigenous communities unlikely (Palma, 2017).

When governments prioritize natural resources for commercial projects over local use, communities are left forgotten and exposed to increased health risks, as in the case of a Coca-Cola bottling plant in the Mexican state of Chiapas. The bottling facility, located in the city of San Cristóbal de las Casas, home to one of Mexico's largest Indigenous populations, has drained water supplies and increased soft drink

Prize-winning photograph symbolizing Coca-Cola as a death sentence in Mexico. (Tomas Castelazo / *Wikimedia Commons*)

consumption with dangerous consequences for local public health (Guéguen, 2022; Yeung, 2025). Food and beverage giant FEMSA is licensed to extract hundreds of gallons of water for plant operations each day, and receives generous government subsidies on its water rates (Lopez & Jacobs, 2018; Yeung, 2025). In contrast, drinking water for the San Cristóbal community is extracted from shallow wells prone to drought and high levels of pathogens that can cause serious illness (Yeung, 2025). Survival remains difficult, particularly for the city's large low-income Mayan population, whose taps often run dry for weeks (Yeung, 2025). Those without a car must walk almost two hours to secure water at local trucks or stores (Pskowski, 2017). Due to these shortages, residents consume an average of over two liters (or more than half a gallon) of soda per day, as soda tends to be cheaper than bottled water and safer than the tap (Yeung, 2025). As a result, Chiapas has seen the highest annual increase in the diabetes mortality rate of any Mexican state since 1990, increasing 30 percent between 2013 and 2016 alone (Gutiérrez-León et al., 2022; Lopez & Jacobs, 2018). Research finds that people with Mayan ancestry are generally predisposed to diabetes, making the shortage of clean water and surplus of sugary beverages in San Cristóbal all the more inequitable and dangerous (Domínguez-Cruz et al., 2020; Lopez & Jacobs, 2018; Rodríguez Mega, 2015). Additionally, droughts have limited crop yields, threatening local access to fresh, nutritious food (Leroy et al., 2023). As government policies continue to cede water permits to profitable soda production, San Cristóbal's Indigenous population bears the brunt of public health ramifications.

The disproportionate impacts of catastrophes

In the case of catastrophic industrial accidents, ecosystems and marginalized communities, including laborers, also tend to disproportionately pay the cost. The 2010 explosion of BP's Deepwater Horizon drilling rig sent oil gushing into the Gulf of Mexico for 87 days, releasing an estimated 134 million gallons of oil in the largest marine oil spill (Marine Mammal Commission, 2015). The disaster resulted from a confluence of risks: engineering failures, regulatory errors, and corporate negligence (Bratspies, 2011; Krauss & Fountain, 2011; Robertson & Krauss, 2014). BP responded to the disaster by creating the Vessels of Opportunity program, which hired impacted locals—a majority of whom were from low-income and immigrant Gulf Coast communities—to clean up the spill. However, the safety protocols were inadequate. Poor vetting led to some non-locals taking clean-up jobs, and the wages were minimal (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Inequitable risk exposure left program participants and local residents suffering from what became known as "BP syndrome," a collection of chronic respiratory issues and fatal cancers, and a 25% increase in depressive illnesses (Osofsky et al., 2011). Despite extensive legal appeals in the years since, these communities have struggled to secure compensation for their economic and health losses (Lakhani, 2020; Sneath & Laughland, 2023). Meanwhile, the spill devastated ecosystems, with oil reaching depths of over a thousand meters and impacting over a thousand kilometers of shoreline (Beyer et al., 2016). Marine life, including plankton, fish, birds, and sea mammals, suffered a host of health impacts such as disease, impaired reproduction, reduced growth, and death (Beyer et al., 2016).

While catastrophic technological failures impact a variety of populations, marginalized communities, where many large infrastructure projects tend to be sited, are at heightened risk in times of disaster. This is particularly true for communities where waste—often treated as an afterthought in technological system design—is managed. In the case of London's early sewer systems, poor communities living and working around the Thames were unable to escape the constant smell of raw sewage and related cholera outbreaks (Collinson, 2019). While this proved a design and distribution

Workers contracted by BP clean up oil on a beach, Port Fourchon, LA (May 23, 2010). (*PO3 Patrick Kelley / Wikimedia Commons*)

problem in London's waste system, cases such as deteriorating sewage treatment plants along the Ganges River in India reveal how these problems are exacerbated when these systems catastrophically fail. As the population living in the Ganges basin rapidly increases, existing sewage treatment plants (STPs) have been unable to keep up, dumping millions of gallons of untreated waste into the river each day and causing widespread illness and ecological damage (Scarr et al., 2019; Global Water Intelligence, 2020). The Indian government has responded to these problems with initiatives like the Namami Gange Project, which seeks to improve water quality and update STP infrastructure, but complicated tendering processes for new plants and high energy and land demands to operate them has led to minimal progress (Pawariya, 2016). Climate change has intensified natural disasters and worsened these bureaucratic and capacity challenges, as increased catastrophic flooding around the Ganges overwhelms systems with stormwater, leaving sewage untreated and often bypassed directly into the river (Gupta, 2024; Padhi & Mankotia, 2019). While impacts of Ganges pollution may stretch beyond those living on the river, the poorer communities that depend directly on the Ganges for food, drinking water, and livelihoods are most harmed by the failures of waste management systems (Ridzuan, 2021). Similarly for nuclear energy, when the riskiest parts of the fuel cycle are situated in or near marginalized communities, these communities will bear a disproportionate price for catastrophic technological failures. The nuclear mining industry already has such a history; in 1979, a mill tailings dam near Church Rock, New Mexico, failed and spilled over a thousand tons of uranium waste into the nearby Puerco River (Gilbert, 2019). To date, this has been the largest accidental radiological release in the United States, affecting the livelihood and health of nearby Navajo/Diné communities. With the expansion of the nuclear industry, SMRs will continue to disadvantage vulnerable populations if industry and governments do not treat the most environmentally burdensome parts of nuclear energy production with attention and care.

We expect that the marginalized communities affected by SMRs across the fuel cycle—from the power plants to sites of uranium extraction and processing—will experience disproportionate harms from any catastrophic accidents that may occur. In addition to the Church Rock mill tailings spill mentioned above, this includes nuclear power plant disasters, such as those at Fukushima and Chernobyl, which, while rare, have devastating impacts on humans and the surrounding ecosystem. These disasters have impacted low-income people most, particularly low-paid temporary workers exposed to heightened radiation during clean up and post-accident plant operations (Hjelmgaard, 2016; Saidazimova & Bigg, 2006; United Nations Human Rights, 2018). Nearby communities impacted by the disasters have shown increased rates of depressive symptoms, post-traumatic stress disorder (PTSD), anxiety, alcoholism, and even cancer in some cases (Bromet, 2014; Oe et al., 2021; Tanisho et al., 2016; Tsutsui et al., 2024). With intensifying extreme weather events (Organization for Economic Co-operation and Development & NEA, 2021), geopolitical instability (Herviou et al., 2022), and unchecked technological enthusiasm and relaxed regulation (Nuclear Newswire, 2025), the safety and operability of nuclear plants and nuclear fuel cycle facilities could be further compromised, increasing the risk of a future catastrophic accident.

The burden of self-advocacy

Disproportionate health impacts force marginalized communities to experience yet another burden: advocating for themselves. Residents in the historically African American Diamond neighborhood in Norco, Louisiana, abutted by a Shell Chemicals plant, alleged for decades that the facility was unsafe and emitted toxic air pollutants (Ottinger, 2009). This led, they argued, to serious respiratory illnesses among residents. However, both Shell and the government dismissed these concerns, noting that their air monitoring system—which measured average concentrations of toxic chemicals over long periods—showed no pollution increase. In response, Diamond residents worked with local engineers to develop their own "bucket" monitoring system, which captured spikes in toxic chemical releases using inexpensive buckets to trap the air (Lerner, 2006). In other words, they found a way to prove the toxic chemical release in scientific terms that the courts and regulators would understand. Ultimately, Shell agreed to install a $10 million pollution and monitoring control system at its plant as part of a consent decree for improper industrial fume releases, which had been violating the U.S. Clean Air Act since 1997 (Hasselle, 2018; Reuters, 2018). However, the settlement did not adequately address residents' health concerns, and many are left with lifelong illnesses due to Shell's negligence (Ottinger, 2013).

Consider pesticide drift, the off-site movement of pesticide during its application in agricultural activity. Pesticides contaminate water sources, nature, and people, causing DNA damage, cancer, and respiratory illness (Pathak et al., 2022). Rural communities in the United States, particularly low-income, male farmworkers from immigrant backgrounds and with limited education, are most vulnerable to its environmental and health impacts (Arcury et al., 2014; Donley et al., 2022; Ward et al., 2006). There are few clear, universal guidelines for reporting pesticide drift across states, a process which can involve contacting a state pesticide regulatory agency, the Environmental Protection Agency (EPA), the Occupational Health and Safety Administration (OSHA), or pesticide manufacturers depending on the incident (U.S. EPA, 2024b). Much discretion is also left up to states in managing and communicating drift to communities, particularly when drift occurs across state borders and jurisdictions. This uncertainty deters many from effectively reporting drift, and because drift itself is difficult to measure, regulations are often ineffective and burdensome (Ricchio, 2018). Moreover, the navigation of state-specific procedures falls on victims of drift, who report difficulty in being able to correctly identify which agencies to report to for compensation and protection (Ricchio, 2018). In the United States in particular, "egregious harm" must be proven for the costs of victims' health to outweigh the economic benefits of the agriculture industry (Harrison, 2011). In the case of radiological impacts on humans and the environment, we expect that it will be similarly difficult for health effects to be reported and taken seriously if they do not neatly match legal frameworks for understanding and ameliorating risk and harm.

The AIDS epidemic of the 1980s and 1990s provides another important example of marginalized groups' advocating to change regulation and research practice. By 1987, over 50,000 people—primarily gay men—had died of AIDS since the first cases were reported in 1981 (U.S. Centers for Disease Control and Prevention, 2001). Until that point, the United States federal government had not sufficiently responded to the urgent public health crisis, and clinical drug trial frameworks were not equipped for the scale and speed of the rapidly accelerating epidemic. In response to the government's inaction, AIDS activists in the United States formed ACT UP, the AIDS

ACT UP "die-in" on the lawn of Building 1 of the U.S. National Institutes of Health during the "Storm the NIH" demonstration on May 21, 1990. (*NIH History Office, Branson Collection*)

Coalition to Unleash Power—a savvy, diverse grassroots campaign of activists advocating for better treatment and drugs for AIDS patients (Schulman, 2021). Educating itself with deep knowledge of the drug approval bureaucracy, the group targeted the Food and Drug Administration (FDA) and National Institutes of Health (NIH) to demand a more effective—and more ethical—response to the AIDS epidemic (Crimp, 2011; Schulman, 2021). The FDA regulatory practice at the time consisted of rigorous testing and trials before drugs could be used in humans—a far more stringent and slow framework than in many other places in the world. ACT UP contested this framework and demanded the shortening of the drug approval process, removing double-blind placebo studies, and providing full insurance coverage of these costs; they also advocated for a wider demographic representation in clinical drug trials and called for the recognition of "every AIDS death as an act of racist, sexist, and homophobic violence" (Crimp, 2011). The coalition was ultimately successful in transforming the U.S. government's response to the AIDS crisis—as well as biomedical research practices in the long term—not just through political activism and civil disobedience, but also by developing credible expertise that enabled the effective challenging of scientific authority (Epstein, 1996). In effect, AIDS activists had to shoulder multiple burdens—not only leading protests, but also acquiring the technical knowledge needed to demand action of the federal regulatory institutions to save their sick and dying communities.

In the case of the nuclear industry—specifically the uranium mining sector—limited regulations governing radiation exposure and compensation pathways place health burdens squarely on those affected. Radiation monitoring schemes that guide worker compensation are piecemeal, inconsistent across countries, and contingent on individual labor agreements (IAEA, 2003). This leaves substantial gaps, evidenced by the ongoing struggle of South African uranium miners to receive recognition or payment for health harms linked to radiation exposure (Hecht, 2012). In the United States, the Radiation Exposure and Compensation Act (RECA), which provides a one-time payment for health harms incurred from atomic weapons tests and uranium mining, milling, and transport, only covers uranium workers exposed before 1971 and impacted by government activity (Radiation Exposure Compensation Act, 1990). In 2024, the U.S. Congress let RECA expire (Miri, 2024), though in 2025, the Act was reauthorized, allowing the filing of claims until 2027 and even expanding eligible populations (Obee, 2025). With only a few concrete cleanup plans for the more than 500 abandoned uranium mines (AUMs) on Navajo lands (U.S. EPA, 2022; U.S. EPA, 2024c), impacted communities on or near Navajo Nation are subject to continued radiation exposure (Morales, 2016).

Yet Native American communities have long advocated for attention to this exposure, efforts which have culminated in action, such as a $600 million settlement between the U.S. Department of Justice and Navajo Nation for the cleanup of 94 abandoned uranium mines on Navajo land in 2017 (U.S. EPA, 2025b). Native-led organizations such as Diné Care, a group that gathers testimonials from former mine workers and pushes for timely compensation for uranium exposure, has helped Native community members file claims to RECA and receive funds for related medical care (Diné Care, n.d.). The Navajo/Diné-led group Haul No! successfully advocated for reform to RECA in 2000 and continues to fight uranium mining projects such as Pinyon Plain, a mine located on traditional cultural property just seven miles from Grand Canyon National Park (Haul No!. n.d.). The Pinyon Plain mine recently began operating despite almost a decade of Native-led opposition, echoing a more widespread resurgence in the interest in uranium mining that puts the health and environmental concerns of Native American communities into the spotlight (Moore, 2025). As uranium mining expands alongside advanced nuclear energy development, we expect that more resource extraction will make compensation and remediation efforts for Native communities more difficult and force them to keep spending time and resources to advocate for their rights.

Map of abandoned uranium mines and Najavo Nation. (*U.S. EPA*)

The criminalization of dissent about environmental concerns

When marginalized communities mobilize against unfavorable projects, they are not only often overruled by governments and corporations in favor of building critical infrastructure; their civil disobedience is often met with force and legal action (Lakhani & Beaumont, 2024). The U.S. government and private developer Energy Transfer Partners (ETP) described the Dakota Access Pipeline (DAPL), a 1,172 mile-long underground pipeline transporting up to 750,000 barrels of crude oil per day, as a technologically advanced, safe, and environmentally sensitive way of supporting American energy independence (Dakota Access Pipeline, n.d.). Both Native tribes and environmental groups opposed the effort, noting the pipeline's impacts on sacred sites, drinking water, the land, and wildlife (Hersher, 2017; NYC Stands with Standing Rock, 2016). Concerns of environmental harm were not speculative—the Ohio EPA had

Stop Cop City graffiti along the Proctor Creek Greenway Trail, Atlanta, Georgia. (*Tyler Lahti / Wikimedia Commons*)

criticized ETP for spilling millions of gallons of drilling fluid and smothering plants and wildlife in wetlands during the construction and operation of past energy infrastructure projects (Mufson, 2017). There were months of protest against the pipeline on the Standing Rock Reservation, and the Chairman of the Standing Rock Sioux even addressed the UN Human Rights Council, asking for construction to stop. However, the police and U.S. National Guard violently suppressed the protests, and federal courts disregarded the tribe's concerns during the planning and permitting processes (CBS News, 2016; Levin, 2017). Pipeline construction ultimately moved forward, and since completion in 2017, DAPL has leaked at least five times, the largest spill requiring soil remediation on nearby land (Guha, 2023; Lakhani, 2022).

Dissenters may also become targets of outsized legal charges, as seen in the case of Cop City. In March of 2023, protestors caused damage to equipment at the Cop City construction site, and dozens were arrested at a nearby music festival on charges of domestic terrorism (Riess et al., 2023). Warrants contained little substantiated evidence of illegal activity, instead using probable cause on the grounds of muddied shoes and mutual aid phone numbers written on belongings as a basis for arrests (Rico, 2023). Later that year, three activists were arrested on charges of money laundering and charity fraud under RICO (or the Racketeer Influenced and Corrupt Organizations Act, a statute often used against organized crime groups) for their involvement with the Atlanta Solidarity Fund, an organization covering bail and providing legal services to Cop City activists (Rojas & Keenan, 2023). Georgia's judiciary has since dismissed the money laundering charges, believing the attorney general did not have the right to bring the court to case, as well as the domestic terrorism charges, concluding that the state violated the right of protestors to due process and a speedy trial with its frequent delays and failure to issue an indictment (Pratt, 2025; Rico, 2024).

In sum, our case study analysis in this section shows that the expansion of advanced nuclear energy will disproportionately shift burdens onto already marginalized communities, sacrificing them in the name of crisis and national interest. Vulnerable communities will bear the environmental harms of co-located industries, extractive activities, and catastrophic accidents. They will also be left to themselves to advocate for their rights, potentially risking criminalization from protest about environmental concerns.

MARGINALIZED COMMUNITIES WILL EXPERIENCE INEQUITABLE ENERGY ACCESS

Marginalized communities bear disproportionate health and environmental burdens of SMRs while also receiving limited or no benefits of the technology. While proponents of SMRs emphasize their potential as a reliable, cheap, and clean energy source, the electrical grid often does not reach marginalized communities; and, when it does, tends to be less reliable (Ariza, 2025; Reta & Gout, 2021). In the United States, wealthier neighborhoods tend to have upgraded, resilient power lines (Sovacool et al., 2024), while low-income communities face more frequent blackouts and delays in restoration (Do et al., 2023). Even where the grid infrastructure is unreliable, wealthier residents can afford to purchase generators or solar panels to bridge their power resources, an option unavailable to low-income residents. Energy inequity can be further exacerbated in states interested in supporting tech development. Arizona, for example, is working quickly to ensure adequate energy supplies for a growing number of data centers, while denying power to many of its primarily Navajo residents because of "concerns about how the funds would be used" (Verma, 2024). This all has direct health consequences, with Native communities in Arizona unable to refrigerate fresh food at home or use medical devices that require electricity, like supplemental oxygen (Verma, 2024).

Disparate power allocation harming marginalized groups is a familiar story. As mentioned above, the Akwesasne people did not consent to construction of the Moses-Saunders Dam. And while it powers local industry, local communities have reaped inconsistent electrical benefits from the dams (Johnson-Zafiris, 2024). In fact, despite a 2008 settlement attempt to include equitable power allocations for tribal members, Ontario Power Generation refused to include electricity supply as part of the agreement (Thompson et al., 2008). This inequitable energy access is not just unethical, it also produces direct health risks, particularly because most people cannot afford generators. Akwesasne members living close to the dam endure blackouts during winters which drop indoor air temperatures to dangerous levels, and community members who rely on medical equipment like oxygen tanks must forgo lifesaving treatment (Johnson-Zafiris, 2024). Meanwhile, a nearby cryptocurrency mining facility operates around the clock.

> Preferential treatment of corporations over people can limit a community's access to its own local resources.

Preferential treatment of corporations over people can limit a community's access to its own local resources. In San Cristóbal de las Casas, Chiapas, the company operating the Coca-Cola bottling facility, Femsa, receives generous licenses for deep well extraction

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and government subsidies on its water rates (Lopez & Jacobs, 2018; Yeung, 2025). Due to the company's access to the best wells, Femsa has drained local water supplies and cut off access to clean, safe drinking water to local populations (Guéguen, 2022; Yeung, 2025). In contrast, drinking water for the local population in San Cristóbal comes from shallow wells suffering from low levels of water and high levels of pathogens that can cause serious illness (Yeung, 2025). On top of this, droughts have reduced crop yields, endangering local access to fresh food (Leroy et al., 2023). As government policies continue to prioritize handing out water permits to the profitable corporation, San Cristóbal's predominantly Indigenous population keeps turning to Coca-Cola as its main source of liquid, as clean water is difficult to access and bottled water is often more expensive than the sugary drink (Yeung, 2025).

Ontario Power Generation's power station at the Moses-Saunders Dam on the Saint Lawrence River. (*RH Saunders Generating Station*)

Paradoxically, these inequitable risks from inequitable resource allocation are likely to grow with increased extreme weather events due to climate change, particularly in communities without ample resources for disaster response or climate resilience (Fedchenko, 2024; Reta & Gout, 2021). For instance, two-thirds of residents in Atlanta, Detroit, and Phoenix, majority non-white cities, would be at risk for heat exhaustion or heat stroke if a heat wave and blackout coincided (Flavelle, 2021). During the 2021 Texas ice storm, which was likely exacerbated by climate change, almost half of the households in areas with greater minoritized populations experienced prolonged power outages, compared to only about 10% in predominantly white areas (National Center for Disaster Preparedness, 2023). This figure reflects both grid failures and higher-income households' access to generators. Energy resilience is directly tied to climate resilience, as inequities in energy systems heighten climate risks for underserved communities (Jessel et al., 2019).

Climate-related power outages at nuclear plants have risen in recent decades and are expected to increase further, even with the new design features of advanced nuclear reactors (Ahmad, 2021; Fedchenko, 2024). Nevertheless, the Nuclear Regulatory Commission (NRC) insufficiently integrates climate risks into siting decisions and evaluations of infrastructural resilience, relying on historical data rather than data including climate projections of extreme weather to assess risk (U.S. GAO, 2024a). But even if the NRC considers these issues in SMR siting, energy access will depend on grid infrastructure, which is inequitably distributed and maintained. For example, as described in the Introduction, proponents suggest that

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SMRs and microreactors can be particularly useful in rural areas. However, these areas are more vulnerable to outages due to older, limited local grid infrastructure (Xiao & Liang, 2024). As the rate of extreme weather events increases, so will power outages, and, as our case studies demonstrate, this will increase environmental vulnerabilities such as limited access to drinking water, food, and electricity in historically marginalized communities.

These case studies warn us that SMRs or industries co-locating with SMRs may have similar implications of limited energy access, and will exacerbate existing strains on resources and energy supply especially in marginalized communities where access to resources is already limited. In the United States, recent aims by the tech industry to draw electricity directly from existing nuclear power plants—and to power their data centers with SMRs yet to be built—have been blocked by regulation (Howland, 2025; Moseman, 2024). The Federal Energy Regulatory Commission (FERC) expressed concerns about fair energy distribution if data centers are directly connected to the electricity-generating power plant behind the meter (Moseman, 2024). The tech industry could in this way skirt fees that could help maintain grid stability and may deprive the grid of electricity needed to sustain communities, potentially even raising electricity prices for ratepayers (Camacho, 2025; Moseman, 2024).

Overall, based on our analogical case study analysis in this chapter, we expect the expansion of advanced nuclear energy to exacerbate environmental and health burdens, especially on marginalized communities. Though framed as a solution to the climate crisis, SMRs—even if they are successful in replacing fossil fuel plants—will enable industrial growth that is environmentally harmful. Recent tech industry investments in SMRs to power data centers are just one example of this. The expanded development and construction of SMRs will also increase demand for uranium mining, an industry widely under-regulated and governed by inconsistent standards internationally. As a result, SMRs are likely to exacerbate, either directly or indirectly, environmental risks—including air and water pollution, increased waste, and habitat destruction—and subsequent health burdens. These problems will disproportionately affect marginalized communities, who lack the resources to prevent or manage them. Potential catastrophic accidents, while rare, will affect vulnerable populations the most. Communities with environmental concerns will be forced to advocate for themselves to address these risks and prevent harms. Protest or resistance to constructing uranium extraction and processing facilities, SMRs, or co-located industrial infrastructure in or near communities may be criminalized. Finally, corporate and government priorities are likely to squeeze vulnerable communities of their local resources and limit access to the energy benefits that SMRs may bring to the communities that need it most.

Chapter 6: Abandoning Promises of Local Development and Empowerment

KEY TAKEAWAYS:

- SMRs will fail to provide local jobs and economic development for host communities.
- Transitioning fossil fuel workforces to the SMR workforce will be difficult.
- The SMR industry will site its riskiest infrastructure and jobs in marginalized communities, exposing them to health and environmental harms.
- Developer interests will undermine community engagement in SMR planning, siting, and operation.
- SMRs will fail to foster community self-governance of nuclear energy.

Proponents argue that small modular reactors (SMR) will benefit local communities both economically and politically. They anticipate that newly built nuclear plants, particularly in rural or low-income regions, will foster job creation that will reinvigorate local economies. Developers imagine the complete transformation of former coal towns, with unemployed workforces and decommissioned plants, a logical starting point (Jack, 2024; Nuclear Business Platform, 2023; U.S. DOE-NE, 2024a). This strategy could save money and limit permitting hassles, while attracting rural communities desperate for new employment sources. Yet SMR jobs require expertise that most rural communities do not possess, and coal workers will likely struggle to gain employment in the industry as a result.

Given their small scale, SMRs could also enable greater citizen autonomy in local energy governance. Conventional nuclear has lacked robust public participation in past planning and governance processes, due to enormous plant size, security concerns, and the perception that these discussions are highly technical (Lovering & Baker, 2021). However, at a moment of growing interest in democratic deliberation in science and technology policymaking, advocates assert that local cooperatives and small municipal utility companies will own the new reactors, which will then encourage self-governance and wider community consent (Lovering & Baker, 2021). Ultimately, this approach to small-scale power generation and local ownership could be more responsive to community energy needs. However, several obstacles stand in the way.

SMRS WILL PROVIDE MINIMAL BENEFITS TO THE LOCAL ECONOMY

Despite the promises that SMRs will transform local economies, nuclear expertise is not easily transferable. It will be difficult for less-educated populations to access these jobs. High-paying jobs at nuclear power plants, conventional or advanced, require degrees in engineering, reactor physics, and nuclear science (IAEA, 2022b; Jacobs & Jantarasami, 2023; NRC, 2023b; NRC, n.d.). Further, plant operators and supervisors must have at least one year of plant training and pass a licensing exam in order to receive a license to work in any member state (IAEA, 2006). Licensing exams cover thermodynamics, reactor theory, and reactor components, areas of expertise likely out of reach for those without a college degree (IAEA, 2006; NRC, 2021). Overall, of the 30 million additional workers needed in the clean energy and low-emissions technology sectors by 2030, 60% will need postsecondary degrees (Watson & Ashton, 2022). In the United States, where the coal-to-nuclear workforce transition has become a policy talking point, approximately one-quarter of coal workers will require extensive retraining (Hansen et al., 2022; Jacobs & Jantarasami, 2023). This retraining consists of up to 15 months

Romanian writer Panait Istrati, with local miners, reports the causes and spread of the Lupeni coal miners' strike, Romania. (*Elena Dumitriu* / Humazur / Wikimedia Commons)

of educational programs and a minimum of three years of plant experience before a former coal worker can apply for operator licensing (Jacobs & Jantarasami, 2023). Existing coal workforce transition programs often provide tuition vouchers for technical education programs and direct payments to businesses to incentivize hiring former coal workers (Dahl et al., 2023). The cost of these programs varies across countries, but can range anywhere from $7,000 to $45,000 per worker, a sum which can quickly add up for the national and regional governments funding them (Dahl et al., 2023). Meanwhile, the United States DOE has set aside $100 million to bolster nuclear safety curriculums and workforce development (U.S. DOE-NE, 2024c). But this funding provides no mechanism to connect fossil fuel workers with program benefits and fails to address the unique challenges these groups will face in acquiring nuclear expertise and training (U.S. DOE-NE, 2024c). Without meaningful efforts to bridge educational gaps and facilitate training

An Automatic Teller Machine in Chicago. (*Jason Cupp / Flickr*)

pathways, coal communities will struggle to gain nuclear expertise in time for local plant construction.

Even with such initiatives, workforce training programs are at the mercy of political and economic conditions. Consider the failed coal-to-wind retraining program in Romania's Jiu Valley. Since the 1990s, roughly 90% of Jiu Valley's coal workers have lost their jobs as the industry battles economic inefficiencies and new climate protections (LaBelle et al., 2021). To address this, in 2019, national officials partnered with the Romanian Wind Energy Association (RWEA) to kickstart a workforce retraining program for former miners. They aimed to train 5,000 wind technicians and 3,000 electricity network technicians over a decade, seeking to reinvigorate local labor markets while bolstering Romania's transition to renewable energy (LaBelle et al., 2021). Yet after Romania's ruling coalition government collapsed that summer, national funding for the program fell through and left the RWEA to steer the pilot program alone. Ultimately, the RWEA took only 50 applicants on wind farm tours and sent just one applicant for wind power training in Scandinavia (LaBelle et al., 2021). Similarly, coal workforces will be left behind if the nuclear industry's transition plans are similarly disjointed and vulnerable to sociopolitical turmoil (Nicola & Schmitz, 2022).

If they do manage to get specialized training, SMR workers may be forced to leave their communities to take a job in the nuclear industry. Prison developers in the United States often emphasize employment benefits to combat community hesitancy related to siting a prison nearby, yet in practice it can be difficult for residents to get jobs in the area. The industry favors veteran corrections officers, with a strong seniority system that places early-career officers in undesirable and distant prisons until they achieve a high enough rank to choose more favorable sites, including ones closer to home (Gilmore, 2007; King et al., 2004). In order to eventually get a local job, a worker may have to spend years far away from home. And in the rare cases where they do secure a job at a local prison, the work may be difficult or unsafe because they are low on the experience hierarchy and lack specialized skills (King et al., 2004). In sum, a new prison nearby does not guarantee good jobs near home. Like prisons, nuclear plants rely on an internal hierarchy where more experienced workers have access to higher paying jobs with more favorable hours (U.S. Congress Office of

Technology Assessment, 1991). Newly trained SMR workers may struggle to secure these favorable jobs (or any jobs at all) without the required experience.

Meanwhile, even highly specialized workers face increasingly diminished job opportunities and fast-changing expertise demands due to automation. SMR developers envision human-less operations to achieve safer, more efficient, and more reliable operations (Arave, 2024). Artificial Intelligence (AI) in particular may be able to complete routine tasks faster and more accurately than humans, while also optimizing overall fuel consumption and energy output of plants (Picot, 2023). Of course, automation has long affected labor and, specifically, employment opportunities (Holzer, 2022). Consider ATMs, which have made banking more efficient but restructured the sector's workforce. Though bank teller roles and other in-person financial services have not disappeared, banks have an ever-shrinking pool of on-site workers (Bureau of Labor Statistics, n.d.). New ATMs incorporate remote teller assistance via webcams (Townsend, 2017). This push for automation and remote operations has reduced salary and rent burdens for banks but also diminished local job opportunities and community trust in banking (CAPACD et al., 2014). Marginalized communities in particular emphasize the importance of personal relationships and customer service in banking, exemplifying how the industry has eroded local trust in pursuit of greater efficiency (CAPACD et al., 2014). The industry continues to embrace automated banking services and has done little to redress this erosion of public trust. Like automated banking, SMR automation will create new kinds of jobs (particularly in data management and AI, which do not need to be performed locally) but risks shrinking industry employment on the whole.

> Without meaningful efforts to bridge educational gaps and facilitate training pathways, coal communities will struggle to gain nuclear expertise.

Developers also argue that SMR projects will bring new people, money, and industries to the area, but this is likely to fall short when new jobs do not go to local residents (Glasmeier & Farrigan, 2007). Prison developers in the United States similarly emphasize local economic development to garner support from host communities. Yet because most prison jobs are filled by those living outside the community, local tax revenues do not increase, and the salaries are spent elsewhere (King et al., 2004). Promises of increased profits for local businesses will go unrealized if new jobs are taken by workers living outside the community. And local communities, particularly rural ones, often do not have the resources to increase housing, food, and energy supplies for prison workers that do choose to relocate locally (King et al., 2004). Developers also assert prisons create new local industries that help maintain prison operations, yet prisons are not found to generate significant "spin-off" jobs or bolster local economic competition, especially in rural towns with fewer resources (King et al., 2004).

Finally, Ecuador's Coca Codo Sinclair Dam case illustrates not only how infrastructure projects deliver far fewer economic benefits to local communities than they promise but also how this can produce social destabilization. Both government officials and Sinohydro, the Chinese firm that led construction of the dam in the Ecuadorian Amazon, created high expectations for jobs and economic development in surrounding communities (Vallejo et al., 2018). This included the promise that local people would get 70% of dam-related jobs (Teräväinen, 2019; Vallejo et al., 2018). However, because they lacked engineering expertise and were not offered training, local residents only got approximately 40%, and all were in temporary construction. Once the dam was complete, workers could not easily return to their previous employment in industries such as agriculture. Regional unemployment increased, and many families experienced financial instability. Although Sinohydro imported most of its high-expertise jobs from China, some Ecuadorian engineers—from urban areas—got jobs at the dam. But they struggled to operate equipment because of communication issues; for example, equipment labels were sometimes incorrectly translated from Chinese to Spanish (Casey & Krauss, 2018). Like their prison counterparts, dam developers also promised that local businesses would increase their profits by selling food, housing, and other goods both on and off construction sites (Vallejo et al., 2018). But providing on-site services required formal partnership with Sinohydro and meeting onerous bureaucratic requirements, including registration with tax and public procurement offices, which proved an obstacle for most small, local industries (Business & Human Rights Resource Centre [BHRRC], 2022; Vallejo et al., 2018). Meanwhile, although nearby property owners benefited from short-term increases in rental and business revenues, alcohol use, street fights, and theft increased in tandem (Vallejo et al., 2018).

SMRS WILL REINFORCE LOCAL WORKFORCE INEQUALITIES

Like conventional nuclear energy, SMR employment is likely to reinforce local socioeconomic and health inequalities. Historically, nuclear power plants in the United States have been located in wealthy white communities with highly educated workforces and strong English skills (Cranmer et al., 2023). In the highest nuclear power-producing states of Pennsylvania and Illinois, for example, communities hosting the states' top-generating plants are overwhelmingly white with poverty rates well below the state average (Burman, 2024; U.S. Census Bureau, 2022a; U.S. Census Bureau, 2022b). Nuclear plant jobs in these communities require specialized education and are well paid and stable as a result. By contrast, uranium mining and milling jobs require fewer specialized skills, are poorly paid, and are often unsafe for human health and the environment because radioactive dust contaminates air, groundwater, and workers' bodies (U.S. EPA, n.d.). Perhaps as a result, they tend to be performed by low-income and less educated communities of color. As noted in the Introduction, much of the world's supply of uranium comes from mines in Kazakhstan, Namibia, and Niger where exports to nuclear energy leaders such as the United States, Russia, and more recently, China, continue to sustain local industries (Bersimbaev & Bulgakova,

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2015; Hecht, 2012; El Obeid, 2021). In the United States, Australia, and Canada, uranium mining and milling has historically been sited on Indigenous land and disproportionately employed and harmed Indigenous populations (Coates et al., 2023; Dawson & Madsen, 2011; Leyton-Flor & Sangha, 2024; Schroer, 2022). In the American West alone, more than 500 abandoned uranium mines on Navajo land await cleanup by the EPA as of 2025, while nearby Indigenous populations risk radiation exposure in the meantime (Forté, 2025; U.S. EPA, 2025a). Despite this, global workplace protections are inconsistent and inadequate in mining and milling industries compared to the stringent oversight at nuclear power plants, leaving marginalized communities at risk (National Research Council, 2012).

Marginalized communities and workers are also likely to be treated as dispensable. In 1920s America, the U.S. Radium Company (USRC) employed young female workers from immigrant and working-class backgrounds in its factory. The "Radium Girls," as they were called, painted hundreds of watch dials with toxic radium-laced paint daily to make them luminous (Grady, 1998). USRC chemists, aware of the dangerous health impacts of radium, used screens and masks to handle the material (New Jersey Government [NJ Gov], 2016). But factory management never relayed these dangers to workers or provided protective gear. Instead, they instructed the women to repeatedly press their brushes to their lips to give paint strokes an exacting edge, exposing their bodies to high levels of radiation and greater health risks (NJ Gov, 2016). As sick workers came forward with conditions like jaw necrosis and tooth decay, the USRC attempted to avoid culpability and profit losses (Balkansky, 2019; Rudzis, 2017). Tactics included altering a workplace safety report that found widespread radium contamination in the factory, falsely attributing workers' illnesses to syphilis, and purposefully delaying litigation efforts of victims (NJ Gov, 2016).

"The Radium Girls" painting the hands and spheres of watches and compasses. (*Wikimedia Commons*)

Protests and litigation have led to improved regulation of the nuclear industry, increased safety measures, and worker compensation in some places, but they are not consistent everywhere and expose marginalized communities to disproportionate risks. On one hand, the United States established the Radiation Exposure Compensation Act (RECA) in 1990 to provide restitution for workers and communities sickened by uranium mining (Radiation Exposure Compensation Act, 1990). In 2024, the U.S. Congress let RECA expire (Miri, 2024), though in 2025, the Act was reauthorized, allowing the filing of claims until 2027 and even expanding eligible populations (Obee, 2025). No such direct compensation programs exist elsewhere (Mandel, 2021). In prominent uranium-producing nations like Namibia and Kazakhstan, changes in health and safety have been slower (Business & Human

Rights Resource Centre, 2022; El Obeid, 2021; Wilde-Ramsing et al., 2011). Limited knowledge -sharing about uranium mining's occupational hazards, as well as government suppression of workers' unions, has diminished opportunities for miners to organize for safer conditions in these places (Omarova, 2023; Shindondola-

Tractor spraying pesticide on field, Germany. (*Stefan Thiesen* / *Wikimedia Commons*)

Mote, 2008). When SMR proponents argue that uranium mining has been sufficiently reformed in recent decades, they overlook lagging protections and heightened risks for marginalized communities in some of the most prolific uranium industries in the world.

We see a similar pattern of inequitable distribution of risks and benefits across "green" industries. Lithium ion batteries are framed as a key technology for decarbonizing and mitigating climate change, yet the users of electric vehicles and similar technologies that are powered by lithium ion batteries tend to be wealthy and white (Dugdale, 2022), while socioeconomically disenfranchised Indigenous communities tend to mine lithium around the world (Greenfield, 2022; Hauser, 2024; Kurmelovs, 2022; Penn & Lipton, 2021; Redvers et al., 2023). Lithium processing involves toxic chemicals that can contaminate groundwater, soil, and the air, causing adverse health impacts for nearby populations and ecosystems (Kaunda, 2020). Mining also requires vast amounts of water, worsening droughts in arid communities where lithium is most abundant (Greenfield, 2022; Wetlands International, 2023). And yet, these communities lack proper health care access and are therefore less prepared to combat mining-related illness (Redvers et al., 2023). They also lack the political power to mitigate lithium mining's environmental and health impacts (Amnesty Interntional, n.d.).

Unfortunately, the private sector invariably views marginalized communities as acceptable collateral damage for meeting production demands. This was clear in the Radium Girls case, and today we see this across industries. Agriculture companies, for example, have grown comfortable burdening rural, immigrant communities with the hazards of pesticide drift in pursuit of more lucrative crop production. Pesticides are, of course, common in agriculture, but air currents can push the chemicals from the crops they are supposed to treat into neighboring natural spaces, water sources, and residential areas. This "drift" can have enormous negative health impacts, including heightened instances of cancer and endocrine disruption in humans and wildlife, as well as decreased biodiversity and soil fertility in the environment (Aktar et al., 2009; Bowser & Tharp, 2022; Damalas & Koutroubas, 2016). Farm workers—largely from communities of color, with undocumented immigrant backgrounds, and with low levels of education—are among the most affected (Harrison, 2011). Like lithium and uranium mining communities and the Radium Girls, they have few protections (Arcury et al., 2014; Castillo et al., 2021; Donley et al., 2022). Given the importance of pesticides in producing high volumes of crops, farmers are unlikely to give them up. But they also know that in many places, where few employment alternatives exist to agricultural work, they have a captive labor force.

Similarly, decades before the Coca Codo Sinclair Dam was built, engineers warned that its location in a natural disaster-prone valley could threaten the safety of workers and local communities as well as the health of the Ecuadorian Amazon (Casey & Krauss, 2018). But the government pushed on, hoping to ensure Ecuador's stable supply of electricity and reducing the nation's dependence on fossil fuels. Construction crews then observed faulty steel equipment, and in 2014, a pressure well collapsed and killed 13 workers (Casey & Krauss, 2018). Workers went on strike to protest noncompliance with labor rights regulations, including health, safety, and wage protections (BHRRC, 2022; Lozano, 2019). But Sinohydro threatened to fire or even press charges against protestors (Varas & Paz y Miño, 2023). Meanwhile, neighboring communities continue to lack reliable or affordable energy access, and do not share in the benefits of the nation's energy transition (Casey & Krauss, 2018).

The nuclear industry's history, considered in the context of the legacies of other technologies like pesticides, radium, lithium ion batteries, and dams, demonstrates a clear pattern of inequity. Despite lofty promises, marginalized communities tend to have access to the least attractive jobs, exposing them to risks and providing few protections. Further, they rarely have access to the technology's benefits. While proponents of SMR tout it as a vehicle for job creation, there is little evidence that developers will be able to counteract the likely inequitable distribution of the riskiest jobs without proactive attention.

SMR DEVELOPER INTERESTS WILL CURTAIL COMMUNITY SELF-GOVERNANCE

Large private and state-owned utilities have dominated global nuclear power development for decades, making it difficult for local communities to exert influence over decisionmaking including mining, milling, plant siting, energy distribution, and pricing (NEA, 2009; Union of Concerned Scientists, 2022). Despite community protests over the environmental and health impacts of potential accidents at the Seabrook Station Nuclear Power Plant in the United States or the Temelín Nuclear Power Station in the Czech Republic, for example, developers continued building new plants (Radio Prague International, 1998; Turner, 2011). Nevada's Yucca Mountain is a rare exception. Here, Indigenous communities, concerned about potential radiation exposure for future generations and the destruction of culturally significant, sacred land, aligned with the state of Nevada, whose opposition in Congress halted a nuclear waste repository project after decades of grassroots opposition (KTNV Las Vegas, 2023; Solis, 2019).

SMR proponents argue that their small-scale, modular technologies can encourage local energy self-governance, but reversing decades

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of top-down nuclear power development will be a difficult task. Developers will need to foster community consent and collaborative design in plant siting, civilian nuclear education, and local energy ownership to be successful (Lovering & Baker, 2021). Analogical case studies teach us that this kind of public engagement and trust-building must be fostered over the long term and be expansive in scope, rather than simply focused on gaining one-time consent.

SMR proponents argue that their small-scale, modular technologies can encourage local energy self-governance, but reversing decades of top-down nuclear power development will be a difficult task.

Without such practices, infrastructure development can have long-term, catastrophic impacts on communities. In 1954, the American and Canadian governments flooded vast amounts of land in the Mohawk Nation's Akwesasne Territory to construct a commercial seaway and hydroelectric power dam, known as the Moses-Saunders Power Dam (Johnson-Zafiris, 2024; Shaw & Kaczkowski, 2009). In the process, they destroyed large swathes of Akwesasne land without local consultation, and the influx of polluting ships and factories sickened nearby communities with chronic illnesses (Johnson-Zafiris, 2024; Thomas-Blate, 2016). The pollution of waterways and air has also since infringed on the Akwesasne's right to use natural resources for food, medicine, and traditional ways of life (Johnson-Zafiris, 2024). In 2008, in light of decades of Akwesasne suffering, the Mohawk Council of Akwesasne (MCA, or the governing body of the Akwesasne community located in present-day Canada) reached a settlement with Ontario Power Generation (OPG) (Johnson-Zafiris, 2024). It granted the MCA a formal apology, $45 million in compensation, and the transfer of several Akwesasne islands flooded during seaway construction (Johnson-Zafiris, 2024). However, these retroactive and monetary amends could not reverse years of harm inflicted on the Akwesasne people. Ultimately, ignoring local interests cost the OPG millions, but more importantly, cost many in the Akwesasne community their livelihoods. Without taking community needs, knowledge, and consent into account, SMRs are likely to similarly harm communities and encounter local pushback.

More closely related to SMRs, the Romanian Jiu Valley case demonstrates both how communities can provide important knowledge to developers and how ignoring this knowledge can increase public alienation. For over 30 years, coal miners struggled to find new employment opportunities as the region's coal industry shrank. When the Romanian Wind Energy Association (RWEA) finally established a workforce training program in 2019, it failed to engage community members in its planning and execution (LaBelle et al., 2021; Romanian Energy Ministry, 2019). Jiu Valley residents expressed concern over the loss of community identity and local economic power linked to the declining coal industry, yet the RWEA and Romanian government's efforts to transition away from coal were detached from this input (LaBelle et al., 2021). Mine communities were left feeling alienated, expressing distrust in their government and coal corporations through protests (Turp-Balazs, 2021). In 2021, hundreds of Jiu Valley coal miners protested their declining wages, with as many as 60 people barricading themselves inside a mine and threatening to go on hunger strike (Turp-Balazs, 2021). Political negotiations have also alienated Jiu Valley miners (LaBelle et al., 2021). Bucharest politicians, rather than Jiu Valley community members, represent the region in energy transition talks with the European Union, further limiting local governance of the process and its socioeconomic impacts (LaBelle et al., 2021). In failing to incorporate the input of the Jiu Valley community, these top-down efforts have harmed local self-determination in shaping a post-coal future. If the coal-to-nuclear workforce transition is similarly myopic and missing local input, communities will be unprepared for the energy transition and sidelined from governance by developers.

When developers promise or are required to incorporate public input into decision-making and do not follow through, this too harms social cohesion. Take the development of Atlanta's Public Safety Training Center (known as "Cop City"). Initially a prison farm, city officials planned to turn the land into a park after community input called for more local green spaces (Center for Civic Innovation, 2023). But by 2021, the Atlanta City Council and Atlanta Police Foundation (a multi-million dollar nonprofit with corporate backers like Delta and Coca-Cola) had decided, behind closed doors, to build a massive, $90 million police training compound (Huynh, 2021; Simon, 2023). The secrecy continued when then-mayor Keisha Lance Bottoms failed to include community members on the advisory council guiding the center's development despite written plans to do so in an administrative order (Office of the Mayor, City of Atlanta, 2021). When the public finally learned of the training center, just two months before its approval would go to council vote, there were widespread protests (Huynh, 2021). In response, city officials introduced a public comment period to let council members hear the concerns in full (Pratt, 2023). The council heard a staggering 17 hours of feedback, most decrying the project as a tool for militarizing local law enforcement and destroying green spaces in adjacent, predominantly-Black neighborhoods (Huynh, 2021). Yet the plan was ultimately approved by the city council (Huynh, 2021). When the city council met to approve project funding two years later, it again heard public comments. But the hundreds of participants were let into City Hall two hours late, barred from bringing food or water into the building, and were given only one sign-up sheet, dramatically limiting the number of people who could speak (Pratt, 2023). Not surprisingly, despite overwhelming opposition, the city council voted to approve

Fântânele-Cogealac Wind Farm, Romania. (*Sandri Alexandra* / Wikimedia Commons)

A scale measures water levels in a polder, Zoerermeer, Netherlands. (*Vincent van Zeijst* / *Wikimedia Commons*)

millions of dollars in funding (King, 2023; Rico, 2023).

Local resistance to Cop City continues. In 2023, environmental activists created a forest encampment protesting Cop City; Georgia state troopers shot and killed one activist as they cleared it, sparking protests both nationally and internationally (Radde, 2023; Rico, 2023). There was also a grassroots campaign to place a Cop City referendum on the city ballot, but local activists accused city officials of slowing down signature verification of petitions (French, 2024). The case illustrates that developers must take community input into account and that efforts to suppress it are likely to create long-term acrimony, uncertainty, and risk for all parties.

However, it is possible to engage citizens successfully in the development of complex technical infrastructure, through trusted stakeholder partnerships. Consider India's Baliraja Dam, stewarded by grassroots activism. Traditionally, local perspectives and environmental conditions received little attention in the drought-prone southwestern state of Maharashtra (Morrison, 2010). By the final decades of the 20th century, 2% of all farmers used 70% of irrigation water, with lucrative cash crops prioritized over small family farms (Phadke, 2002). In 1984, the political organization Mukti Sangharsh Chalval (MSC or Struggle for Liberation Movement) initiated water redistribution through the Baliraja Dam project (Rout, 2009). It first surveyed local families on water conditions before establishing a "Council for Drought Eradication" composed of village representatives (Phadke, 2002). MSC and the council then developed a cooperative ownership model, which enabled local families to shape where and how much water is distributed (Phadke, 2022). Democratic governance of infrastructure can clearly succeed when initiated by dependable outside stakeholders who approach development, governance, and ownership critically and from the bottom up.

Dutch water governance demonstrates how embedding democratic decisionmaking and stable funding structures in a national political order can also foster successful community-based governance. The Dutch national government owns and operates all water utilities in the Netherlands; 21 water boards, made up of elected members of the public, as well as representatives from business, agricultural, and environmental sectors, govern these utilities at the regional level (Havekes, 2017; SOCOTEC, n.d.). These boards, which manage water quality, quantity, and flood protections, are autonomous and decentralized, with duties, powers, and structure outlined in the Dutch Constitution and the Water Board

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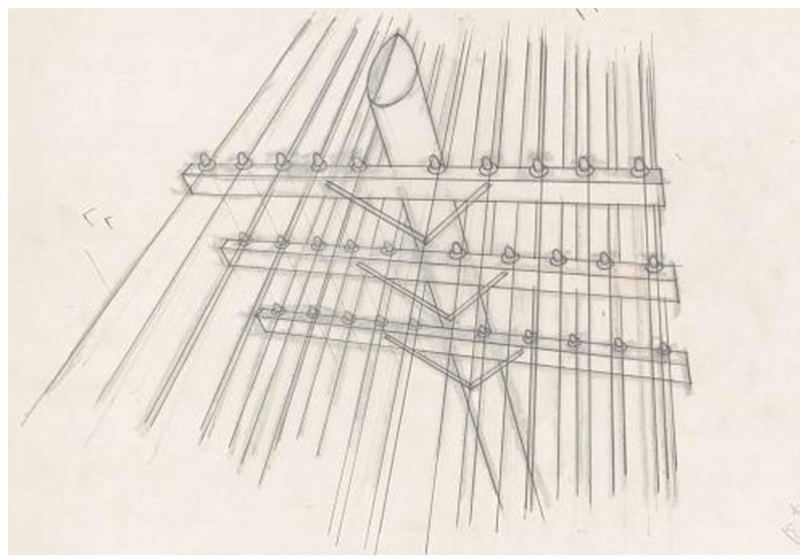
Act of 1991 (Havekes, 2017). Residents of each region elect members to their water board's "general body" for a four-year term; this body appoints five individuals to an "executive assembly" that steers policy implementation (Havekes, 2017). The general body also recommends a water board chair to oversee all water management duties (Havekes, 2017). Along with taxes levied on residents, water boards fund operations through their majority ownership of the Dutch Water Bank, a public bank providing loans at the lowest possible cost to the water sector (Acioly et al., 2016). The Netherlands has turned over one of its most crucial concerns of public policy, technology, budget, and life (after all, over one-quarter of its land mass is below sea level) to its citizens. This demonstrates enormous trust, and shows again that citizen-led governance in highly consequential, technical areas is possible. It requires governments to provide clear legal frameworks, budgets, and buy-in, and then step aside, demonstrating their trust in citizens.

It will be extremely difficult for SMR companies to establish and maintain this kind of local governance given the industry's financing models. Most players, whether public or private, aim to operate multiple sites, sometimes across several countries. Therefore, they are likely to prioritize scalability, efficiency, and of course, revenues over local needs. Consider early telephony in the United States. Initially, small telephone cooperatives, governed by local users, developed reasonably-priced services in rural areas (Garcia, 2005). Members owned (and often physically expanded and maintained) telephone lines themselves, giving users a say in the pricing and scale of local services. The dominant Bell Telephone Company then used the economic downturn caused by the Great Depression to purchase and consolidate struggling rural cooperatives, forcing many communities to forfeit control over their telephone rates and local infrastructure (Gabel, 1969). Today, telephone cooperatives make up roughly 5% of the nation's subscribers, but at their height, these cooperatives numbered in the thousands (NTCA - The Rural Broadband Association, n.d.). The dominance of large telecommunications corporations left the majority of Americans unable to fight inflated telephone rates and reductions in service quality (University of Wisconsin Center for Cooperatives, n.d.). SMR communities will be similarly vulnerable to the profit and efficiency aims of developers, particularly given the emerging oligopoly in the SMR industry.



Study of telephone poles. (*Library of Congress Prints and Photographs Division*)

SMR's high costs are also likely to complicate self-governance goals, as already revealed in the collapse of one promising SMR project in Utah. NuScale worked with Utah Associated Municipal Power Systems, a state-supported non-profit servicing municipal utilities across several Western states, to develop a co-op ownership model for its reactors (Lovering & Baker, 2021). This model allowed municipalities to buy and scale energy production according to local demand and even pull out of the project if it no longer aligned with their interests (Lovering & Baker, 2021). But the costs were ultimately too high for municipalities to bear, and the project was cancelled (Bright, 2023). The fault lies not with the local ownership model, but the precarity of the marketplace, and reveals what may be a crucial stumbling block for SMR self-governance.

Finally, it is important to note that local participation is not a panacea for the sociopolitical turmoil that often accompanies infrastructure projects. Democratic engagement can produce informed refusal (Benjamin, 2016) and fray local social fabric. Peculiar, Missouri, experienced a phenomenon that is becoming all too common: an opaque effort by an undisclosed tech giant to build a local data center, which would house computer systems and associated components needed to process the data associated with AI and other digital technologies (O'Donovan, 2024). In the small hamlet outside Kansas City, development executives and the mayor promised residents that the data center (funded by an an unnamed tech company) would bring economic opportunity and jobs (Tan, 2024). But community members worried the project would alter the town's rural character, and they created an online campaign and yard signs reading "No Data Centers" to garner public support (Tan, 2024). In response, developers went as far as to talk to local residents in their living rooms, but required nondisclosure agreements, and upon closer scrutiny retreated to closed-door meetings with Peculiar's mayor and town administrator (Tan, 2024). Later, at a town hall meeting, anti-data-center residents and the town's pro-data-center mayor almost clashed over the plan. Even after the proposal was rejected by local elected officials, public trust in Peculiar's leadership remains tenuous (Tan, 2024).

In short, SMR proponents make a variety of promises about the technology's benefits for local communities, from plentiful and accessible jobs, to economic development, to energy self-governance; yet this chapter shows that achieving these outcomes will be much more difficult. Without giving more attention to on-the-ground realities and building proactive decisionmaking in technology design and policy action, there will likely be minimal local economic benefits and a lack of democratic governance. Additionally, marginalized communities are likely to be further marginalized in the process. But there are also stories of success. The Baliraja Dam and Dutch water governance exemplify possible paths to achieving community governance, both through grassroots efforts and national-level policy. However, unless the SMR industry prioritizes local consent and engagement in the same way it prioritizes cheap and efficient operations, promises of community development and empowerment will go unrealized.

Policy Recommendations

As the world seeks more reliable, low-carbon sources of energy, many hopes and expectations rest on emerging technologies such as small modular reactors (SMRs) and other advanced nuclear energy systems. However, if this technology is adopted without robust governance frameworks that are sensitive to labor practices, environmental impacts, and broader societal implications, there is significant risk that its harms will outweigh the benefits. Robust governance would help ensure that the implementation of SMRs serves the public interest rather than predominantly corporate and geopolitical actors.

Comprehensively manage safety and risk

1

RECOMMENDATION 1: **ADOPT MEASURES TO MINIMIZE RISK ACROSS THE NUCLEAR FUEL CYCLE.**

Governments, the nuclear industry, and international organizations must comprehensively manage risk across the nuclear fuel cycle. This should include:

a. Mandating publicly accessible environmental justice reviews for all nuclear energy-related projects, including uranium extraction and processing, power plant construction, industrial co-siting, and spent nuclear fuel management. These reviews should have longitudinal frameworks that account for historical environmental burdens and compounding exposure risk across the entire nuclear fuel cycle.

b. Adopting policies that ensure responsible sourcing of uranium and discourage the purchase of uranium that does not meet strict environmental and ethical standards across the nuclear fuel cycle. This means transparency for the life cycle of the uranium to ensure clear communication of labor and environmental standards throughout the mining, transport, and processing stages. International and national certifications can also be created to give compliant companies a competitive advantage.

c. Adopting policies that ensure geopolitically responsible sourcing of HALEU fuel for SMRs and discourage the entrenching of exploitative geopolitical relationships.

d. Supporting labor protections for workers across the fuel cycle, especially for mining, and implementing existing international labor standards that prioritize the safety and health of workers.

e. Developing international protection guidelines that address the historical exploitation and vulnerability of Indigenous lands.

Conduct inclusive and collaborative public participation

2

RECOMMENDATION 2: **FOSTER EMPOWERED PUBLIC INVOLVEMENT.**

Governments and SMR developers must foster inclusive and collaborative public participation in governance, design, development, siting, operation, and waste management. These processes should empower publics to have a meaningful choice over the governance and planning of their nuclear infrastructure, including community veto power. In addition:

a. Communities, national governments, and international agencies should co-develop standards for collaboration, including mandates for early-stage engagement for governance, design, planning, siting, industrial co-location, operation, and decommissioning.

b. National governments should support the enforcement of community engagement standards.

c. Plant developers and co-siting industries should also fund community engagement, encourage stakeholder dialogue, create venues for communities to communicate concerns (e.g., local governance boards comprising a representative group of citizens from the host communities), and support organizations to address and implement these concerns.

d. Licensing authorities should require guidelines for energy allocation and land use that are developed collaboratively between communities and developers.

e. Governments should protect the right to dissent and engage in civil protest about regional, national, and international nuclear projects.

3

RECOMMENDATION 3: **BUILD PUBLIC CAPACITY TO BALANCE INDUSTRY DOMINANCE.**

Government and philanthropy must invest in public capacity for nuclear energy development and regulation as a counterweight to industry influence. This can include facilitating collaborations with academia, government research facilities, and industry; creating financial support for networks of environmental justice groups, think tanks, and civil rights litigation firms; resources for impacted populations, especially Indigenous communities; and fostering research on socially and ecologically robust strategies for the safe and equitable use of nuclear energy technology.

4

RECOMMENDATION 4: **REQUIRE TRANSPARENT EVALUATION OF ENVIRONMENTAL AND SOCIAL IMPACTS.**

Government agencies funding SMR research and development must require prospective developers to submit social and environmental impact reports and plans for how to mitigate or prevent the anticipated burdens of SMRs. In the evaluation and approval process, these should be given equal weight to the technical merit of evaluations such as safety assessments. This will require expanding the types of experts on review panels. Continued government support should be conditional on their successful implementation.

Implement strong financial controls

5

RECOMMENDATION 5: **MINIMIZE DEPENDENCE ON PRIVATE AND FOREIGN INVESTORS.**

National and local regulators should implement strong financial controls on SMR development and investment. This includes:

- Limiting private funding and foreign investment in the production of SMRs to prevent investor and geopolitical interests from influencing decisions in ways that outweigh domestic concerns.
- Prioritizing investments that build domestic capacity for regulation and oversight; research, development, and deployment; and environmental justice in order to avoid long-term dependencies when countries accept foreign investment in SMRs.

6

RECOMMENDATION 6: **PRIORITIZE DOMESTIC BENEFITS.**

Countries that receive foreign investment for uranium extraction should implement controls on natural resource export to ensure domestic benefits. This could include establishing state-owned companies for uranium mining and processing, the profits of which should return to directly affected regions and communities.

Strengthen and adapt legal and regulatory frameworks

7

RECOMMENDATION 7: **SHIFT FINANCIAL RISK BURDENS AWAY FROM PUBLICS.**

National and local governments should shift financial risk burdens from publics to investors and developers. This can be done through:

a. “Polluters pay” frameworks for SMRs and co-siting industries to ensure financial liability for environmental degradation and pollution, environmental clean-up, and necessary technological maintenance for safe operations and decommissioning.

b. Re-evaluation and revision of existing legislation to shift the financial and physical risks of failures, such as severe accidents or failed infrastructure projects, away from communities and taxpayers to the nuclear industry.

c. Liability limits and financial protections for the nuclear industry should not be used as incentives for SMR development.

8

RECOMMENDATION 8: **PROTECT REGULATORY AGENCIES FROM INDUSTRY INFLUENCE.**

National governments must protect their regulatory agencies from industry influence. Governments should enact policies prohibiting a “revolving door” between regulatory roles and roles advocating for nuclear energy both in industry and government. This could include requiring waiting periods before changing positions, implementing transparency measures that track employment history and relationships, and increasing funding and interagency support to be less dependent on industry experts.

Equitably distribute benefits

9

RECOMMENDATION 9: **EQUITABLY DISTRIBUTE ENERGY RESOURCES.**

Regional utilities must dedicate a percentage of power to meet community needs, as determined by community governance boards. Utilities should provide discounted rates on power for host, mining, and waste storage communities, including residential, school, and local business customers.

10

RECOMMENDATION 10: **EQUITABLY REDISTRIBUTE PROFITS.**

National governments should enact policies that ensure equitable redistribution of profits from the activities across the entire nuclear fuel cycle—including mining, processing, power generation, and waste management—to the communities and territories most affected by industry activity. They should include a self-determination process for representatives of those communities to make decisions about distribution and spending mechanisms.

11

RECOMMENDATION 11: **INVEST IN JOB TRAINING AND LOCAL ECONOMIC TRANSITIONS.**

National, regional, and local governments should work together to create accessible, responsive, and comprehensive job training programs for host communities, providing tuition waivers, scholarships, application assistance, and licensing exam preparation for locals. Typically, job assistance programs in communities transitioning between industries have not been effective or enduring. Therefore, it is especially important to supply these programs with sufficient resources and connect them to local knowledge to sustain them over the long term. When job transition programs are deemed unfeasible or unlikely, other robust, long-standing forms of compensation should be supplied to communities, such as funding for healthcare, infrastructure, and local cultural and education needs.

Identify, repair, and remediate harms

12

RECOMMENDATION 12: **ACKNOWLEDGE AND REPAIR PAST DAMAGE, PROTECT AGAINST FUTURE HARMS.**

International agencies and national and local governments must acknowledge, repair, and remediate past social, economic, and environmental damage from nuclear-related activities and protect previously affected communities from repeated harms. This can be done through:

a. A government council or commission that formally recognizes and reconciles past harms caused by the nuclear enterprise and provides substantive financial compensation, health care, restoration of mineral rights, environmental remediation, and legal protections against future harms for affected communities.

b. Adherence to existing sovereignty and environmental protection agreements, including the United Nations Declaration on the Rights of Indigenous Peoples and the Rio Declaration.

References

ABC News. (2016, November 3). *Why a previously proposed route for the Dakota Access Pipeline was rejected.* https://abcnews.go.com/US/previously-proposed-route-dakota-access-pipeline-rejected/story?id=43274356

Abdelnour, S., & Saeed, A. M. (2014). Technologizing humanitarian space: Darfur advocacy and the rape-stove panacea. *International Political Sociology, 8*(2), 145–163. https://doi.org/10.1111/ips.12049

Abdelnour, S. (2015). The cookstove–rape prevention myth and the limits of techno-saviorism. In S. Hostettler, A. Gadgil, & E. Hazboun (Eds.), *Sustainable Access to Energy in the Global South* (pp. 205–215). Springer International Publishing. https://doi.org/10.1007/978-3-319-20209-9_18

Abdulla, A., Azevedo, I. L., & Morgan, M. G. (2013). Expert assessments of the cost of light water small modular reactors. *Proceedings of the National Academy of Sciences, 110*(24), 9686–9691. https://doi.org/10.1073/pnas.1300195110

Abel, M. E. (1970). Agriculture in India in the 1970s. *Economic and Political Weekly, 5*(13), A5–A14.

Acioly, A., van der Kerk, A., & Fonseca, C. (2016). *Dutch Water Bank—A useful model for developing countries? Finance Brief 11.* Public Finance for WASH. https://www.publicfinanceforwash.org/sites/default/files/uploads/Finance%20Brief_11%20-%20Dutch%20Water%20Bank%20-%20a%20useful%20model%20for%20developing%20countries.pdf

Acton, J. M., & Hibbs, M. (2012, March 6). *Why Fukushima was preventable* [Paper]. Carnegie Endowment for International Peace. https://carnegieendowment.org/research/2012/03/why-fukushima-was-preventable

Aga, A. (2021, January 24). *Farm protests in India are writing the Green Revolution's obituary.* Scientific American. https://www.scientificamerican.com/article/farm-protests-in-india-are-writing-the-green-revolutions-obituary/

Agbebiyi, K., Creeks, A., & Mendoza, A. (2023). *PE profits from destroying the Atlanta forest.* Private Equity Stakeholder Project. https://pestakeholder.org/wp-content/uploads/2023/03/PE-Profits-from-Destroying-the-Atlanta-Forest_March_2023_compressed.pdf

Aguilera, N. (2023, February 28). *Controversy in Ecuador's largest China-built infrastructure project.* Voice of America. https://projects.voanews.com/china/global-footprint/english/projects/infrastructure/controversy-in-ecuadors-largest-china-built-infrastructure-project.html

Ahmad, A. (2021). Increase in frequency of nuclear power outages due to changing climate. *Nature Energy, 6*(7), 755–762. https://doi.org/10.1038/s41560-021-00849-y

Ahmad, S. (2020, January 15). *The lithium triangle: Where Chile, Argentina, and Bolivia meet.* Harvard International Review. https://hir.harvard.edu/lithium-triangle/

Ahn, A., Teplinsky, E., McMurray, N., Qvist, M., Cothron, E., Merrifield, J., Houghtalen, N., Kincer, J., & Tolliver, C. (2024). *The global race for advanced nuclear is on.* Clean Air Task Force. https://www.catf.us/resource/global-race-advanced-nuclear/

Aktar, Md. W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: Their benefits and hazards. *Interdisciplinary Toxicology, 2*(1), 1–12. https://doi.org/10.2478/v10102-009-0001-7

Alcorn, C. (2023, November 15). *Environmental impact targeted in new push against 'Cop City.'* Center for Public Integrity. http://publicintegrity.org/environment/pollution/environmental-justice-denied/environmental-impact-targeted-in-new-push-against-cop-city

Aldred, J., & Stoddard, K. (2008, May 26). Timeline: Nuclear power in the United Kingdom. *The Guardian.* https://www.theguardian.com/environment/2008/jan/10/nuclearpower.energy

Altamimi, A. (2024). Harnessing the integration of chat GPT in higher education: The evaluation of stakeholders sentiments using NLP techniques. *Discover Sustainability, 5*(1). https://doi.org/10.1007/s43621-024-00774-6

Amano, Y. (2013, February 8). *Nuclear power after Fukushima.* International Atomic Energy Agency. https://www.iaea.org/newscenter/statements/nuclear-power-after-fukushima

Amazon. (2024). *Amazon enlists nuclear small modular reactors in push for net carbon-zero.* https://www.aboutamazon.com/news/sustainability/amazon-nuclear-small-modular-reactor-net-carbon-zero

American Friends Service Committee. (2023, September 20). *The companies and foundations behind Cop City.* https://afsc.org/companies-and-foundations-behind-cop-city

American Nuclear Society. (2024). *DOE to invest $900M in next-generation nuclear.* Nuclear NewsWire. https://www.ans.org/news/article-6140/doe-to-invest-900m-in-nextgeneration-nuclear

American Social History Project. (n.d.). S*ettler colonialism and Indigenous resistance.* Retrieved January 6, 2025, from https://shec.ashp.cuny.edu/exhibits/show/settler-colonialism-and-indige

Amnesty International. (n.d.). *Indigenous peoples' rights are human rights.* Amnesty International. Retrieved December 2, 2024, from https://www.amnesty.org/en/what-we-do/indigenous-peoples

Anderson, J. L. (2022). Extractive industries and the transformation of American environments. In C. G. Pestana, E. Gould, & P. Mapp (Eds.), *The Cambridge History of America and the World: Volume 1: 1500–1820* (pp. 96–114). Cambridge University Press. https://doi.org/10.1017/9781108297455.006

Andreasson, S., & Ruback, T. J. (2021). "Our oil would burn bright til morning:" Geopolitics, resource securitization, and Anglo-American competition for whale oil, 1783–1818. E*nergy Research & Social Science, 76,* 102035. https://doi.org/10.1016/j.erss.2021.102035

Andres, R. B., & Breetz, H. L. (2011). *Small nuclear reactors for military installations: Capabilities, costs, and technological implications* (No. SF No. 262). Institute for National Strategic Studies. https://ndupress.ndu.edu/Portals/68/Documents/stratforum/SF-262.pdf

Andreucci, D., García López, G., Radhuber, I. M., Conde, M., Voskoboynik, D. M., Farrugia, J. D., & Zografos, C. (2023). The coloniality of green extractivism: Unearthing decarbonisation by dispossession through the case of nickel. *Political Geography, 107,* 102997. https://doi.org/10.1016/j.polgeo.2023.102997

Andrews, D., Newton, E. J., Adibi, N., Chenadec, J., & Bienge, K. (2021). A circular economy for the data centre industry: Using design methods to address the challenge of whole system sustainability in a unique industrial sector. *Sustainability, 13*(11). https://doi.org/10.3390/su13116319

Apt, J. (2017). The other reason to shift away from coal: Air pollution that kills thousands every year. *Scientific American.* https://www.scientificamerican.com/article/the-other-reason-to-shift-away-from-coal-air-pollution-that-kills-thousands-every-year

Arave, A. (2024, October 3). Programming for cost efficiency: An intern's innovation in nuclear automation. *Idaho National Laboratory.* https://inl.gov/feature-story/programming-for-cost-efficiency-an-interns-innovation-in-nuclear-automation

Arcury, T. A., Nguyen, H. T., Summers, P., Talton, J. W., Holbrook, L. C., Walker, F. O., Chen, H., Howard, T. D., Galván, L., & Quandt, S. A. (2014). Lifetime and current pesticide exposure among Latino farmworkers in comparison to other Latino immigrants. *American Journal of Industrial Medicine, 57*(7), 776–787. https://doi.org/10.1002/ajim.22324

Ariza, M. A. (2025, May 15). *Redlining shaped the power grid. Communities of color are still paying the price.* Environmental Health News. https://floodlightnews.org/redlining-shaped-the-power-grid-communities-of-color-are-still-paying-the-price

Arms Control Association. (2024). *Arms control and proliferation profile: North Korea.* https://www.armscontrol.org/factsheets/arms-control-and-proliferation-profile-north-korea

Arnold, C. (2014). Once upon a mine: The legacy of uranium on the Navajo Nation. *Environmental Health Perspectives, 122*(2). https://doi.org/10.1289/ehp.122-A44

Asabere-Ameyaw, A., Anamuah-Mensah, J., Dei, G. J. S., & Raheem, K. (2014). Chapter 1: Introduction. In A. Asabere-Ameyaw, J. Anamuah-Mensah, G. S. Dei, & K. Raheem (Eds.), *Indigenist African development and related issues: Towards a transdisciplinary perspective* (pp. 1–13). SensePublishers. https://doi.org/10.1007/978-94-6209-659-2_1

Asayama, S., & Ishii, A. (2017). Selling stories of techno-optimism? The role of narratives on discursive construction of carbon capture and storage in the Japanese media. *Energy Research & Social Science, 31,* 50–59. https://doi.org/10.1016/j.erss.2017.06.010

Atlanta Police Foundation. (n.d.). *Public Safety Training Center.* Retrieved November 25, 2024, from https://atlantapolicefoundation.org/programs/public-safety-training-center

Atlas, W. I., Ban, N. C., Moore, J. W., Tuohy, A. M., Greening, S., Reid, A. J., Morven, N., White, E., Housty, W. G., Housty, J. A., Service, C. N., Greba, L., Harrison, S., Sharpe, C., Butts, K. I. R., Shepert, W. M., Sweeney-Bergen, E., Macintyre, D., Sloat, M. R., & Connors, K. (2021). Indigenous systems of management for culturally and ecologically resilient Pacific salmon (Oncorhynchus spp.) fisheries. *BioScience, 71*(2), 186–204.

Atomic Energy Act, Pub. L. No. 83–703, 42 U.S.C. (1954). https://www.congress.gov/bill/83rd-congress/house-bill/9757

Atomic Heritage Foundation. (2018, December 5). *Uranium mining.* https://ahf.nuclearmuseum.org/ahf/history/uranium-mining/

Attebery, R. (2024, September 18). *California can right a historic wrong by recognizing tribal authority for cultural burns.* CalMatters. http://calmatters.org/commentary/2024/09/wildfire-cultural-burn-california-tribes

Avalos, N. (2020, June 25). *Indigenous stewardship and the death rattle of white supremacy.* Political Theology Network. https://politicaltheology.com/indigenous-stewardship-and-the-death-rattle-of-white-supremacy

Axe, D. (2011). How the Navy's warship of the future ran aground. *Wired.* https://www.wired.com/2011/08/future-warship-ran-aground

Aylwin, J. (2025, May 1). *A just energy transition? The impacts of lithium extraction on the Andean Salt Flats of Argentina, Bolivia, and Chile.* Debates Indígenas. https://debatesindigenas.org/en/2025/05/01/a-just-energy-transition-the-impacts-of-lithium-extraction-on-the-andean-salt-flats-of-argentina-bolivia-and-chile/

Azhar, A. (2024, August 6). Argonne leverages generative AI to empower nuclear plant operators. *AI Wire.* https://www.aiwire.net/2024/08/06/argonne-leverages-generative-ai-to-empower-nuclear-plant-operators

Baker, M. (2024, September 18). *Havasupai Tribe continues to oppose controversial uranium mine as Energy Fuels assures safety.* Arizona Mirror. https://azmirror.com/2024/09/18/havasupai-tribe-continues-to-oppose-controversial-uranium-mine-as-energy-fuels-assures-safety

Balkansky, A. (2019, March 19). Radium girls: Living dead women. *The Library of Congress.* https://blogs.loc.gov/headlinesandheroes/2019/03/radium-girls-living-dead-women

Bandura, R., & Hardman, A. (2023, November 16). *Environmental, social, and governance best practices applied to mining operations.* Center for Strategic & International Studies. https://www.csis.org/analysis/environmental-social-and-governance-best-practices-applied-mining-operations

Banu, D.-M., Obreja, A.-M., Popescu, I.-C., & Mihai, S. (2022). Geological risk management process and its particularities for a uranium site—Case study. *Sustainable Extraction and Processing of Raw Materials Journal, 3*(3), 16–26. https://doi.org/10.58903/c16182112

Barandiarán, J. (2019). Lithium and development imaginaries in Chile, Argentina and Bolivia. *World Development, 113,* 381–391. https://doi.org/10.1016/j.worlddev.2018.09.019

Baranski, M. R. (2015). Wide adaptation of Green Revolution wheat: International roots and the Indian context of a new plant breeding ideal, 1960–1970. Studies in History and Philosophy of Science Part C: *Studies in History and Philosophy of Biological and Biomedical Sciences, 50,* 41–50. https://doi.org/10.1016/j.shpsc.2015.01.004

Barnéoud, L. (2022, April 4). The huge waste of expired Covid-19 vaccines. *Le Monde.* https://www.lemonde.fr/en/science/article/2022/04/04/the-huge-waste-of-expired-covid-19-vaccines_5979632_10.html

Barnhill-Dilling, S. K., Rivers, L., & Delborne, J. A. (2019). Rooted in recognition: Indigenous environmental justice and the genetically engineered American chestnut tree. *Society & Natural Resources, 33*(1), 83–100. https://doi.org/10.1080/08941920.2019.1685145

Baron, J., & Herzog, S. (2020). Public opinion on nuclear energy and nuclear weapons: The attitudinal nexus in the United States. *Energy Research & Social Science, 68.* https://doi.org/10.1016/j.erss.2020.101567

BBC News. (2011, April 12). *Timeline: Nuclear plant accidents.* BBC News. https://www.bbc.com/news/world-13047267

Bearak, M. (2025, June 11). World Bank ends its ban on funding nuclear power projects. *The New York Times.* https://www.nytimes.com/2025/06/11/climate/world-bank-nuclear-power-funding-ban.html

Becker, T., Biegart, C., Hamm, H., Hermeyer, G., Kriener, M., LaDuke, W., Pentz Gunter, L., Pepper, M., Schneider, M., & Snyder, S. (2020). *Uranium atlas—Data & facts about the raw material of the nuclear age.* Nuclear Free Future Foundation. https://www.nuclear-free.com/files/assets_nuclear_free_foundation/de/download/Uranatlas%20englisch/UraniumAtlas_2020_web2.pdf

Bedsworth, L., & Taylor, M. (2007). Learning from California's zero-emission vehicle program. *California Economic Policy, 3*(4). https://www.ppic.org/wp-content/uploads/content/pubs/cep/EP_907LBEP.pdf

Belarte, M. C., Anguera, M., Mateu, M., & Quiles, M. P. (2024). Baking bread in the Riff area (Morocco): An ethnographic approach to the study of Iron Age archaeological ovens. *EXARC Journal, 4,* 1–12.

Bell, S. E., Daggett, C., & Labuski, C. (2020). Toward feminist energy systems: Why adding women and solar panels is not enough. *Energy Research & Social Science, 68.* https://doi.org/10.1016/j.erss.2020.101557

Beltran, L., & Uchoa, P. (2024, January 30). *Lessons from Indigenous leaders to protect the Amazon rainforest.* World Economic Forum. https://www.weforum.org/stories/2024/01/lessons-from-indigenous-leaders-to-protect-the-amazon-rainforest

Bemis, E., & Bagué, K. (n.d.). *The digging is the least thing of all: Health & medicine at the Panama Canal.* Exhibits at the University of Florida Libraries. Retrieved October 6, 2025, from https://exhibits.domains.uflib.ufl.edu/TheDigging/

Benjamin, R. (2016). Informed refusal: Toward a justice-based bioethics. *Science, Technology, & Human Values, 41*(6), 967–990. https://doi.org/10.1177/0162243916656059

Benjamin, R. (2019). *Race after technology: Abolitionist tools for the New Jim Code.* Polity Press. https://www.politybooks.com/bookdetail?book_slug=race-after-technology-abolitionist-tools-for-the-new-jim-code--9781509526390

Benke, E. (2023, June 13). *Finland's plan to bury spent nuclear fuel for 100,000 years.* BBC. https://www.bbc.com/future/article/20230613-onkalo-has-finland-found-the-answer-to-spent-nuclear-fuel-waste-by-burying-it

Bergen, J. P. (2016). Reversibility and nuclear energy production technologies: A framework and three cases. *Ethics, Policy & Environment, 19*(1), 37–59. https://doi.org/10.1080/21550085.2016.1173281

Berkemeier, M., Bowen, W. Q., Hobbs, C., & Moran, M. (2014). *Governing uranium in the United Kingdom.* Danish Institute for International Studies (Report No. 2014:02). https://www.diis.dk/en/research/governing-uranium-in-the-united-kingdom

Bersimbaev, R. I., & Bulgakova, O. (2015). The health effects of radon and uranium on the population of Kazakhstan. *Genes and Environment, 37*(1), 18. https://doi.org/10.1186/s41021-015-0019-3

Bertrand, P., Pirtle, Z., & Tomblin, D. (2017). Participatory technology assessment for Mars mission planning: Public values and rationales. *Space Policy, 42,* 41–53. https://doi.org/10.1016/j.spacepol.2017.08.004

Beyer, J., Trannum, H., Bakke, T., Hodson, P., & Collier, T. (2016). Environmental effects of the Deepwater Horizon oil spill: A review. *Marine Pollution Bulletin, 110*(1), 28–51. https://doi.org/10.1016/j.marpolbul.2016.06.027

Bijker, W. E., Parke Hughes, T., & Pinch, T. (Eds.). (1987). *The social construction of technological systems: New directions in the sociology and history of technology* (1st ed.). MIT Press.

Biswas, S. S. (2023). Role of ChatGPT in public health. *Annals of Biomedical Engineering, 51*(5), 868–869. https://doi.org/10.1007/s10439-023-03172-7

Black, G., Shropshire, D., & Araújo, K. (2021). Small modular reactor (SMR) adoption: Opportunities and challenges for emerging markets. In D. T. Ingersoll & M. D. Carelli (Eds.), *Handbook of small modular nuclear reactors* (2nd ed., pp. 557–593). Elsevier. https://doi.org/10.1016/B978-0-12-823916-2.00022-9

Blackwell, M., & Nocera, S. E. (1989). Debt-equity swaps. In *Analytical Issues in Debt*. International Monetary Fund. https://www.elibrary.imf.org/display/book/9781557750419/ch15.xml

Blix, H. (1987). The next 10 years: Major challenges shaping the IAEA's future. *IAEA Bulletin, 29*(3). https://www.iaea.org/publications/magazines/bulletin/29-3/next-10-years-major-challenges-shaping-iaeas-future

Block, S. (2021). Mining energy-transition metals: National aims, local conflicts. *MSCI.* https://www.msci.com/www/blog-posts/mining-energy-transition-metals/02531033947

Blue Ribbon Commission on America's Nuclear Future. (2012). *Blue Ribbon Commission on America's Nuclear Future: Report to the secretary of energy.* https://curie.pnnl.gov/document/blue-ribbon-commission-americas-nuclear-future-report-secretary-energy-0

Bollyky, T. J., & Brown, C. P. (2020, July 27). *The Tragedy of Vaccine Nationalism.* Foreign Affairs. https://www.foreignaffairs.com/articles/united-states/2020-07-27/vaccine-nationalism-pandemic

Borges, M. R. (2017). *Regulation and regulatory capture.* XIV International Colloquium, Cape Town. https://www.worldacademy.org/files/colloquium_2017/papers/Regulation_regulatory_capture_M.Borges.pdf

Boulet, P., Hoen, E., Perehudoff, K., Mara, K., & Tan, E. (2021). *Advanced purchase agreements for COVID-19 vaccines*. The Left in the European Parliament. https://left.eu/content/uploads/2021/07/Advanced-purchase-agreements-1.pdf

Bowser, A., & Tharp, C. (2022). *Understanding pesticide drift and drift reduction strategies.* Pesticide Safety Education Program, Montana State University. https://www.montana.edu/extension/pesticides/reference/drift.html

Bratspies, R. (2011). A regulatory wake-up call: Lessons from BP's Deepwater Horizon disaster. *Golden Gate University Environmental Law Journal, 5*(1). https://digitalcommons.law.ggu.edu/gguelj/vol5/iss1/3

Bright, M. (2022, August 22). *The Inflation Reduction Act creates a whole new market for carbon capture.* Clean Air Task Force. https://www.catf.us/2022/08/the-inflation-reduction-act-creates-a-whole-new-market-for-carbon-capture

Bright, Z. (2023, November 9). NuScale cancels first-of-a-kind nuclear project as costs surge. *E&E News by POLITICO.* https://www.eenews.net/articles/nuscale-cancels-first-of-a-kind-nuclear-project-as-costs-surge

Bringel, B., & Svampa, M. (2024). Energy transition and the new shape of green colonialism: The emergence of the decarbonisation consensus. In *Dependency Theories in Latin America.* Routledge.

Bromet, E. J. (2014). Emotional consequences of nuclear power plant disasters. *Health Physics, 106*(2), 206-210. https://doi.org/10.1097/HP.0000000000000012

Brown, A. (2018, January 9). *Five spills, six months in operation: Dakota Access track record highlights unavoidable reality — pipelines leak.* The Intercept. https://theintercept.com/2018/01/09/dakota-access-pipeline-leak-energy-transfer-partners

Browne, S. (2015). *Dark matters: On the surveillance of blackness.* Duke University Press. https://doi.org/10.1215/9780822375302

Brugge, D., & Goble, R. (2002). The history of uranium mining and the Navajo people. *American Journal of Public Health, 92*(9), 1410–1419. https://doi.org/10.2105/ajph.92.9.1410

Brulliard, K. (2023, November 20). A fading coal town hitches its hopes to Bill Gates's clean-energy dream. *The Washington Post.* https://www.washingtonpost.com/nation/2023/11/20/kemmerer-wyoming-coal-nuclear-bill-gates

Bucată, R. (2020, May 29). Ailing Romanian coal region sees new hope in EU Green Deal. *Balkan Insight.* https://balkaninsight.com/2020/05/29/ailing-romanian-coal-region-sees-new-hope-in-eu-green-deal/

Buck, A. (1983). *The Atomic Energy Commission.* U.S. Department of Energy. https://www.energy.gov/management/articles/history-atomic-energy-commission

Budjeryn, M. (2024, October 2). Why Russia is more likely to go nuclear in Ukraine if it's winning. *Bulletin of the Atomic Scientists.* https://thebulletin.org/2024/10/why-russia-is-more-likely-to-go-nuclear-in-ukraine-if-its-winning/

Budnitz, R. J., Rogner, H.-H., & Shihab-Eldin, A. (2018). Expansion of nuclear power technology to new countries – SMRs, safety culture issues, and the need for an improved international safety regime. *Energy Policy, 119,* 535–544. https://doi.org/10.1016/j.enpol.2018.04.051

Budowle, R., & Duba, A. (Eds.). (2024). *Engaging Wyoming communities in an environmental justice approach for advanced nuclear energy facility siting: Historical energy and industrial analysis report* (Department of Energy Nuclear Energy University Program Award #DE-NE0009297 Milestone #M3NU-22-WY-UW_-030210-032). University of Wyoming.

Bugayova, N., & Kagan, F. (2021, December 5). Nord Stream 2 poses a long-term national security challenge for the US and its allies. *Institute for the Study of War.* https://understandingwar.org/research/russia-ukraine/nord-stream-2-poses-a-long-term-national-security-challenge-for-the-us-and-its-allies/

Bunn, M. (2001, July 15). Russian import of foreign spent fuel: Status and policy implications. *Proceedings of the 42nd Annual Meeting of the Institute of Nuclear Materials Management.* INMM Annual Meeting, Indian Wells, California. https://www.belfercenter.org/publication/russian-import-foreign-spent-fuel-status-and-policy-implications

Bunn, M. (2009). Reducing the greatest risk of nuclear theft & terrorism. *Daedalus, 138*(4), 112–123. https://www.jstor.org/stable/40544006

Buono, P. (2020, November 2). Quiet fire. *The Nature Conservancy.* https://www.nature.org/en-us/magazine/magazine-articles/indigenous-controlled-burns-california

Bureau of Labor Statistics. (n.d.). *Occupational outlook handbook, tellers.* U.S. Department of Labor. Retrieved October 10, 2024, from https://www.bls.gov/ooh/office-and-administrative-support/tellers.htm

Burman, T. (2024, November 27). Map shows states generating the most nuclear energy. *Newsweek.* https://www.newsweek.com/map-states-most-nuclear-power-1992218

Business & Human Rights Resource Centre. (2022, March 12). *Ecuador: Coca Codo Sinclair Hydroelectric Project.* https://www.business-humanrights.org/en/latest-news/ecuador-coca-codo-sinclair-hydroelectric-project

Butterworth, P. (2023, March 20). Carbon capture economics: *Why $200 /tCO2 is the crucial figure.* CRU Group. https://www.crugroup.com/en/communities/thought-leadership/sustainability/carbon-capture-economics-why-$200-tco2-is-the-crucial-figure

Camacho, F. "A. J. ". (2024, December 19). *Oklo inks record deal for using nuclear to power data centers.* Politico Pro. https://subscriber.politicopro.com/article/eenews/2024/12/19/oklo-inks-record-deal-for-using-nuclear-to-power-data-centers-00195148

Camacho, F. "A. J. ". (2025, September 30). *Tech industry awaits FERC action on electricity co-location.* E&E News by POLITICO. https://www.eenews.net/articles/tech-industry-awaits-ferc-action-on-electricity-co-location

Carbon Capture Coalition. (n.d.). *About the carbon capture coalition.* Retrieved December 20, 2024, from https://carboncapturecoalition.org/about-us

Carothers, C. (2023). *Centering Indigenous and community fisheries in global fisheries governance.* Mercatus Center at George Mason University. https://www.mercatus.org/research/policy-briefs/centering-indigenous-and-community-fisheries-global-fisheries-governance

Casey, B. (2024, July 15). US is Set to Expand Global Lead in Capturing Carbon. *BloombergNEF.* https://about.bnef.com/blog/us-is-set-to-expand-global-lead-in-capturing-carbon

Casey, N., & Krauss, C. (2018, December 24). It doesn't matter if Ecuador can afford this dam. China still gets paid. *The New York Times.* https://www.nytimes.com/2018/12/24/world/americas/ecuador-china-dam.html

Castillo, F., Mora, A. M., Kayser, G. L., Vanos, J., Hyland, C., Yang, A. R., & Eskenazi, B. (2021). Environmental health threats to Latino migrant farmworkers. *Annual Review of Public Health, 42,* 257–276. https://doi.org/10.1146/annurev-publhealth-012420-105014

Catună, V. (2022). *From "Valley of Tears" to land of clean energy communities.* Greenpeace International. https://www.greenpeace.org/international/story/57393/romania-coal-solar-transition-clean-energy-communities-street-art/

Cavince, A. (2022, January 16). *Shame of rich countries sending expired vaccines to Africa.* Capital News. https://www.capitalfm.co.ke/news/2022/01/shame-of-rich-countries-sending-expired-vaccines-to-africa/

CBS News. (2016, October 27). *Dakota Access pipeline protesters face off with authorities.* https://www.cbsnews.com/news/dakota-access-pipeline-protesters-face-off-with-authorities

CEA. (2016, December 12). *ASTRID: An option for the fourth generation of nuclear reactors.* https://www.cea.fr/english/Pages/research-areas/nuclear-energy/astrid-an-option-for-the-fourth-generation-nuclear-reactors.aspx

Center for Civic Innovation. (2023, March 16). An overview of public engagement on 'Cop City.' *Medium.* https://medium.com/center-for-civic-innovation/an-overview-of-public-engagement-on-cop-city-b0ae277f8e23

Center for Climate and Energy Solutions. (n.d.). *Carbon Capture.* Retrieved January 10, 2025, from https://www.c2es.org/content/carbon-capture

Center for Food Safety. (2014, March 25). *Borlaug dedication ignores human and environmental consequences of the Green Revolution.* https://www.centerforfoodsafety.org/press-releases/3010/borlaug-dedication-ignores-human-and-environmental-consequences-of-the-green-revolution

Center for International Environmental Law. (n.d.). Carbon capture and storage (CCS): Frequently asked questions. *CIEL Blog.* https://www.ciel.org/carbon-capture-and-storage-ccs-frequently-asked-question

Chamie, J. (2018, January 25). *More women stay at home than men.* Yale Global Online. https://archive-yaleglobal.yale.edu/content/more-women-stay-home-men

Charette, R. N. (2018, January 24). *Michigan's MiDAS unemployment system: Algorithm alchemy created lead, not gold.* IEEE Spectrum. https://spectrum.ieee.org/michigans-midas-unemployment-system-algorithm-alchemy-that-created-lead-not-gold

Chatzis, I. (2016). *Decommissioning and environmental remediation: An overview* [IAEA Bulletin]. International Atomic Energy Agency. https://www.iaea.org/sites/default/files/5710405-overview.pdf

Cheban, O. (2015). *Ukraine and Soviet nuclear history.* Wilson Center. https://www.wilsoncenter.org/publication/ukraine-and-soviet-nuclear-history

Chiang, T. (2019). *Exhalation* (1st ed.). Knopf Doubleday Publishing Group.

Cho, A. (2023, November 10). Deal to build pint-size nuclear reactors is canceled. *Science.* https://www.science.org/content/article/deal-build-pint-size-nuclear-reactors-canceled

Chu, A., & Smyth, J. (2024, October 20). Nuclear energy stocks hit record highs on surging demand from AI. *Financial Times.* https://www.ft.com/content/33eeadbe-edf4-40b5-b973-e76c570d0681

Ciobanu, C., & Stoica, M. (2018, May 15). *The hidden costs of coal in Romania.* Al Jazeera. https://www.aljazeera.com/gallery/2018/5/15/the-hidden-costs-of-coal-in-romania

City of Atlanta Department of City Planning. (2017). *The Atlanta city design: Aspiring to the beloved community.* City of Atlanta, Department of City Planning. https://online.flowpaper.com/72b006f2/ACDSecondPrintFINAL180820

Clamen, M., & Macfarlane, D. (2018). Plan 2014: The historical evolution of Lake Ontario–St. Lawrence River regulation. *Canadian Water Resources Journal / Revue Canadienne Des Ressources Hydriques, 3*(4), 416–431. https://doi.org/10.1080/07011784.2018.1475263

Clark, N. (2011, July 20). Jet order by American is a coup for Boeing's rival. *The New York Times.* https://www.nytimes.com/2011/07/21/business/global/american-places-record-order-with-2-jet-makers.html

Clean Air Act, Pub. L. No. 88–206, 42 U.S.C. (1963). https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter85&edition=prelim

Clean Water Act, Pub. L. No. 92–500, 33 U.S.C. (1972). https://uscode.house.gov/view.xhtml?path=/prelim@title33/chapter26&edition=prelim

Clifford, C. (2023, May 4). *Westinghouse announces a new small nuclear reactor—A notable step in the industry's efforts to remake itself.* CNBC. https://www.cnbc.com/2023/05/04/westinghouse-announces-a-small-nuclear-reactor.html

Climate Central. (2022, September 14). *Surging weather-related power outages.* https://www.climatecentral.org/climate-matters/surging-weather-related-power-outages

Coates, K., Holroyd, C., & Baumann, B. (2023). Indigenous Peoples and the uranium mining sector in northern Saskatchewan. In N. D. Brunet & S. Longboat (Eds.), *Local Communities and the Mining Industry* (1st ed., pp. 140–157)). Routledge. https://doi.org/10.4324/9781003182375

Cohn, C. (1987). Sex and death in the rational world of defense intellectuals. *Signs: Journal of Women in Culture and Society, 12*(4), 687–718. https://doi.org/10.1086/494362

Cohn, S. M. (1997). *Too cheap to meter: An economic and philosophical analysis of the nuclear dream.* State University of New York Press. https://sunypress.edu/Books/T/Too-Cheap-to-Meter

Colby, J. (n.d.). *The United States and the Caribbean, 1877–1920.* Gilder Lehrman Institute of American History. Retrieved October 6, 2025, from https://www.gilderlehrman.org/history-resources/essays/united-states-and-caribbean-1877-1920

Collinson, A. (2019, March 26). *How Bazalgette built London's first super sewer.* Museum of London. https://www.londonmuseum.org.uk/collections/london-stories/how-bazalgette-built-londons-first-super-sewer

Columbus, O. (2023). Small modular reactors (SMRs): A beginner's guide. *Last Energy.* https://www.lastenergy.com/blog/small-modular-reactors-smrs-a-beginners-guide

Conca, J. (2019, December 14). How the U.S. Navy remains the masters of modular nuclear reactors. *Forbes.* https://www.forbes.com/sites/jamesconca/2019/12/23/americas-nuclear-navy-still-the-masters-of-nuclear-power

Conde, M., & Kallis, G. (2012). The global uranium rush and its Africa frontier. Effects, reactions and social movements in Namibia. *Global Environmental Change, 22*(3), 596–610. https://doi.org/10.1016/j.gloenvcha.2012.03.007

Containerlift. (2023, August 24). T*he Panama Canal: A monumental feat of engineering, history, and geopolitical intrigue.* https://www.containerlift.co.uk/the-panama-canal-a-monumental-feat-of-engineering-history-and-geopolitical-intrigue/

Coombs, K. (2022). *Highways and environmental justice.* Environmental Law Education Center. Retrieved on October 14, 2024, from https://elecenter.com/1394/highways-and-environmental-justice

Cooper, A. (2019). Hear me out. *Missouri Medicine, 116*(6), 469–471.

Cooper, A. (2024, August 14). *Reckoning with the devastating legacy of federal Indian boarding school policies.* Mellon Foundation. https://www.mellon.org/grant-story/reckoning-with-the-devastating-legacy-of-federal-indian-boarding-school-policies

Corkhill, C., Joyce, M., Lacey, D., & Thrift, N. (2025, January 13). *Small and advanced nuclear reactors: Closing the fuel cycle?* Bulletin of the Atomic Scientists. https://thebulletin.org/premium/2025-01/small-and-advanced-nuclear-reactors-closing-the-fuel-cycle

Cornell, S. (2008). Indigenous peoples, poverty and self-determination in Australia, New Zealand, Canada and the United States. In R. Eversole, J.-A. McNeish, & A. D. Cimadamore (Eds.), *Indigenous Peoples and Poverty: An International Perspective* (p. 321). Bloomsbury Publishing. https://www.bloomsbury.com/us/indigenous-peoples-and-poverty-9781848137059/

Coronel Vargas, G., Au, W. W., & Izzotti, A. (2020). Public health issues from crude-oil production in the Ecuadorian Amazon territories. *Science of The Total Environment, 719.* https://doi.org/10.1016/j.scitotenv.2019.134647

Cothron, E., & Koshgarian, Z. (2024). *From Reactors to Repositories: Disposal Pathways for Advanced Nuclear Reactor Waste.* Nuclear Innovation Alliance. https://nuclearinnovationalliance.org/reactors-repositories-disposal-pathways-advanced-nuclear-reactor-waste

Cowan, R. S. (1983). *More work for mother: The ironies of household technology from the open hearth to the microwave.* Basic Books. https://www.hachettebookgroup.com/titles/ruth-schwartz-cowan/more-work-for-mother/9780465047321/?lens=basic-books

Cranmer, Z., Steinfield, L., Miranda, J., & Stohler, T. (2023). Energy distributive injustices: Assessing the demographics of communities surrounding renewable and fossil fuel power plants in the United States. *Energy Research & Social Science, 100,* 103050. https://doi.org/10.1016/j.erss.2023.103050

Crimp, D. (2011, December 6). Before occupy: How AIDS activists seized control of the FDA in 1988. *The Atlantic.* https://www.theatlantic.com/health/archive/2011/12/before-occupy-how-aids-activists-seized-control-of-the-fda-in-1988/249302

Csizmadia, C. (2023, February 9). *From Alaska to Maine: State nuclear energy policy action is booming.* Nuclear Energy Institute. https://www.nei.org/news/2023/alaska-to-maine-state-nuclear-energy-policy-action

Curley, A. (2021). Resources is just another word for colonialism. In M. Himley, E. Havice, & G. Valdivia (Eds.), *The Routledge Handbook of Critical Resource Geography.* Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9780429434136-7/resources-another-word-colonialism-andrew-curley

Cushing, L. J., Li, S., Steiger, B. B., & Casey, J. A. (2023). Historical red-lining is associated with fossil fuel power plant siting and present-day inequalities in air pollutant emissions. *Nature Energy, 8*(1), 52–61. https://doi.org/10.1038/s41560-022-01162-y

Dahl, C., Squire, C., & Cui, R. (2023). *International experience in a just coal workforce transition through fiscal support* [Working Paper]. University of Maryland School of Public Policy. https://spp.umd.edu/research-impact/publications/policy-brief-international-experience-just-coal-workforce-transition

Daigle, B., DeCarlo, S., & Lotze, N. (2024). Big change goes small: Are small modular reactors (SMRs) the future of nuclear energy? Office of Industry and Competitiveness Analysis, U.S. International Trade Commission. https://www.usitc.gov/publications/332/working_papers/smrs_fo_ma.pdf

Dakota Access Pipeline. (n.d.). D*akota Access Pipeline Facts.* Retrieved January 5, 2024, from https://daplpipelinefacts.com

Daly, A. (2023, June 21). *Inside the Idaho town first in the world to be lit by nuclear power.* BoiseDev. https://boisedev.com/news/2023/06/21/inl-arco-power

Damalas, C. A., & Koutroubas, S. D. (2016). Farmers' exposure to pesticides: Toxicity types and ways of prevention. *Toxics, 4*(1), 1. https://doi.org/10.3390/toxics4010001

Danelski, D. (2024, December). *AI's deadly air pollution toll.* University of California, Riverside. https://news.ucr.edu/articles/2024/12/09/ais-deadly-air-pollution-toll

Dave, P. (2023, May 31). ChatGPT is cutting non-English languages out of the AI revolution. *Wired.* https://www.wired.com/story/chatgpt-non-english-languages-ai-revolution

Dawson, S. E., & Madsen, G. E. (2011). Psychosocial and health impacts of uranium mining and milling on Navajo lands. *Health Physics, 101*(5), 618–625. https://doi.org/10.1097/HP.0b013e3182243a7a

Day, P. (2023, September 21). New nuclear may be delayed by uncertain fuel supplies. *Reuters.* https://www.reuters.com/business/energy/new-nuclear-may-be-delayed-by-uncertain-fuel-supplies-2023-09-21

de Bengy Puyvallée, A., & Storeng, K. T. (2022). COVAX, vaccine donations and the politics of global vaccine inequity. *Globalization and Health, 18*(1), 26. https://doi.org/10.1186/s12992-022-00801-z

de Carbonnel, A. (2013, July 22). *Russian nuclear ambition powers building at home and abroad.* Reuters. https://www.reuters.com/article/markets/russian-nuclear-ambition-powers-building-at-home-and-abroad-idUSL5N0F90YK/

De Cauwer, H., Barten, D. G., Tin, D., Mortelmans, L. J., Ciottone, G. R., & Somville, F. (2023). 50 Years of terrorism against the nuclear industry: A review of 91 incidents in the global terrorism database. *Prehospital and Disaster Medicine, 38*(2), 199–206. https://doi.org/10.1017/S1049023X2300002X

Defense Innovation Unit. (2024, June 5). *DIU, army to prototype advanced nuclear power for military installations.* https://www.diu.mil/latest/diu-and-u-s-army-to-prototype-advanced-nuclear-power-for-military

Dement, C., & Inglis, M. (2024). Artificial intelligence-assisted criminal justice reporting: An exploratory study of benefits, concerns, and future directions. *Criminology & Criminal Justice, 0(0)* https://doi.org/10.1177/17488958241274296

Denoun, M., Goumri, M., Le Renard, C., & Pottin, A. (21 October 2024). Nuclear revival and legacies. Insights from the Humanities and Social sciences International Conference [Paper presentation]. *Nuclear revival and legacies. Insights from the Humanities and Social sciences International Conference,* Marne-La-Vallée, France. https://orbi.uliege.be/handle/2268/325069

Depotter, J. (2023). *Research about indications within the increasing demand for renewable energy* [Ghent University]. https://libstore.ugent.be/fulltxt/RUG01/003/150/997/RUG01-003150997_2023_0001_AC.pdf

Dewan, A., Nilsen, E., & Robinson, L. (2024, February 1). *New-wave reactor technology could kick-start a nuclear renaissance—And the US is banking on it.* CNN. https://www.cnn.com/2024/02/01/climate/nuclear-small-modular-reactors-us-russia-china-climate-solution-intl/index.html

Dexian. (2024, October 31). *How improvements in LLMs boost efficiency and deepen insights.* Dexian. https://dexian.com/blog/improvements-in-llms

Diné Care. (n.d.). *About Us.* Retrieved October 2, 2025, from https://www.dine-care.org/about-dine-care

Dixon, K., & Wheatley, T. (2023, June 6). *Where "Cop City" leaders stumbled when seeking public support.* Axios. https://www.axios.com/local/atlanta/2023/06/06/atlanta-cop-city-messaging

Do, V., McBrien, H., Flores, N., Northrop, A., Schlegelmilch, J., Kiang, M., & Casey, J. (2023). Spatiotemporal distribution of power outages with climate events and social vulnerability in the USA. *Nature Communications, 14*(2470). https://doi.org/10.1038/s41467-023-38084-6

Dolzikova, D. (2024, June 6). Despite the risks, Russia continues to use Ukraine's Zaporizhzhia nuclear plant as a source of leverage. *Bulletin of the Atomic Scientists.* https://thebulletin.org/2024/06/despite-the-risks-russia-continues-to-use-ukraines-zaporizhzhia-nuclear-plant-as-a-source-of-leverage

Domínguez-Cruz, M. G., Muñoz, M. de L., Totomoch-Serra, A., García-Escalante, M. G., Burgueño, J., Valadez-González, N., Pinto-Escalante, D., & Díaz-Badillo, A. (2020). Maya gene variants related to the risk of type 2 diabetes in a family-based association study. *Gene, 730*(144259). https://doi.org/10.1016/j.gene.2019.144259

Donley, N., Bullard, R. D., Economos, J., Figueroa, I., Lee, J., Liebman, A. K., Martinez, D. N., & Shafiei, F. (2022). Pesticides and environmental injustice in the USA: Root causes, current regulatory reinforcement and a path forward. *BMC Public Health, 22*(1), 708. https://doi.org/10.1186/s12889-022-13057-4

Donley, N., Bullard, R. D., Economos, J., Figueroa, I., Lee, J., Liebman, A. K., Martinez, D. N., & Shafiei, F. (2022). Pesticides and environmental injustice in the USA: Root causes, current regulatory reinforcement and a path forward. *BMC Public Health, 22*(708). https://doi.org/10.1186/s12889-022-13057-4

Donovan, J. (2023, December 7). *Repurposing coal power plant sites with low carbon nuclear.* IAEA. https://www.iaea.org/newscenter/news/repurposing-coal-power-plant-sites-with-low-carbon-nuclear

Dow Chemical. (2023). *Dow and X-energy advance efforts to deploy first advanced small modular nuclear reactor at industrial site under DOE's Advanced Reactor Demonstration Program.* https://corporate.dow.com/en-us/news/press-releases/dow-x-energy-collaborate-on-smr-nuclear.html

Dugdale, K. (2022, December 19). Electric vehicle inequities. *IPMI.* https://www.parking-mobility.org/2022/12/19/electric-vehicle-inequities

EDF Group. (2022, February 5). *EDF announces that its small modular reactor NUWARD will be the case study for a European early joint regulatory review led by the French nuclear safety authority with the participation of the Czech and Finnish safety authorities.* [Press Release]. https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/edf-announces-that-its-small-modular-reactor-nuwardtm-will-be-the-case-study-for-a-european-early-joint-regulatory-review-led-by-the-french-nuclear-safety-authority-with-the-participation-of

EHS Today. (2001, April 30). *The cost of a canal.* https://www.ehstoday.com/archive/article/21912450/the-cost-of-a-canal

Eichhorn, S. J. (2020). How the West was won: A deconstruction of politicised colonial engineering. *The Political Quarterly, 91*(1), 204–209. https://doi.org/10.1111/1467-923X.12773

Eielson Air Force Lab. (2024). *Micro-reactor pilot program at Eielson AFB.* https://www.eielson.af.mil/microreactor/

EJ Atlas. (2022, September 29). *Acaparamiento de agua por parte de FEMSA Coca Cola en San Cristóbal de las Casas, Chiapas, Mexico [Water grabbing by FEMSA Coca Cola in San Cristobal de las Casas, Chiapas, Mexico].* https://ejatlas.org/print/extractivismo-de-agua-femsa-coca-cola-chiapas-mexico

Eliazer Nelson, A. R. L., Ravichandran, K., & Antony, U. (2019). The impact of the Green Revolution on indigenous crops of India. Journal of Ethnic Foods, 6(1), 8. https://doi.org/10.1186/s42779-019-0011-9

El Obeid, S. (2021). *Uranium in Namibia: yellowcake fever.* The French Institute of International Relations. https://www.ifri.org/en/papers/uranium-namibia-yellowcake-fever

Endres, D. (2009). From wasteland to waste site: The role of discourse in nuclear power's environmental injustices. *Local Environment, 14*(10), 917–937. https://doi.org/10.1080/13549830903244409

Endres, D. (2012). Sacred land or national sacrifice zone: The role of values in the Yucca Mountain participation process. *Environmental Communication, 6*(3), 328–345. https://doi.org/10.1080/17524032.2012.688060

Energy Information Administration. (2023). *Nuclear explained—U.S. nuclear industry.* https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php

Energy Information Administration. (n.d.-a). *How much carbon dioxide is produced per kilowatthour of U.S. electricity generation?* Retrieved November 10, 2024, from https://www.eia.gov/tools/faqs/faq.php?id=74&t=3

Energy Information Administration. (n.d.-b). *What are the greenhouse gas and air pollutant emissions factors for fuels and electricity?* Retrieved December 12, 2024, from https://www.eia.gov/tools/faqs/faq.php?id=76&t=11

Energy Reorganization Act, Pub. L. No. 93–438, 88 Stat. 1233 (1974). https://www.congress.gov/bill/93rd-congress/house-bill/11510

Environmental Integrity Project. (2023, December 14). *EPA's rules for verifying carbon capture projects are riddled with holes.* https://environmentalintegrity.org/news/epas-rules-for-verifying-carbon-capture-projects-are-riddled-with-holes

Epstein, S. (1996). *Impure science: AIDS, activism, and the politics of knowledge* (1st ed.). University of California Press. https://www.ucpress.edu/books/impure-science/paper

Epstein, S. (1998). Chapter 5: Points of departure. In *Impure science: AIDS, activism, and the politics of knowledge* (pp. 181–208). University of California Press. https://www.ucpress.edu/books/impure-science/paper

Equal Justice Initiative. (2024, July 31). *Federal investigation finds at least 973 children died in federal Indian boarding schools.* https://eji.org/news/federal-investigation-finds-at-least-973-children-died-in-federal-indian-boarding-schools

Erdensanaa, D. (2023, June). Dow's river: Who reigns on the Brazos? *Texas Observer.* https://www.texasobserver.org/dow-brazos-river-pollution-nurdles

European Commission. (2019). *Strategy for the economic and social development of the Jiu Valley, a coal region in transition in Romania.* https://reform-support.ec.europa.eu/what-we-do/green-transition/strategy-economic-and-social-development-jiu-valley-coal-region-transition-romania_en

European Commission. (n.d.). *2050 long-term strategy.* Retrieved September 29, 2025, from https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en

European Commission. (n.d.). *Just transition fund.* Retrieved February 6, 2025, from https://commission.europa.eu/funding-tenders/find-funding/eu-funding-programmes/just-transition-fund_en

Ewing, J. (2022, August 8). Electric cars too costly for many, even with aid in climate bill. *The New York Times.* https://www.nytimes.com/2022/08/08/business/energy-environment/electric-vehicles-climate-bill.html

EXIM. (2023, November 3). *Chair Lewis emphasizes Export-Import Bank of the U.S.' nuclear priorities at U.S.-Africa Nuclear Energy Summit in Ghana.* https://www.exim.gov/news/chair-lewis-emphasizes-export-import-bank-nuclear-priorities-africa-nuclear-energy-summit

Fattouh, B., Vakhshouri, S., Henderson, J., Keppler, J. H., Kåberger, T., Nilsson, L. J., Schernikau, L., Allison, W., Rogner, H.-H., Shihab-Eldin, A., Mansouri, N. Y., Budnitz, R. J., Heinonen, O., Nilsson, A., McCombie, C., Chapman, N., Kinghorn-Mills, J., Ferrazza, F., Fiorentini, E., ... Hochman, T. (2024). Nuclear energy in the global energy landscape: Advancing sustainability and ensuring energy security? *The Oxford Institute for Energy Studies, 139.* https://www.oxfordenergy.org/wpcms/wp-content/uploads/2024/02/OEF-139-.pdf

Fedchenko, V. (2024, January 26). Small modular reactors may have climate benefits, but they can also be climate-vulnerable. *Stockholm International Peace Research Institute.* https://www.sipri.org/commentary/blog/2024/holding-page-vitalys-blog-smrs-and-climate-vulnerability

Federal Aviation Administration. (n.d.-a). *About the FAA designee program.* Retrieved November 14, 2024, from https://www.faa.gov/other_visit/aviation_industry/designees_delegations/about

Federal Aviation Administration. (n.d.-b). *Delegation and designee background.* Retrieved November 20, 2024, from https://www.faa.gov/about/history/deldes_background

Federal Aviation Administration. (n.d.-c). *Individual designees overview.* Retrieved December 11, 2024, from https://www.faa.gov/other_visit/aviation_industry/designees_delegations/individual_designees

Ferguson, C. D., & Jansson, M. (2013). Past problems with Japan's regulatory system. In *Regulating Japanese Nuclear Power in the Wake of the Fukushima Daiichi Accident* (pp. 5–11). Federation of American Scientists. https://www.jstor.org/stable/resrep18921.5

Ferrant, G., Pesando, L. M., & Nowacka, K. (2014). Unpaid care work: The missing link in the analysis of gender gaps in labour outcomes. *OECD Development Centre.* https://www.oecd.org/content/dam/oecd/en/publications/reports/2014/12/unpaid-care-work-the-missing-link-in-the-analysis-of-gender-gaps-in-labour-outcomes_d26d4043/1f3fd03f-en.pdf

Fisher, E., Mahajan, R. L., & Mitcham, C. (2006). Midstream modulation of technology: Governance from within. *Bulletin of Science, Technology & Society, 26*(6), 485–496. https://doi.org/10.1177/0270467606295402

Fisher, M. (2021). Advanced reactors help pave the way for nuclear power to meet climate goals. *IAEA Bulletin: Nuclear Power and the Clean Energy Transition, 61*(3). http://www.iaea.org/bulletin/advanced-reactors-help-pave-the-way-for-nuclear-power-to-meet-climate-goals

Fitzgerald, E. F., Hwang, S.-A., Lambert, G., Gomez, M., & Tarbell, A. (2005). PCB exposure and in vivo CYP1A2 activity among Native Americans. *Environmental Health Perspectives, 113*(3), 272–277. https://doi.org/10.1289/ehp.7370

Flavelle, C. (2021, May 3). A new, deadly risk for cities in summer: Power failures during heat waves. *The New York Times.* https://www.nytimes.com/2021/05/03/climate/heat-climate-health-risks.html

Fleet, T. (2024, November 13). LLMs and the nuclear challenge. *Nuclear Engineering International.* https://www.neimagazine.com/analysis/llms-and-the-nuclear-challenge

Foltynova, K. (2022, September 21). *Russia's stranglehold on the world's nuclear power cycle.* Radio Free Europe/Radio Liberty. https://www.rferl.org/a/russia-nuclear-power-industry-graphics/32014247.html

Food and Drug Administration. (2019, March 14). *The history of FDA's role in preventing the spread of HIV/AIDS*. Food and Drug Administration. https://www.fda.gov/about-fda/fda-history-exhibits/history-fdas-role-preventing-spread-hivaids

Forté, C. A. (2025, May 6). US uranium mining legacy still harms the Navajo Nation. *Union of Concerned Scientists, The Equation.* https://blog.ucs.org/chanese-forte/us-uranium-mining-legacy-still-harms-the-navajo-nation

France-Presse, A. (2015, December 5). Nuclear waste returned to Australia, raising concerns about future dump site. *The Guardian.* https://www.theguardian.com/environment/2015/dec/05/nuclear-waste-returned-to-australia-raising-concerns-about-future-dump-site

Frankel, T. C., & Whoriskey, P. (2016, December 19). Tossed aside in the 'white gold' rush Indigenous people are left poor as tech world takes lithium from under their feet. *Washington Post.* https://www.washingtonpost.com/graphics/business/batteries/tossed-aside-in-the-lithium-rush

French, P. (2024, February 9). Faced with 'Cop City' referendum push, Atlanta changes up its election rules. *Bolts.* https://boltsmag.org/cop-city-referendum-signature-matching-atlanta

Frost, R. (2024, January 4). *Europe is divided on nuclear power: Which countries are for and against it?* Euro News. https://www.euronews.com/green/2024/04/01/europe-is-divided-on-nuclear-power-which-countries-are-for-and-against-it

Fullerton, D. G., Bruce, N., & Gordon, S. B. (2008). Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 102*(9), 843–851. https://doi.org/10.1016/j.trstmh.2008.05.028

Gabay, A. (2024, June 24). *Study: More than half of Australia's clean energy mines lie on Indigenous land.* Mongabay Environmental News. https://news.mongabay.com/2024/06/study-more-than-half-of-australias-clean-energy-mines-lie-on-indigenous-land

Gabel, R. (1969). The early competitive era in telephone communication, 1893-1920. *Law and Contemporary Problems, 34*(2), 340. https://doi.org/10.2307/1191094

Gadgil, A. J., & Booker, K. (2011). Cookstove dissemination in Haiti: Improving collaboration and information-sharing. *Boiling Point, 59.* https://gadgillab.berkeley.edu/wp-content/uploads/2014/04/2010HEDON_HaitiCookstoveReport.pdf

Gallegos, I. O., Rossi, R. A., Barrow, J., Tanjim, M. M., Kim, S., Dernoncourt, F., Yu, T., Zhang, R., & Ahmed, N. K. (2024). Bias and fairness in large language models: A survey. *Computational Linguistics, 50*(3), 1097–1179. https://doi.org/10.1162/coli_a_00524

Galligan, C., Rosenfeld, H., Kleinman, M., & Parthasarathy, S. (2020). *Cameras in the classroom: Facial recognition technology in schools.* Science, Technology, and Public Policy Program, University of Michigan. https://stpp.fordschool.umich.edu/research/research-report/cameras-classroom-facial-recognition-technology-schools

Ganchev, I. (2020). China pushed the pink tide and the pink tide pulled China: Intertwining economic interests and ideology in Ecuador and Bolivia (2005–2014). *World Affairs, 183*(4), 359–388. https://doi.org/10.1177/0043820020965968

Garcia, D. L. (2005). Cooperative networks and the rural-urban divide. In R. Latham & S. Sassen (Eds.), *Digital Formations: IT and New Architectures in the Global Realm* (pp. 117–145). Princeton University Press. https://doi.org/10.1515/9781400831616.117

Gardner, T. (2020, November 17). *U.S. nuclear power industry group sees reprocessing as potential waste fix.* Reuters. https://www.reuters.com/article/business/environment/us-nuclear-power-industry-group-sees-reprocessing-as-potential-waste-fix-idUSKBN27W30T

Gardner, T. (2024, January 9). US seeks to jump-start production of higher-energy uranium now made in Russia. *Reuters.* https://www.reuters.com/world/us/us-seeks-jump-start-production-higher-energy-uranium-now-made-russia-2024-01-09

Garzón, P., & Castro, D. (2018). China-Ecuador relations and the development of the hydro sector. In *Building Developement for a New Era: China's Infrastructure Projects in Latin America and the Caribbean.* Asian Studies Center at University of Pittsburgh Center for International Studies. https://www.researchgate.net/publication/340610137_China-Ecuador_relations_and_the_development_of_the_Hydro_Sector

Gates, D. (2019, March 17). Flawed analysis, failed oversight: How Boeing, FAA certified the suspect 737 MAX flight control system. *The Seattle Times.* https://www.seattletimes.com/business/boeing-aerospace/failed-certification-faa-missed-safety-issues-in-the-737-max-system-implicated-in-the-lion-air-crash

Gavin, G., & Jack, V. (2024, November 5). EU eyes new clampdown on Russian nuclear sector. *POLITICO.* https://www.politico.eu/article/eu-eyes-new-clampdown-russia-nuclear-sector-hungary-viktor-orban

Gelles, D., Kitroeff, N., Nicas, J., & Ruiz, R. R. (2019, March 23). Boeing was 'go, go, go' to beat Airbus with the 737 Max. *The New York Times.* https://www.nytimes.com/2019/03/23/business/boeing-737-max-crash.html

Gen IV International Forum. (2025, June 16). *FAQ - Gen IV systems design, benefits and challenges* [Presentation]. https://www.gen-4.org/resources/presentations/faq-gen-iv-systems-design-benefits-and-challenges

Gen IV International Forum. (n.d.). *Generation IV goals, technologies and GIF R&D roadmap.* Retrieved February 19, 2025, from https://www.gen-4.org/generation-iv-criteria-and-technologies

Gibson, J. (2023). Fission forward. In *National security science—The energy issue.* Los Alamos National Laboratory. https://www.lanl.gov/media/publications/national-security-science/1123-fission-forward

Giges, N. (2014, October 8). *Time for passive safety at nuclear plants.* The American Society of Mechanical Engineers. https://www.asme.org/topics-resources/content/Time-Passive-Safety-Nuclear-Plants

Giglio, E. (2021). Extractivism and its socio-environmental impact in South America. Overview of the "lithium triangle." *América Crítica,* 5(1), 47–53.

Gilbert, S. (2019, August 12). Church Rock, America's forgotten nuclear disaster, is still poisoning Navajo lands 40 years later. *Vice.* https://www.vice.com/en/article/church-rock-americas-forgotten-nuclear-disaster-is-still-poisoning-navajo-lands-40-years-later

Gilinsky, V. (2024, November 21). *Congress wants to turn the nuclear regulator into the US industry's cheerleader—again.* Bulletin of the Atomic Scientists. https://thebulletin.org/2024/11/congress-wants-to-turn-the-nuclear-regulator-into-the-us-industrys-cheerleader-again

Gilmore, R. W. (2002). Race and globalization. In R. Johnston, P. J. Taylor, & M. Watts (Eds.), *Geographies of Global Change: Remapping the World* (2nd ed., pp. 261–274). Wiley-Blackwell. https://www.wiley.com/en-nz/Geographies+of+Global+Change%3A+Remapping+the+World%2C+2nd+Edition-p-9780631222866

Gilmore, R. W. (2007). *Golden gulag: Prisons, surplus, crisis, and opposition in globalizing California* (1st ed.). University of California Press. https://www.jstor.org/stable/10.1525/j.ctt5hjht8

Glasmeier, A. K., & Farrigan, T. (2007). The economic impacts of the prison development boom on persistently poor rural places. *International Regional Science Review, 30*(3), 274–299. https://doi.org/10.1177/0160017607301608

Global Climate and Health Alliance (Director). (2023, October 31). *The climate and us: What Indigenous knowledge can teach us about land stewardship in the Arctic* [Video]. Youtube. https://www.youtube.com/watch?v=o30bpI6n8FM

Global Energy Association. (2024, July 26). *Rolls-Royce to develop microreactor for outer space.* https://globalenergyprize.org/en/2024/07/26/rolls-royce-to-develop-microreactor-for-outer-space

Global Market Insights, Inc. (2024). *Carbon Capture and Storage Market, Size Report 2025–2034.* https://www.gminsights.com/industry-analysis/carbon-capture-and-storage-market

Global Water Intelligence. (2020, May 1). *Effective pumping to sustainably clean the holy River Ganges of tannery wastewater and effluents.* https://www.globalwaterintel.com/articles/effective-pumping-to-sustainably-clean-the-holy-river-ganges-of-tannery-wastewater-and-effluents-andritz

Goldschmidt, P. (2003, September 25). *Major challenges currently facing the international nuclear non-proliferation regime.* IAEA. https://www.iaea.org/newscenter/statements/major-challenges-currently-facing-international-nuclear-non-proliferation-regime

Goldschmidt, P. (2013, June 25). *Serious deficiencies exposed by latest IAEA safeguards implementation report.* Carnegie Endowment for International Peace. https://carnegieendowment.org/research/2013/06/serious-deficiencies-exposed-by-latest-iaea-safeguards-implementation-report

Gómez, E. J. (2019). Coca-Cola's political and policy influence in Mexico: Understanding the role of institutions, interests and divided society. *Health Policy and Planning, 34*(7), 520–528. https://doi.org/10.1093/heapol/czz063

Gonsalves, G., & Yamey, G. (2021). The covid-19 vaccine patent waiver: A crucial step towards a "people's vaccine." *BMJ, 373.* https://doi.org/10.1136/bmj.n1249

Gonzalez Monserrate, S. (2022, February 14). *The staggering ecological impacts of computation and the cloud.* MIT Schwarzman College of Computing. https://computing.mit.edu/news/the-staggering-ecological-impacts-of-computation-and-the-cloud

Goodyear, S. (2023, September 7). *Greenpeace opposes nuclear energy. Young climate activists say that's "old-fashioned."* CBC Radio. https://www.cbc.ca/radio/asithappens/dear-greenpeace-nuclear-energy-1.6958765

Google. (2022, November 21). *Our commitment to climate-conscious data center cooling.* https://blog.google/outreach-initiatives/sustainability/our-commitment-to-climate-conscious-data-center-cooling

Google. (2024, October 14). *New nuclear clean energy agreement with Kairos Power.* https://blog.google/outreach-initiatives/sustainability/google-kairos-power-nuclear-energy-agreement

Gopinathan, P., Subramani, T., Barbosa, S., & Yuvaraj, D. (2023). Environmental impact and health risk assessment due to coal mining and utilization. *Environmental Geochemistry and Health, 45*(10), 6915–6922. https://doi.org/10.1007/s10653-023-01744-z

Gould, A. (2022, November 17). *Nuclear power won't be green until there's a plan for uranium mining.* The Breakthrough Institute. https://thebreakthrough.org/journal/no-18-fall-2022/nuclears-uranium-problem

Gould, A. (2022, November 17). State of play: The legacy of uranium mining on U.S. tribal lands. *Good Energy Collective.* https://www.goodenergycollective.org/resources/the-legacy-of-uranium-mining-on-us-tribal-lands

Gouran, D. S., Hirokawa, R. Y., & Martz, A. E. (1986). A critical analysis of factors related to decisional processes involved in the Challenger disaster. *Central States Speech Journal, 37*(3), 118–135. https://doi.org/10.1080/10510978609368212

Government of Canada. (2024, August 28). Small but mighty: Unveiling the power of small modular reactors. *The Science of Health.* https://science.gc.ca/site/science/en/blogs/science-health/small-mighty-unveiling-power-small-modular-reactors

Grady, D. (1998, October 6). A glow in the dark, and a lesson in scientific peril. *The New York Times.* https://www.nytimes.com/1998/10/06/science/a-glow-in-the-dark-and-a-lesson-in-scientific-peril.html

Graetz, G. (2015). Energy for whom? Uranium mining, Indigenous people, and navigating risk and rights in Australia. *Energy Research & Social Science, 8,* 113–126. https://doi.org/10.1016/j.erss.2015.05.006

Graf von Hardenberg, W. (2011). Nuclear power, no thanks! The aftermath of Chernobyl in Italy and the nuclear power referendum of 1987. *Arcadia 2011*(3). https://www.environmentandsociety.org/arcadia/nuclear-power-no-thanks-aftermath-chernobyl-italy-and-nuclear-power-referendum-1987

Graham, G. S. (1935). The migrations of the Nantucket whale fishery: An episode in British colonial policy. *The New England Quarterly, 8*(2), 179–202. https://doi.org/10.2307/360870

Greene, W. C. (2007). A history of AIDS: Looking back to see ahead. *European Journal of Immunology, 37*(S1), S94–S102. https://doi.org/10.1002/eji.200737441

Greenfield, N. (2022, April 26). *Lithium mining is leaving Chile's Indigenous communities high and dry (literally).* Natural Resources Defense Council (NRDC). https://www.nrdc.org/stories/lithium-mining-leaving-chiles-indigenous-communities-high-and-dry-literally

Greenpeace. (n.d.). *Nuclear power is dirty, dangerous and expensive. Say no to new nukes.* Greenpeace. Retrieved October 10, 2024, from https://www.greenpeace.org/usa/climate/issues/nuclear

Griese, N. L. (1977). AT&T: 1908 origins of the nation's oldest continuous institutional advertising campaign. *Journal of Advertising, 6*(3), 18–23. https://doi.org/10.1080/00913367.1977.10672703

Grinde, D. A. (1974). Erie's railroad war: A case study of purposive violence for a community's economic advancement. *Western Pennsylvania History: 1918 - 2023,* 15–23.

Grossi, R. M. (2024, January 17). *5 reasons nuclear energy is key to the climate transition.* World Economic Forum. https://www.weforum.org/agenda/2024/01/nuclear-energy-transistion-climate-change

Guéguen, L. (2022, August 22). San Cristobal de las Casas, the Mexican town that drank more coke than water. *VOICES.* https://voiceskopje.org/2022/08/22/san-cristobal-de-las-casas-the-mexican-town-that-drank-more-coke-than-water

Guha, N. (2023, October 9). *6 years after Standing Rock, Native tribes still fight Dakota Access Pipeline.* Truthout. https://truthout.org/articles/5-years-after-standing-rock-native-tribes-still-fight-dakota-access-pipeline

Gunderson, R., Stuart, D., & Petersen, B. (2020). The fossil fuel industry's framing of carbon capture and storage: Faith in innovation, value instrumentalization, and status quo maintenance. *Journal of Cleaner Production, 252.* https://doi.org/10.1016/j.jclepro.2019.119767

Gupta, S. (2024, September 30). Climate change and flood risks in the Ganga and Brahmaputra basins. *RMSI Blog.* https://www.rmsi.com/blog/2024/09/climate-change-and-flood-risks-in-the-ganga-and-brahmaputra-basins

Guston, D. H., & Sarewitz, D. (2002). Real-time technology assessment. *Technology in Society, 24*(1–2), 93–109. https://doi.org/10.1016/S0160-791X(01)00047-1

Gutiérrez-León, E., Escamilla-Santiago, R. A., Martínez-Amezcua, P., Bilal, U., Lazo, M., Ogaz-González, R., & López-Cervantes, M. (2022). Trends and effect of marginalization on diabetes mellitus-related mortality in Mexico from 1990 to 2019. *Scientific Reports, 12*(1), 9190. https://doi.org/10.1038/s41598-022-12831-z

Hafner, K. (2024, July 10). *Youngkin, Dominion announce "moonshot" goal to build nation's first small modular nuclear reactor.* WHRO Public Media. https://www.whro.org/environment/2024-07-10/youngkin-dominion-announce-moonshot-goal-to-build-nations-first-small-modular-nuclear-reactor

Haines, M. B. (2020). (Nation) building civic epistemologies around nuclear energy in India. *Journal of Responsible Innovation, 7*(1), 34–52. https://doi.org/10.1080/23299460.2020.1771145

Halper, E. (2024, September 20). Microsoft deal would reopen Three Mile Island nuclear plant to power AI. *The Washington Post*. https://www.washingtonpost.com/business/2024/09/20/microsoft-three-mile-island-nuclear-constellation

Halperin, S. (n.d.). *Neocolonialism.* Britannica. Retrieved October 6, 2025, from https://www.britannica.com/topic/neocolonialism

Hamblin, J. D. (2012). Fukushima and the motifs of nuclear history. *Environmental History, 17*(2), 285–299. https://doi.org/10.1093/envhis/ems001

Hamblin, J. D. (2021). *The wretched atom: America's global gamble with peaceful nuclear technology* (1st ed.). Oxford University Press. https://doi.org/10.1093/oso/9780197526903.001.0001

Hamlett, P., Cobb, M. D., & Guston, D. H. (2013). National citizens' technology forum: Nanotechnologies and human enhancement. In S. Hays, J. Robert, C. Miller, & I. Bennett (Eds.), *Nanotechnology, the brain, and the future* (Vol. 3, pp. 265–283). Springer. https://doi.org/10.1007/978-94-007-1787-9_16

Han, Y., Wu, Z., Li, P., Wierman, A., & Ren, S. (2024). *The unpaid toll: Quantifying the public health impact of AI* (No. arXiv:2412.06288). https://doi.org/10.48550/arXiv.2412.06288

Hansen, J., Jenson, W., Wrobel, A., Stauff, N., Biegel, K., Kim, T., Belles, R., & Omitaomu, F. (2022). *Investigating benefits and challenges of converting retiring coal plants into nuclear plants* (INL/RPT-22-67964, Revision 2), 18866. U.S. Department of Energy. https://doi.org/10.2172/1886660

Hansen, J., Jenson, W., Wrobel, A., Stauff, N., Biegel, K., Kim, T., Belles, R., & Omitaomu, F. (2022). *Investigating Benefits and Challenges of Converting Retiring Coal Plants into Nuclear Plants* (INL/RPT-22-67964-Revision 2) https://doi.org/10.2172/1886660

Haraway, D. (1984). Teddy bear patriarchy: Taxidermy in the garden of Eden, New York City, 1908-1936. *Social Text, 11,* 20–64. https://doi.org/10.2307/466593

Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies, 14*(3), 575–599. https://doi.org/10.2307/3178066

Harder, A. (2019, May 16). *Green New Deal activists dismiss nuclear power as clean energy alternative.* Axios. https://www.axios.com/2019/05/16/green-new-deal-activists-dismiss-nuclear-power

Hardy, I. (2023, October 31). The benefits of consuming large language models (LLMs) like ChatGPT. *Medium.* https://medium.com/design-bootcamp/the-benefits-of-consuming-large-language-models-llms-like-chatgpt-5ac4f3957d24

Harrison, J. L. (2011). *Pesticide drift and the pursuit of environmental justice.* The MIT Press. https://www.jstor.org/stable/j.ctt5hhd79

Harvey, J., Meijer, J., Ozer, H., Al-Qadi, I. L., Saboori, A., Kendall, A. (2016). *Pavement life cycle assessment framework* (No. FHWA-HIF-16-014). U.S. Department of Transportation. https://rosap.ntl.bts.gov/view/dot/38470

Hasegawa, A., Tanigawa, K., Ohtsuru, A., Yabe, H., Maeda, M., Shigemura, J., Ohira, T., Tominaga, T., Akashi, M., Hirohashi, N., Ishikawa, T., Kamiya, K., Shibuya, K., Yamashita, S., & Chhem, R. K. (2015). Health effects of radiation and other health problems in the aftermath of nuclear accidents, with an emphasis on Fukushima. *The Lancet, 386*(9992), 479–488. https://doi.org/10.1016/S0140-6736(15)61106-0

Hassan, A., & Keenan, S. (2023, March 7). What is 'Cop City'? The Atlanta police center protests, explained. *The New York Times.* https://www.nytimes.com/article/cop-city-atlanta-protests.html

Hassan, F., Yamey, G., & Abbasi, K. (2021). Profiteering from vaccine inequity: A crime against humanity? *BMJ, 374.* https://doi.org/10.1136/bmj.n2027

Hasselle, D. (2018). Shell plant at Norco stirred controversy decades before Clean Air Act allegations. *Nola.* https://www.nola.com/news/environment/shell-plant-at-norco-stirred-controversy-decades-before-clean-air-act-allegations/article_247dfae1-b34e-51b5-9a9a-f9b695816525.html

Haul No! (2016, December 14). *Facts: Pinyon Plain/Canyon Mine and White Mesa Mill.* https://haulno.com/facts-the-canyon-mine-and-white-mesa-mill

Hauser, H., & Nakib, H. D. (2024, August 7). *The rise of techno-colonialism. Project Syndicate.* https://www.project-syndicate.org/commentary/techno-colonialism-defines-us-china-rivalry-by-hermann-hauser-and-hazem-danny-nakib-2024-08

Havekes, H., Koster, M., Dekking, W., Uijterlinde, R., Wensik, W., & Walkier, R. (2017). *Water governance: The Dutch Water Authority model.* Dutch Water Authorities. https://dutchwaterauthorities.com/wp-content/uploads/2021/05/The-Dutch-water-authority-model.pdf

He, G., Mol, A. P. J., Zhang, L., & Lu, Y. (2013). Public participation and trust in nuclear power development in China. *Renewable and Sustainable Energy Reviews, 23,* 1–11. https://doi.org/10.1016/j.rser.2013.02.028

Hecht, G. (1998). *The radiance of France: Nuclear power and national identity after World War II* (1st ed.). MIT Press. https://mitpress.mit.edu/9780262581967/the-radiance-of-france

Hecht, G. (2002). Rupture-Talk in the Nuclear Age: Conjugating Colonial Power in Africa. *Social Studies of Science, 32*(5/6), 691–727. https://doi.org/10.1177/030631270203200504

Hecht, G. (2004). Colonial networks of power: The far reaches of systems. *Annales Historiques de l'électricité, 2*(1), 147–157. https://doi.org/10.3917/ahe.002.0147

Hecht, G. (2012). *Being nuclear: Africans and the global uranium trade.* The MIT Press. https://www.jstor.org/stable/j.ctt5hhk5k

Hedgpeth, D., & Horwitz, S. (2024, May 29). They took the children: U.S. created Indian boarding schools to destroy cultures and seize land. *The Washington Post.* https://www.washingtonpost.com/investigations/interactive/2024/american-indian-boarding-schools-history-legacy

Heimann, C. F. L. (1993). Understanding the Challenger disaster: Organizational structure and the design of reliable systems. *American Political Science Review, 87*(2), 421–435. https://doi.org/10.2307/2939051

Hernandez, A. (2024, July 1). *France's EDF to redraft small modular reactor design amid cost, technology concerns.* Reuters. https://www.reuters.com/business/energy/frances-edf-drops-plans-develop-its-own-small-nuclear-reactor-technology-2024-07-01

Hersher, R. (2017, February 22). *Key moments in the Dakota Access Pipeline fight.* NPR. https://www.npr.org/sections/thetwo-way/2017/02/22/514988040/key-moments-in-the-dakota-access-pipeline-fight

Herviou, K., Meshkati, N., Ustohalova, V., & Gupta, O. (2022, July 12). *What are the risks of nuclear power plants in wartime?* Polytechnique Insights. https://www.polytechnique-insights.com/en/columns/geopolitics/how-to-protect-nuclear-power-plants-in-wartime

Hewlett, R., & Anderson Jr., O. E. (1962). *The new world: A history of the United States Atomic Energy Commission* (Vol. 1). The Pennsylvania State University Press. https://babel.hathitrust.org/cgi/pt?id=mdp.39015014334711

Hewlett, R. G. (1978). *Federal policy for the disposal of highly radioactive wastes from commercial nuclear power plants: An historical analysis* (DOE/MA-153 Draft). U.S. Department of Energy. https://curie.pnnl.gov/system/files/documents/not%20yet%20assigned/aec_hewlett_history_s.pdf

Hibbs, M. (2022, February 18). *Why Europe is looking to nuclear power to fuel a green future.* Carnegie Endowment for International Peace. https://carnegieendowment.org/posts/2022/02/why-europe-is-looking-to-nuclear-power-to-fuel-a-green-future

Higginbotham, A. (2024). *Challenger: A true story of heroism and disaster on the edge of space.* Avid Reader Press/Simon & Schuster. https://www.simonandschuster.com/books/Challenger/Adam-Higginbotham/9781982176617

History of Computer Communications. (n.d.). *Vail joins the Bell Telephone Company—1878-1887.* Retrieved December 21, 2024, from https://historyofcomputercommunications.info/section/2.7/Vail-Joins-the-Bell-Telephone-Company-1878-1887

Hjelmgaard, K. (2016, April 23). The "liquidator": He cleaned up after Chernobyl — and is paying the price. *USA TODAY.* https://www.usatoday.com/story/news/world/2016/04/17/liquidator-chernobyl-30th-anniversary/82895730

Höffken, J., & Ramana, M. V. (2024). Nuclear power and environmental injustice. *WIREs Energy and Environment, 13*(1). https://doi.org/10.1002/wene.498

Hofmann, V., Kalluri, P. R., Jurafsky, D., & King, S. (2024). AI generates covertly racist decisions about people based on their dialect. *Nature, 633*(8028), 147–154. https://doi.org/10.1038/s41586-024-07856-5

Hogue, H. B. (2010). *Reorganization of the Minerals Management Service in the aftermath of the Deepwater Horizon oil spill* (R41485). Congressional Research Service. https://www.everycrsreport.com/reports/R41485.html

Holt, M., & Brown, P. (2021). *U.S. nuclear plant shutdowns, state interventions, and policy concerns.* Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R46820/3

Holtec International. (2024). *Small modular reactor.* https://holtecinternational.com/products-and-services/smr

Holzer, H. J. (2022, January 19). Understanding the impact of automation on workers, jobs, and wages. *Brookings.* https://www.brookings.edu/articles/understanding-the-impact-of-automation-on-workers-jobs-and-wages

Hook, M. J., & Banks, B. D. (1993). The Indian Mineral Development Act of 1982. *Natural Resources & Environment, 7*(4), 11–54. https://www.jstor.org/stable/40923244

Howland, E. (2025, June 11). *Talen to sell Amazon 1.9 GW from Susquehanna nuclear plant.* Utility Dive. https://www.utilitydive.com/news/talen-amazon-aws-susquehanna-nuclear-data-centert/750440

Howlett, C., & Lawrence, R. (2019). Accumulating minerals and dispossessing Indigenous Australians: Native title recognition as settler-colonialism. *Antipode, 51*(3), 818–837. https://doi.org/10.1111/anti.12516

Hu, S. (2024, June 12). *The Dakota Access Pipeline: What you need to know.* Natural Resources Defense Council (NRDC). https://www.nrdc.org/stories/dakota-access-pipeline-what-you-need-know

Hultman, N., & Koomey, J. (2013). Three Mile Island: The driver of US nuclear power's decline? *Bulletin of the Atomic Scientists, 69*(3). https://doi.org/10.1177/0096340213485949

Humphries, R. (2024, February 5). *Fact Sheet: Nuclear Energy Technologies.* Center for Arms Control and Non-Proliferation. https://armscontrolcenter.org/fact-sheet-nuclear-energy-technologies

Huron River Watershed Council. (2024, December 5). *Injecting captured carbon under Michigan must be done carefully.* https://www.hrwc.org/ccs-needs-and-risks

Huynh, A. (2021, September 9). Atlanta mayor Bottoms says forested land only option for public safety training center. The *Atlanta Journal-Constitution.* https://www.ajc.com/news/atlanta-mayor-bottoms-says-forested-land-only-option-for-public-safety-training-center/LMYFNLZQRRE4ZGDFQDTHIIPDYA

Idaho National Laboratory. (n.d.). Microreactors. Idaho National Laboratory. Retrieved December 13, 2024, from https://inl.gov/trending-topics/microreactors/

Igoe, K. (2025, April 17). *The geopolitical complexities of nuclear development in developing countries.* https://hsph.harvard.edu/exec-ed/news/the-geopolitical-complexities-of-nuclear-development-in-developing-countries/

Indian Mineral Development Act, Pub. L. No. 97–382, 25 U.S.C. (1982). https://uscode.house.gov/view.xhtml?path=/prelim@title25/chapter23&edition=prelim

Indigenous Peoples Burning Network. (n.d.). Indigenous Peoples Burning Network. Fire Networks. Retrieved November 25, 2024, from https://firenetworks.org/ipbn

International Atomic Energy Agency. (n.d.-a). *50 Years of nuclear energy.* https://www.iaea.org/sites/default/files/gc/gc48inf-4-att3_en.pdf

International Atomic Energy Agency. (n.d.-b). *Integrated nuclear infrastructure review.* Retrieved October 22, 2024, from https://www.iaea.org/sites/default/files/20/06/integrated-nuclear-infrastructure-review.pdf

International Atomic Energy Agency. (n.d.-c). *Nuclear installations.* Retrieved November 8, 2024, from https://www.iaea.org/topics/nuclear-installations

International Atomic Energy Agency. (1964). The Geneva Conference—How it began. *IAEA Bulletin.* (Vols. 6–3). https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull6-3/06305100303.pdf

International Atomic Energy Agency. (1999). *Near surface disposal of radioactive waste* (Safety Standards Series No. WS-R-1, p. 28). https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1073_web.pdf

International Atomic Energy Agency. (2002). *Management of radioactive waste from the mining and milling of ores* (Safety Standards Series No. WS-G-1.2, p. 39). https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1134_scr.pdf

International Atomic Energy Agency. (2003). *Occupation radiation protection: Protecting workers against exposure to ionizing radiation* (No. STI/PUB/1145; p. 515). https://www.iaea.org/publications/6698/occupational-radiation-protection-protecting-workers-against-exposure-to-ionizing-radiation

International Atomic Energy Agency. (2006). *Authorization of nuclear power plant control room personnel: Methods and practices with emphasis on the use of simulators.* IAEA. https://www-pub.iaea.org/MTCD/Publications/PDF/te_1502_web.pdf

International Atomic Energy Agency. (2010). *Best practice in environmental management of uranium mining* (No. NF-T-1.2; p. 37). https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1406_web.pdf

International Atomic Energy Agency. (2013). *Nuclear reactor technology assessment for near term deployment* (Nuclear Energy Series No. NP-T-1.10, pp. 1–94). https://www.iaea.org/publications/8950/nuclear-reactor-technology-assessment-for-near-term-deployment

International Atomic Energy Agency. (2016, September 8). *IAEA mission says China's nuclear regulator effective; should continue to enhance safety programme.* https://www.iaea.org/newscenter/pressreleases/iaea-mission-says-chinas-nuclear-regulator-effective-should-continue-to-enhance-safety-programme

International Atomic Energy Agency. (2018). *Occupational radiation protection* (Safety Standards General Safety Guide No. GSG-7, p. 335). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1785_web.pdf

International Atomic Energy Agency. (2022a). *Artificial intelligence for accelerating nuclear applications, science and technology* (pp. 1–98) [Text]. https://www.iaea.org/publications/15198/artificial-intelligence-for-accelerating-nuclear-applications-science-and-technology

International Atomic Energy Agency. (2022b). *Recruitment, qualification and training of personnel for nuclear power plants* (IAEA Safety Standards). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB2029_web.pdf

International Atomic Energy Agency. (2024a). *Incident and trafficking database (ITDB).* https://data.iaea.org/dataset/incident-and-trafficking-database-itdb

International Atomic Energy Agency. (2024b). Milestones in the Development of a National Infrastructure for Nuclear Power (Text No. STI/PUB/2073). IAEA. https://doi.org/10.61092/iaea.zjau-e8cs

International Atomic Energy Agency. (2024c). Nuclear harmonization and standardization initiative (NHSI). https://nucleus.iaea.org/sites/smr/SitePages/Nuclear-Harmonization-and-Standardization-Initiative.aspx

International Atomic Energy Agency. (2024d). Small modular reactors: Advances in SMR developments 2024. In Small Modular Reactors: Advances in SMR Developments 2024 (pp. 1–48). https://www-pub.iaea.org/MTCD/Publications/PDF/p15790-PUB9062_web.pdf

International Atomic Energy Agency. (2024e, June 27). IAEA DG Grossi to World Bank: Global consensus calls for nuclear expansion, this needs financial support. https://www.iaea.org/newscenter/news/iaea-dg-grossi-to-world-bank-global-consensus-calls-for-nuclear-expansion-this-needs-financial-support

International Atomic Energy Agency. (2025, August 4). *IAEA expands global initiative to boost knowledge of small modular reactors.* http://www.iaea.org/newscenter/news/iaea-expands-global-initiative-to-boost-knowledge-of-small-modular-reactors

International Atomic Energy Agency Power Reactor Information System. (2024). *Nuclear share of electricity generation in 2023.* https://pris.iaea.org/pris/worldstatistics/nuclearshareofelectricitygeneration.aspx

International Campaign to Abolish Nuclear Weapons. (2023, December 8). *Nuclear tensions keep rising on Korean Peninsula.* https://www.icanw.org/nuclear_tensions_rise_on_korean_peninsula

International Energy Agency. (n.d.). *Policy developments: Global EV outlook 2023.* IEA. Retrieved January 6, 2025, from https://www.iea.org/reports/global-ev-outlook-2023/policy-developments

International Energy Agency. (2019). *Nuclear power in a clean energy system.* IEA. https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

International Energy Agency. (2022a). Executive summary. In *Direct air capture: A key technology for net zero.* IEA. https://www.iea.org/reports/direct-air-capture-2022

International Energy Agency. (2022b). *World Energy Outlook 2022.* IEA. https://www.iea.org/reports/world-energy-outlook-2022

International Energy Agency. (2022c, June 23). *"France 2030 investment plan"- Small modular reactor investment.* IEA. https://www.iea.org/policies/15028-france-2030-investment-plan-small-modular-reactor-investment

International Energy Agency. (2024a). Executive Summary. In *Electricity 2024: Analysis and forecast to 2026.* IEA. https://www.iea.org/reports/electricity-2024/executive-summary

International Energy Agency. (2024b). *Trends in electric cars – Global EV outlook 2024 – analysis.* IEA. https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars

International Labour Organization. (2023, June 1). *Zaporizhzhia nuclear power plant workers subjected to forced labour by Russian forces, say trade unions.* https://www.ilo.org/resource/news/zaporizhzhia-nuclear-power-plant-workers-subjected-forced-labour-russian

International Panel on Fissile Materials. (2011, April 20). *Rosatom confirms it will not bring foreign-origin spent fuel to Russia.* IPFM Blog. https://fissilematerials.org/blog/2011/04/rosatom_confirms_it_will_.html

Jack, V. (2024, February 20). Romania bets on long shot 'baby nukes' as coal cliff edge looms. *Politico.* https://www.politico.eu/article/romania-long-shot-baby-nukes-coal-cliff-edge-looms

Jackson, L. (2014, November 19). Cesspools and sewers: Toilets in dirty old London. *Yale University Press.* https://yalebooks.yale.edu/2014/11/19/cesspools-and-sewers-toilets-in-dirty-old-london

Jacobs, J., & Jantarasami, L. (2023). *Can advanced nuclear repower coal country?* Bipartisan Policy Center. https://bipartisanpolicy.org/report/nuclear-repower-in-coal-country

Jacobs, M. D. (2006). *Indian boarding schools in comparative perspective: The removal of Indigenous children in the United States and Australia, 1880-1940.* University of Nebraska Faculty Publications, Department of History. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1019&context=historyfacpub

Jacoby, M. (2020, March 30). As nuclear waste piles up, scientists seek the best long-term storage solutions. *C&EN.* https://cen.acs.org/environment/pollution/nuclear-waste-pilesscientists-seek-best/98/i12

Jain, M., Kumar, D., Chaudhary, J., Kumar, S., Sharma, S., & Singh Verma, A. (2023). Review on E-waste management and its impact on the environment and society. *Waste Management Bulletin, 1*(3), 34–44. https://doi.org/10.1016/j.wmb.2023.06.004

Jasper, J. M. (1990). Nuclear politics: Energy and the state in the United States, Sweden, and France [Monograph]. *Princeton Legacy Library Series 1126.* Princeton University Press. https://doi.org/10.2307/j.ctt7zv8c6

Jayarajan, N., & Piotukh, V. (2023). Regulating innovative reactor designs. *IAEA Bulletin, 64*(3). https://www.iaea.org/bulletin/regulating-innovative-reactor-designs

Jayarajan, N., & Piotukh, V. (2023). Regulating innovative reactor designs. In *Nuclear innovations for net zero* (Vol. 64). IAEA Bulletin. https://www.iaea.org/bulletin/regulating-innovative-reactor-designs

Jennetta, A., & Vorotnikov, V. (2025, October 1). *Biden administration imposes fresh sanctions on top Russian nuclear company executives. S&P Global Commodity Insights.* https://www.spglobal.com/commodity-insights/en/news-research/latest-news/electric-power/011025-biden-administration-imposes-fresh-sanctions-on-top-russian-nuclear-company-executives

Jennings, T. (2014, July 7). *Remembering the largest radioactive spill in U.S. history.* New Mexico In Depth. https://nmindepth.com/2014/remembering-the-largest-radioactive-spill-in-u-s-history

Jerez, B., Garcés, I., & Torres, R. (2021). Lithium extractivism and water injustices in the Salar de Atacama, Chile: The colonial shadow of green electromobility. *Political Geography, 87,* 102382. https://doi.org/10.1016/j.polgeo.2021.102382

Jessel, S., Sawyer, S., & Hernández, D. (2019). Energy, poverty, and health in climate change: A comprehensive review of an emerging literature. *Frontiers in Public Health, 7.* https://doi.org/10.3389/fpubh.2019.00357

Jessen, T. D., Ban, N. C., Claxton, N. X., & Darimont, C. T. (2021). Contributions of Indigenous knowledge to ecological and evolutionary understanding. *Frontiers in Ecology and the Environment, 20*(2), 93–101. https://doi.org/10.1002/fee.2435

Jiao, H., Ali, S. S., Alsharbaty, M. H. M., Elsamahy, T., Abdelkarim, E., Schagerl, M., Al-Tohamy, R., & Sun, J. (2024). A critical review on plastic waste life cycle assessment and management: Challenges, research gaps, and future perspectives. *Ecotoxicology and Environmental Safety, 271.* https://doi.org/10.1016/j.ecoenv.2024.115942

John, D. A., & Babu, G. R. (2021). Lessons from the aftermaths of Green Revolution on food system and health. *Frontiers in Sustainable Food Systems, 5,* 644559. https://doi.org/10.3389/fsufs.2021.644559

Johnson, S., & Russo, J. (2024, May 6). *China continues rapid growth of nuclear power capacity.* U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=61927

Johnson-Zafiris, M. (2024, March 9). Akwesasne and the history of hydropower. *Science for the People Magazine.* https://magazine.scienceforthepeople.org/online/akwesasne-and-the-history-of-hydropower

Jones, A. (2024, November 29). Ignace, Ontario is selected as location for nuclear waste underground repository. *Canada's National Observer.* https://www.nationalobserver.com/2024/11/29/news/ignace-ontario-location-nuclear-waste-underground-repository

Juskus, R. (2023). Sacrifice zones: A genealogy and analysis of an environmental justice concept. *Environmental Humanities,* 15(1), 3–24. https://doi.org/10.1215/22011919-10216129

Karas, D. (2015). Highway to inequity: The disparate impact of the interstate highway system on poor and minority communities in American cities. *New Visions for Public Affairs, 7.* https://www.ce.washington.edu/files/pdfs/about/Highway-to-inequity.pdf

Karma, R. (2024, May 26). Nuclear energy's bottom line. *The Atlantic.* https://www.theatlantic.com/ideas/archive/2024/05/nuclear-power-climate-change/678483

Kaunda, R. B. (2020). Potential environmental impacts of lithium mining. *Journal of Energy & Natural Resources Law, 38*(3), 237–244. https://doi.org/10.1080/02646811.2020.1754596

Kavi, A. (2024, July 31). Nearly 1,000 Native children died at boarding schools, Interior Dept. Finds. *The New York Times.* https://www.nytimes.com/2024/07/30/us/politics/native-american-boarding-schools.html

Kazakhstan: Authorities identify 21 safety violations in uranium mine & impose fine on co. (2022, September 15). *Atomic Energy.* Retrieved from https://www.business-humanrights.org/en/latest-news/kazakhstan-authorities-identify-21-violations-of-safety-measures-in-uranium-extraction

Keith, T. (2023). *Biden creates a new national monument near the Grand Canyon.* NPR. https://www.npr.org/2023/08/08/1192622716/biden-national-monument-grand-canyon-arizona

Keller, E. F. (1982). Feminism and science. *Signs, 7*(3), 589–602. https://doi.org/10.1086/493901

Kent, D. H. (1973). The Erie war of the gauges. *Journal of Erie Studies, 2*(2), 1–24. https://journals.psu.edu/eriestudies/article/view/33

Khan, A. (2021, February 7). *What is 'vaccine nationalism' and why is it so harmful?* Al Jazeera. https://www.aljazeera.com/features/2021/2/7/what-is-vaccine-nationalism-and-why-is-it-so-harmful

Khandelwal, M., Hill, M. E., Greenough, P., Anthony, J., Quill, M., Linderman, M., & Udaykumar, H. S. (2017). Why have improved cook-stove initiatives in India failed? *World Development, 92*, 13–27. https://doi.org/10.1016/j.worlddev.2016.11.006

Khatatbeh, M., Alzoubi, K., Khabour, O., & Al-Delaimy, W. (2020). Adverse health impacts of living near an oil refinery in Jordan. *Environmental Health Insights, 14.* https://doi.org/10.1177/1178630220985794

Khatib, H., & Difiglio, C. (2016). Economics of nuclear and renewables. *Energy Policy, 96,* 740–750. https://doi.org/10.1016/j.enpol.2016.04.013

Kim, L. (2023). *Nuclear belt and road and U.S.-South Korea nuclear cooperation.* Center for Strategic and International Studies. https://www.csis.org/analysis/nuclear-belt-and-road-and-us-south-korea-nuclear-cooperation

Kim, T., Boing, L., Halsey, W., & Dixon, B. (2022). *Nuclear waste attributes of SMRs scheduled for near-term deployment* (No. ANL/NSE-22/98 Rev. 1). https://doi.org/10.2172/1900154

King, C. (2023, August 21). *'Stop Cop City' activists delay plan to turn in over 100K signatures.* FOX 5 Atlanta. https://www.fox5atlanta.com/news/cop-city-activists-signatures-referendum-ballot-update

King, M., Huntzinger, L., & Nguyen, T. (2011). *Feasibility of nuclear power on U.S. military installations* (No. CRM D0023932.A5/2REV; p. 98). Center for Naval Analyses. https://www.cna.org/analyses/2011/feasibility-of-nuclear-power-on-us-military-installations

Kitroeff, N., Gelles, D., & Nicas, J. (2019, July 27). The roots of Boeing's 737 Max crisis: A regulator relaxes its oversight. *The New York Times.* https://www.nytimes.com/2019/07/27/business/boeing-737-max-faa.html

Kline, R., & Pinch, T. (1996). Users as agents of technological change: The social construction of the automobile in the rural United States. *Technology and Culture, 37*(4), 763–795. https://doi.org/10.2307/3107097

Koenig, D. (2020, August 8). *FAA employees who oversee airplane makers report pressure.* AP News. https://apnews.com/article/375d176efcd5ccee5864bb9cdfe705c2

Kozak, D. (2013, April 1). *In Romania: Cleaning up and moving on.* World Bank. https://www.worldbank.org/en/results/2013/04/01/in-romania-cleaning-up-and-moving-on

Kozeracki, J., Vlahoplus, C., Erwin, K., Propp, A., Razdan, S., Auguste, R., Stuhldreher, T., Walrond, C., Bates, M., Bickford, E., & et al. (2024). *Pathways to commercial liftoff: Advanced nuclear.* U.S. Department of Energy. Retrieved June 19, 2025, from https://web.archive.org/web/20250206065309/http://liftoff.energy.gov/wp-content/uploads/2024/10/LIFTOFF_DOE_AdvNuclear-vX7.pdf

Krall, L. M., Macfarlane, A. M., & Ewing, R. C. (2022). Nuclear waste from small modular reactors. *Proceedings of the National Academy of Sciences, 119*(23). https://doi.org/10.1073/pnas.2111833119

Kramer, A. E. (2025, September 29). Danger and intrigue hang over power cut at Russian-held nuclear plant. *The New York Times.* https://www.nytimes.com/2025/09/29/world/europe/zaporizhzhia-nuclear-power-plant-russia-ukraine.html

Krauss, C., & Fountain, H. (2011, March 23). Report on oil spill pinpoints failure of blowout preventer. *The New York Times.* https://www.nytimes.com/2011/03/24/us/24spill.html

Kreider, M. R., Higuera, P. E., Parks, S. A., Rice, W. L., White, N., & Larson, A. J. (2024). Fire suppression makes wildfires more severe and accentuates impacts of climate change and fuel accumulation. *Nature Communications, 15*(1), 2412. https://doi.org/10.1038/s41467-024-46702-0

Kriech, A. J., & Osborn, L. V. (2022). Review of the impact of stormwater and leaching from pavements on the environment. *Journal of Environmental Management, 319.* https://doi.org/10.1016/j.jenvman.2022.115687

Krige, J. (2006). Atoms for peace, scientific internationalism, and scientific intelligence. *Osiris, 21*(1), 161–181. https://doi.org/10.1086/507140

Krikorian, S. (2019, September 4). France's efficiency in the nuclear fuel cycle: What can "oui" learn? *IAEA Bulletin, 60*(2). https://www.iaea.org/newscenter/newsances-efficiency-in-the-nuclear-fuel-cycle-what-can-oui-learn

Krisher, T. (2020, September 16). *Panel's report blasts Boeing, FAA for crashes, seeks reforms.* AP News. https://apnews.com/article/transportation-b5ea783d264186697388c599176cb9bd

Krook, L., & Maylin, G. A. (1979). Industrial fluoride pollution. Chronic fluoride poisoning in Cornwall Island cattle. *The Cornell Veterinarian, 69 Suppl 8,* suppl 1-70. https://pubmed.ncbi.nlm.nih.gov/467082

KTNV Las Vegas. (2023, September 4). *Exposing the deep roots of the fight over Yucca Mountain.* KTNV Las Vegas. https://www.ktnv.com/news/the-deep-roots-of-the-yucca-mountain-nuclear-waste-fight-and-why-it-continues-to-this-day

Kumar, P., Lorek, T., Olsson, T. C., Sackley, N., Schmalzer, S., & Laveaga, G. S. (2017). Roundtable: New narratives of the Green Revolution. *Agricultural History, 91*(3), 397–422. https://doi.org/10.3098/ah.2017.091.3.397

Kurmelovs, R. (2022, November 10). *How Australia became the world's greatest lithium supplier.* BBC. https://www.bbc.com/future/article/20221110-how-australia-became-the-worlds-greatest-lithium-supplier

Kurokawa, K., & Meshkati, N. (2021, March 5). *10 years after Fukushima, safety is still nuclear power's greatest challenge.* The Conversation. http://theconversation.com/10-years-after-fukushima-safety-is-still-nuclear-powers-greatest-challenge-155541

Kuzemko, C., Blondeel, M., Dupont, C., & Brisbois, M. C. (2022). Russia's war on Ukraine, European energy policy responses & implications for sustainable transformations. *Energy Research & Social Science, 93,* Article 102842. https://doi.org/10.1016/j.erss.2022.102842

LaBelle, M., Bucată, R., & Stojilovska, A. (2021). Radical energy justice: A Green Deal for Romanian coal miners? *Journal of Environmental Policy & Planning, 25*(2), 142–154. https://doi.org/10.1080/1523908X.2021.1992266

Laka Documentation and Research Centre on Nuclear Energy. (n.d.). *Nuclear and radiological incidents: United States of America.* Retrieved October 22, 2024, from https://www.laka.org/docu/ines/location/north-america/united-states-of-america

Lakhani, N., & Beaumont, H. (2024, September 27). *'Fear and intimidation': How peaceful anti-pipeline protesters were hit with criminal and civil charges.* The Guardian. https://www.theguardian.com/us-news/2024/sep/27/mountain-valley-pipeline-protest

Lakhani, N. (2020, April 19). *'We've been abandoned': A decade later, Deepwater Horizon still haunts Mexico.* The Guardian. https://www.theguardian.com/us-news/2020/apr/19/deepwater-horizon-mexico-10-years-on

Lakhani, N. (2022, February 22). *US Supreme Court rejects Dakota Access pipeline appeal.* The Guardian. https://www.theguardian.com/us-news/2022/feb/22/us-supreme-court-dakota-access-pipeline

Lang, K.-O., & Westphal, K. (2017). Nord Stream 2: A political and economic contextualisation. *Stiftung Wissenschaft Und Politik (SWP) [German Institute for International and Security Affairs].* https://nbn-resolving.org/urn:nbn:de:0168-ssoar-51318-5

Langdale, J. V. (1978). The growth of long-distance telephony in the Bell System: 1875–1907. *Journal of Historical Geography, 4*(2), 145–159. https://doi.org/10.1016/0305-7488(78)90185-8

Larkin, B. (2013). The politics and poetics of infrastructure. *Annual Review of Anthropology, 42,* 327–343. https://doi.org/10.1146/annurev-anthro-092412-155522

Larson, A. (2022, December 7). Small modular reactors aren't difficult nuclear waste generators. *POWER.* https://www.powermag.com/small-modular-reactors-arent-difficult-nuclear-waste-generators

Larson, A. (2023, December 7). Impressive milestones achieved on Chinese advanced nuclear power projects. *POWER.* https://www.powermag.com/impressive-milestones-achieved-on-chinese-advanced-nuclear-power-projects

Lasar, M. (2011, September 1). How AT&T conquered the 20th century. *Ars Technica.* https://arstechnica.com/tech-policy/2011/09/how-att-conquered-the-20th-centur

Lee, Y., Cho, J., Sohn, J., & Kim, C. (2023). Health effects of microplastic exposures: Current issues and perspectives in South Korea. *Yonsei Medical Journal, 64*(5), 301–308. https://doi.org/10.3349/ymj.2023.0048

Lee Kleinman, D., Powell, M., Grice, J., Adrian, J., & Lobes, C. (2007). A toolkit for democratizing science and technology policy: The practical mechanics of organizing a consensus conference. *Bulletin of Science, Technology & Society, 27*(2), 154–169. https://doi.org/10.1177/0270467606298331

Legal Defense Fund. (n.d.). *Cop City and public safety in Atlanta FAQ.* Retrieved December 19, 2024, from https://www.naacpldf.org/case-issue/cop-city-faq

Leong, N. (2013). Racial capitalism. *Harvard Law Review, 126*(8), 2152–2225. https://harvardlawreview.org/print/vol-126/racial-capitalism

Le Renard, C. (2018). The Superphénix Fast Breeder nuclear reactor: Cross-border cooperation and controversies. *Journal for the History of Environment and Society, 3,* 107–144. https://doi.org/10.1484/J.JHES.5.116796

Lerner, S. (2006). *Diamond: A struggle for environmental justice in Louisiana's chemical corridor.* MIT Press. https://mitpress.mit.edu/9780262622042/diamond

Lerner, S. (2010). *Sacrifice zones: The front lines of toxic chemical exposure in the United States.* The MIT Press. https://doi.org/10.7551/mitpress/8157.001.0001

Leroy, D., Bocco, G., & Barrasa García, S. (2022). Smallholder farmers' perceptions of and adaptations to water scarcity in an irrigated system in Chiapas, Mexico. *International Journal of Water Resources Development, 39*(5), 773–795. https://doi.org/10.1080/07900627.2022.2142203

Levin, S. (2017, January 18). *Dakota Access pipeline activists say police have used "excessive" force.* The Guardian. https://www.theguardian.com/us-news/2017/jan/18/dakota-access-pipeline-protesters-police-used-excessive-force

Levitt, Z., Parshina-Kottas, Y., Romero, S., & Wallace, T. (2023, August 30). Native American boarding schools took children's culture, and hundreds died. *The New York Times.* https://www.nytimes.com/interactive/2023/08/30/us/native-american-boarding-schools.html

Lewek, J. (2024, September 9). CADENA's disaster relief, resilience-building, and preparedness in Chiapas and beyond. *CAF America.* https://cafamerica.org/blog/cadenas-disaster-relief-resilience-building-and-preparedness-in-chiapas-and-beyond

Lewis, C. (2022). *Connecting America: The century-long journey to the modern highway system* [Indiana University]. https://search.proquest.com/openview/e6b35b3cbcd1edc68696c152e8d5592c/1?pq-origsite=gscholar&cbl=18750&diss

Lewis, J. A. (2022, April 19). *Technology and the shifting balance of power.* Center for Strategic and International Studies. https://www.csis.org/analysis/technology-and-shifting-balance-power

Leyton-Flor, S. A., & Sangha, K. (2024). The socio-ecological impacts of mining on the well-being of Indigenous Australians: A systematic review. *The Extractive Industries and Society, 17,* 101429. https://doi.org/10.1016/j.exis.2024.101429

Lieffers, C. (2018, April 18). *How the Panama Canal took a huge toll on the contract workers who built it.* Smithsonian. https://www.smithsonianmag.com/history/how-panama-canal-took-huge-toll-on-contract-workers-who-built-it-180968822/

Liou, J. (2023, September 13). *What are small modular reactors (SMRs)?* International Atomic Energy Agency. https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs

Liou, J. (2023). Decommissioning by Design: How Advanced Reactors are Designed with Disposal in Mind. *IAEA Bulletin: Nuclear Decommissioning, 64*(1). http://www.iaea.org/bulletin/decommissioning-by-design-how-advanced-reactors-are-designed-with-disposal-in-mind

Liou, J. (2024). Large reactors poised to lead the nuclear power expansion as small modular reactors advance. *IAEA Bulletin 65* (3). https://www.iaea.org/bulletin/large-reactors-poised-to-lead-the-nuclear-power-expansion-as-small-modular-reactors-advance

Lipton, E. (2023, February 4). The Pentagon saw a warship boondoggle. Congress saw jobs. *The New York Times.* https://www.nytimes.com/2023/02/04/us/politics/littoral-combat-ships-lobbying.html

Liu, C., & Fan, W. (2023, September 5). Developing countries look to China in push for smaller nuclear reactors. *Global Times.* https://www.globaltimes.cn/page/202309/1297624.shtml

Long, N. E. (1937). Public relation policies of the Bell System. P*ublic Opinion Quarterly, 1*(4), 5–22. https://doi.org/10.1086/265119

Lopes Ramos, A. (n.d.). *A brief history of the kitchen: How heat and food bring people together.* John Desmond Limited. Retrieved March 27, 2025, from https://www.johndesmond.com/blog/design/a-brief-history-of-the-kitchen

Lopez, G. (2015, December 1). *The Reagan administration's unbelievable response to the HIV/AIDS epidemic.* Vox. https://www.vox.com/2015/12/1/9828348/ronald-reagan-hiv-aids

Lopez, O., & Jacobs, A. (2018, July 14). In town with little water, Coca-Cola is everywhere. So is diabetes. *The New York Times.* https://www.nytimes.com/2018/07/14/world/americas/mexico-coca-cola-diabetes.html

Lovejoy, J., & Anderson, J. (2024). *Environmental Impact Statement for Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU)* (No. DOE/EIS-0559). U.S. Department of Energy. https://www.energy.gov/nepa/doeeis-0559-activities-support-commercial-production-high-assay-low-enriched-uranium-haleu

Lovering, J., & Baker, S. (2021, May 24). Can nuclear power go local? *Issues in Science and Technology.* https://issues.org/nuclear-power-local-democratic-progressive-lovering-hobbs-baker

Lowenstein, J. D. (2017). Standing Rock Sioux Tribe v. U.S. Army Corps of Engineers. *Public Land and Resource Law Review, 0.* https://scholarworks.umt.edu/plrlr/vol0/iss7/19

Lozano, G. (2019, July 25). Ecuador's China-backed hydropower revolution. *Dialogue Earth.* https://dialogue.earth/en/energy/29133-ecuadors-china-backed-hydropower-revolution

Ludwig, M. (2024, December 27). *Gas exports and AI boom poised to spike energy prices for consumers under Trump.* Truthout. https://truthout.org/articles/gas-exports-and-ai-boom-poised-to-spike-energy-prices-for-consumers-under-trump

Luongo, K. (2024, February 23). *Where the U.S. government is funding nuclear export.* Partnership for Global Security. https://partnershipforglobalsecurity.org/where-the-u-s-government-is-funding-nuclear-export/

Lyman, E. (2024, February 28). Conflicts of interest surrounding nuclear laws could undermine US safety. *The Hill.* https://thehill.com/opinion/energy-environment/4491530-conflicts-of-interest-surrounding-nuclear-laws-could-undermine-us-safety

MacArthur, J. B. (2020). Cost savings versus redundant systems: The case of the Boeing 737 MAX debacle. *Journal of Business and Accounting, 13*(1), 4–22. https://asbbs.org/files/2020/JBA_Vol_13.1_Fall_2020.pdf

MacDougall, R. (2006). Long lines: AT&T's long-distance network as an organizational and political strategy. *Business History Review, 80*(2), 297–327. https://doi.org/10.1017/S0007680500035509

Macherey, O., & Carlyon, R. P. (2014). Cochlear implants. *Current Biology, 24*(18), R878–R884. https://doi.org/10.1016/j.cub.2014.06.053

Madianou, M. (2025). *Technocolonialism: When technology for good is harmful.* https://www.politybooks.com/bookdetail?book_slug=technocolonialism-when-technology-for-good-is-harmful--9781509559022

Mahajan, A. (2024). Highways and segregation. *Journal of Urban Economics, 141,* 103574. https://doi.org/10.1016/j.jue.2023.103574

Mahjour, S. K., & Faroughi, S. A. (2023). Risks and uncertainties in carbon capture, transport, and storage projects: A comprehensive review. *Gas Science and Engineering, 119,* 205117. https://doi.org/10.1016/j.jgsce.2023.205117

Malin, S. A. (2015). *The price of nuclear power: Uranium communities and environmental justice.* Rutgers University Press. https://muse.jhu.edu/pub/176/monograph/book/41976

Mally Dean, K. (2022, December 1). *Chicago pile 1: A bold nuclear physics experiment with enduring impact.* Argonne National Laboratory. https://www.anl.gov/article/chicago-pile-1-a-bold-nuclear-physics-experiment-with-enduring-impact

Mandelbaum, M. (1984). The anti-nuclear weapons movements. *PS: Political Science & Politics, 17*(1), 24–32. https://doi.org/10.2307/419117

Mann, A. (2017, June). What's up with that: Building bigger roads actually makes traffic worse. *Wired.* https://www.wired.com/2014/06/wuwt-traffic-induced-demand

Maré, M., & M'rithaa, M. K. (2018). Advancing a clean cookstove culture in sub Saharan Africa: The transformative power of Afrikan innovation. *Machakos University Journal of Science and Technology, 1*(1). https://mksujournals.mksu.ac.ke/advancing-a-clean-cookstove-culture-in-sub-saharan-africa/

Marine Mammal Commission. (2015, November 25). *Deepwater Horizon oil spill in the Gulf of Mexico.* https://www.mmc.gov/priority-topics/offshore-energy-development-and-marine-mammals/gulf-of-mexico-deepwater-horizon-oil-spill-and-marine-mammals

Martin, K. J. (2012). Traditional responsibility and spiritual relatives: Protection of indigenous rights to land and sacred places. In E. Pulitano (Ed.), *Indigenous Rights in the Age of the UN Declaration.* Cambridge University Press. https://www.cambridge.org/core/books/indigenous-rights-in-the-age-of-the-un-declaration/453DBA362F3F401DAE50F6FAB76E9EF2

Martin, R. (2015, October 16). China details next-gen nuclear reactor program. *MIT Technology Review.* https://www.technologyreview.com/2015/10/16/165755/china-details-next-gen-nuclear-reactor-program

Martucci, B. (2024, October 15). *Google, Kairos Power ink 500-MW advanced nuclear reactor deal.* Utility Dive. https://www.utilitydive.com/news/google-kairos-power-advanced-nuclear-reactor-data-center-electricity-demand-ai/729876

Masters, J. (2023, February 14). *Ukraine: Conflict at the crossroads of Europe and Russia.* Council on Foreign Relations. https://www.cfr.org/backgrounder/ukraine-conflict-crossroads-europe-and-russia

Mathewson, E., & Raphael, T. J. (2016, December 1). *Bismarck residents got the Dakota Access Pipeline moved without a fight.* The World from PRX. https://theworld.org/stories/2016/12/01/bismarck-residents-got-dakota-access-pipeline-moved-without-fight

Mayhew, N. (2024, October 21-25). *Safeguards by design and advanced reactors: Overcoming the catch-22 to implementation.* International Conference on Small Modular Reactors and their Applications, Vienna Austria. https://vcdnp.org/wp-content/uploads/2024/09/VCDNP_SMR-Conference_Safeguards-by-Design-for-SMRs.pdf

Mazzieri, A., & Montanari, A. (2024, March 16). *Surviving the white gold rush – life in South America's 'lithium triangle.'* Al Jazeera. https://www.aljazeera.com/features/longform/2024/3/16/surviving-the-white-gold-rush-life-in-south-americas-lithium-triangle-2

McCarthy, J. (2019, June 28). *Gallup vault: Fear and anxiety during the 1980s AIDS crisis.* Gallup. https://news.gallup.com/vault/259643/gallup-vault-fear-anxiety-during-1980s-aids-crisis.aspx

McCurry, J. (2025, February 11). *'An act of betrayal': Japan to maximise nuclear power 14 years after Fukushima disaster.* The Guardian. https://www.theguardian.com/world/2025/feb/12/japan-nuclear-power-plan-emissions-targets-fukushima

McElheny, V. K. (1973, September 28). Splitting up of A.E.C. urged to reassure public on safety. *The New York Times.* https://www.nytimes.com/1973/09/28/archives/splitting-up-of-a-e-c-urged-to-reassure-public-on-safety-fears-by.html

McGeehan, P. (2018, September 19). Bitcoin miners flock to New York's remote corners, but get chilly reception. *The New York Times.* https://www.nytimes.com/2018/09/19/nyregion/bitcoin-mining-new-york-electricity.html

McGeehan, P. (2018, September 19). Bitcoin miners flock to New York's remote corners, but get chilly reception. *The New York Times.* https://www.nytimes.com/2018/09/19/nyregion/bitcoin-mining-new-york-electricity.html#:~:text=New%20York%20Times-,Bitcoin%20Miners%20Flock%20to%20New%20York's%20Remote%20Corners%2C%20but%20Get,an%20abundance%20of%20cheap%20electricity.

McLeary, P. (2022, July 15). *20 years later, the Navy says its littoral combat ships (kind of) work.* POLITICO. https://www.politico.com/news/2022/07/15/20-years-later-the-navy-says-its-littoral-combat-ships-kind-of-work-00046137

Meduza. (2025, October 2). *Russia's Zaporizhzhia savior scheme: How Moscow could use an ongoing blackout to switch Europe's largest nuclear plant from Ukraine's grid to its own.* https://meduza.io/en/feature/2025/10/02/russia-s-zaporizhzhia-savior-scheme

Melamed, J. (2015). Racial capitalism. *Journal of the Critical Ethnic Studies Association, 1*(1), 76–86. https://go.gale.com/ps/i.do?p=AONE&sw=w&issn=23735031&v=2.1&it=r&id=GALE%7CA436231327&sid=googleScholar&linkaccess=abs

Michaelson, R. (2021, December 31). *'Waste colonialism': World grapples with west's unwanted plastic.* The Guardian. https://www.theguardian.com/environment/2021/dec/31/waste-colonialism-countries-grapple-with-wests-unwanted-plastic

Michelson, E. (2016). *Assessing the societal implications of emerging technologies: Anticipatory governance in practice* (1st ed.). Routledge. https://doi.org/10.4324/9781315648842

Mignolo, W. (2006). Citizenship, knowledge, and the limits of humanity. *American Literary History, 18*(2), 312–331. https://doi.org/10.1093/alh/ajj019

Millard, P., & Kueffner, S. (2025, January 9). *A sinkhole is threatening to consume Ecuador's main source of power.* Bloomberg. https://www.bloomberg.com/features/2025-ecuador-power-sinkhole

Miller, C., Romero-Lankao, P., Hudson, A., Eschrich, J., Wylie, R., Bacigalupi, P., Monoian, E., Ferry, R., Wilson, A., Gilleran, M., Echevarria, A., Divya, S., Rivera-Matos, Y., Sperling, J., Olukotun, D., Keeler, L., Gearhart, C., Gabriele, M., Duvall, A., & Schwab, A. (2021). *Cities of light: A collection of solar futures.* Center for Science and the Imagination, Arizona State University. https://csi.asu.edu/books/cities-of-light

Miller, M., & Scheinman, L. (2003). *Israel, India, and Pakistan: Engaging the non-NPT states in the nonproliferation regime.* Arms Control Association. https://www.armscontrol.org/act/2003-12/features/israel-india-and-pakistan-engaging-non-npt-states-nonproliferation-regime

Mining.com. (2025, September 5). *Uranium demand for nuclear power set to surge nearly 30% by 2030.* https://www.mining.com/uranium-demand-for-nuclear-power-set-to-surge-nearly-30-by-2030-world-nuclear-association

Miri, J. (2024, June 21). Radiation Exposure Compensation Act expires amid debate over eligibility expansion. *AIP.* https://ww2.aip.org/fyi/radiation-exposure-compensation-act-expires-amid-debate-over-eligibility-expansion

MIT Energy Initiative. (2018). *The future of nuclear energy in a carbon-constrained world* (No. 8 in MIT Future Of Series). Massachusetts Institute of Technology. https://energy.mit.edu/research/future-nuclear-energy-carbon-constrained-world

Mohan, R., Jha, D., & Evenson, R. (1973). The Indian agricultural research system. *Economic and Political Weekly, 8*(13), A21–A26.

Mohl, R. A. (2000). Planned destruction: The interstates and central city housing. In J. F. Bauman, R. Biles, & K. M. Szylvian (Eds.), *From tenements to the Taylor Homes: In search of an urban housing policy in twentieth-century America* (pp. 226–245). Penn State University Press. https://www.degruyterbrill.com/document/doi/10.1515/9780271072159-015/html

Moore, T. (2025, June 11). *Mining US uranium: Balancing energy needs and environmental concerns.* National Conference of State Legislatures. https://www.ncsl.org/state-legislatures-news/details/mining-us-uranium-balancing-energy-needs-and-environmental-concerns

Morales, L. (2016, April 10). *For the Navajo Nation, uranium mining's deadly legacy lingers.* NPR. https://www.npr.org/sections/health-shots/2016/04/10/473547227/for-the-navajo-nation-uranium-minings-deadly-legacy-lingers

Moran-Thomas, A. (2020, August 5). How a popular medical device encodes racial bias. *Boston Review.* https://www.bostonreview.net/articles/amy-moran-thomas-pulse-oximeter

Morelli, V., & Danielson, L. (2023, September 22). Deserts, water and lithium: Indigenous rights in the energy transition. *Solar Today*. https://ases.org/lithium

Morgan, D. (2003, July 6). Proposed ship speeds into gathering storm. *The Washington Post*. https://www.washingtonpost.com/archive/politics/2003/07/06/proposed-ship-speeds-into-gathering-storm/ffeb9a9b-66be-4874-b9b1-7bc5cf4db968

Morrison, K. D. (2010). Dharmic projects, imperial reservoirs, and new temples of India: An historical perspective on dams in India. *Conservation and Society, 8*(3), 182. https://doi.org/10.4103/0972-4923.73807

Moseman, A. (2024, November 18). *Amazon vies for nuclear-powered data center.* IEEE Spectrum. https://spectrum.ieee.org/amazon-data-center-nuclear-power

Moving Atlanta Forward. (n.d.). *Atlanta Public Safety Training Center.* Retrieved December 11, 2024, from https://www.atltrainingcenter.com

Mudd, G. M. (2001). Critical review of acid in situ leach uranium mining: 1. USA and Australia. *Environmental Geology, 41*(3), 390–403. https://doi.org/10.1007/s002540100406

Mueller, M. (1997). Universal service and the telecommunications act: *Myth made law. Communications of the ACM, 40*(3), 39–47. https://doi.org/10.1145/245108.245119

Mufson, S. (2017, May 8). Pipeline spill by Dakota Access company could have a 'deadly effect.' *The Washington Post.* https://www.washingtonpost.com/news/energy-environment/wp/2017/05/08/pipeline-spill-by-dakota-access-company-could-have-a-deadly-effect

Murakami, T., & Anbumozhi, V. (Eds.). (2022). *Small modular reactor (SMR) deployment: Advantages and opportunities for ASEAN* (No. 10). Economic Research Institute for ASEA and East Asia. https://www.eria.org/uploads/media/Research-Project-Report/RPR-2022-10/Small-Modular-Reactor-%28SMR%29-Deployment-Advantages-and-Opportunities-for-ASEAN.pdf

Nakhle, C. (2022, March 17). *Are small modular reactors the future of nuclear energy?* Geopolitical Intelligence Services. https://www.gisreportsonline.com/r/small-modular-reactors/

Nathanson, M. (2017, November 22). *Damming or damning the Amazon: Assessing Ecuador / China cooperation.* Mongabay Environmental News. https://news.mongabay.com/2017/11/damming-or-damning-the-amazon-assessing-ecuador-china-cooperation/

National Academies of Sciences, Engineering, and Medicine. (2023). *Laying the foundation for new and advanced nuclear reactors in the United States* (p. 26630). The National Academies Press. https://doi.org/10.17226/26630

National CAPACD, National Urban League, & National Council of La Raza. (2014). *Banking in color new findings on financial access for low-and-moderate income communities.* UnidosUS. https://unidosus.org/publications/1203-banking-in-color-new-findings-on-financial-access-for-low-and-moderate-income-communities

National Center for Disaster Preparedness. (2023). *Reflecting on the racial disparities in Texas power outages.* https://ncdp.columbia.edu/ncdp-perspectives/disaster-response-and-equity-texas-power-outrages

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2011). *Deep water: The Gulf oil disaster and the future of offshore driling.* https://www.govinfo.gov/content/pkg/GPO-OILCOMMISSION/pdf/GPO-OILCOMMISSION.pdf

National Energy Technology Laboratory. (n.d.-a). *Carbon Storage FAQs.* National Energy Technology Laboratory. Retrieved December 8, 2024, from https://netl.doe.gov/carbon-management/carbon-storage/faqs/carbon-storage-faqs

National Energy Technology Laboratory. (n.d.-b)*. Commercial carbon dioxide uses: Carbon dioxide enhanced oil recovery.* National Energy Technology Laboratory. Retrieved August 28, 2023, from https://netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/eor

National Environmental Policy Act of 1969, Pub. L. No. 91–190, 42 U.S.C. (1969). https://uscode.house.gov/statviewer.htm?volume=83&page=852

National High Magnetic Field Laboratory. (n.d.). *Electric range.* Retrieved March 27, 2025, from https://nationalmaglab.org/magnet-academy/history-of-electricity-magnetism/museum/electric-range-1892

National Park Service. (2024, March 18). *Indigenous fire practices shape our land.* https://www.nps.gov/subjects/fire/indigenous-fire-practices-shape-our-land.htm

National Research Council. (1957). *The disposal of radioactive waste on land.* The National Academies Press. https://doi.org/10.17226/10294

National Research Council. (2012). *Uranium Mining in Virginia: Scientific, Technical, Environmental, Human Health and Safety, and Regulatory Aspects of Uranium Mining and Processing in Virginia.* The National Academies Press. https://doi.org/10.17226/13266

Native Knowledge 360°. (n.d.). *Treaties still matter: The Dakota Access Pipeline.* National Museum of the American Indian. Retrieved December 18, 2024, from http://nmai.si.edu/nk360/plains-treaties/dapl.cshtml

Nature India. (2009). Borlaug's unfinished crusade. *Nature India.* https://www.nature.com/articles/nindia.2009.304

Neal, W. H., Bell, M. R. G., Hansen, C. A., & Siegfried II, R. W. (2007). *NPC Global Oil & Gas Study* (Oil and gas technology development,Topic Paper #26). https://dl.icdst.org/pdfs/files/4a08dd5df34211f0aebc514c5b83ec40.pdf

Nelkin, D. (1981). Some social and political dimensions of nuclear power: Examples from Three Mile Island. *The American Political Science Review, 75*(1), 132–142. https://doi.org/10.2307/1962164

Nelkin, D. (Ed.). (1992). *Controversy: Politics of technical decisions* (3rd ed., pp. xxv, 258). Sage Publications, Inc. https://psycnet.apa.org/record/1992-97298-000

New Mexico Political Report. (2024, February 26). *Arizona regulators reject proposal to assist Navajo communities impacted by coal-fired power generation.* http://nmpoliticalreport.com/2024/02/26/arizona-regulators-reject-proposal-to-assist-navajo-communities-impacted-by-coal-fired-power-generation

New York State Office of Information and Technology Services. (2023). *Use of biometric identifying technology in schools.* https://its.ny.gov/system/files/documents/2023/08/biometrics-report-final-2023.pdf

Nicola, S., & Schmitz, S. (2022). Discordant agendas on a just transition in Romanian coal mining areas: The case of the Jiu Valley. *Moravian Geographical Reports, 30*(4), 257–269. https://doi.org/10.2478/mgr-2022-0017

Niehoff, R. O. (1948). Organization and administration of the United States Atomic Energy Commission. *Public Administration Review, 8*(2), 91–102. https://doi.org/10.2307/972379

Nilsen, T. (2025, January 16). Floating nuclear power plant completes first fuel cycle. *The Barents Observer.* https://www.thebarentsobserver.com/news/floating-nuclear-power-plant-completes-first-fuel-cycle/423201

NJ Gov. (2016). *Radium girls—the story of US radium's superfund site* (Preservation Snapshot). NJ Gov. https://www.nj.gov/dep/hpo/1identify/nrsr_19_Mar_Radium_girls.pdf

NO RUSSIA Act of 2022, S. 3978, 117 Cong. (2022). https://www.congress.gov/bill/117th-congress/senate-bill/3978

Nowell, C. (2024, August 6). *'Haul no!': Tribes protest uranium mine trucking ore through Navajo Nation.* The Guardian. https://www.theguardian.com/environment/article/2024/aug/06/uranium-mine-ore-navajo-havasupai-grand-canyon

NTCA–The Rural Broadband Association. (n.d.). *History of rural telecommunications.* Retrieved October 29, 2024, from https://www.ntca.org/ruraliscool/history-rural-telecommunications

Nuclear Business Platform. (2023, August 28). *Breaking free from coal: How SMR technology can be a solution in securing ASEAN's energy independence.* Nuclear Business Platform. https://www.nuclearbusiness-platform.com/media/insights/insights/how-smr-technology-can-be-a-solution-in-securing-aseans-energy-independence

Nuclear Energy Agency. (2009). The *financing of nuclear power plants.* OECD. https://doi.org/10.1787/9789264079229-en

Nuclear Energy Agency. (2014). *Managing environmental and health impacts of uranium mining* (No. 7062). https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/7062-mehium.pdf

Nuclear Energy Agency. (2025). *The NEA small modular reactor dashboard: Second edition.* https://www.oecd-nea.org/jcms/pl_90816/the-nea-small-modular-reactor-dashboard-second-edition

Nuclear Energy Innovation and Modernization Act, Pub. L. No. 115–439, 42 U.S.C. (2019). https://www.congress.gov/bill/115th-congress/senate-bill/512

Nuclear Energy Institute. (2015, June 1). *Safety: The nuclear energy industry's highest priority.* https://www.nei.org/resources/fact-sheets/safety-nuclear-energy-industry-highest-priority

Nuclear Energy Research Advisory Committee. (2002). *Observations on a technology roadmap for generation IV nuclear energy systems: Technical roadmap report.* U.S. Department of Energy. https://www.energy.gov/ne/articles/observations-technology-roadmap-generation-iv-nuclear-energy-systems-technical-roadmap

Nuclear Innovation Alliance. (2021, February 16). *Leading think tanks release strategy for development of advanced nuclear energy in the United States.* https://nuclearinnovationalliance.org/leading-think-tanks-release-strategy-development-advanced-nuclear-energy-united-states

Nuclear Innovation Alliance. (n.d.). *Flexibility of advanced nuclear reactors.* Retrieved October 23, 2024, from https://nuclearinnovationalliance.org/sites/default/files/2021-10/NIA%20Advanced%20Reactor%20Flexibility%20Topical%20Brief.pdf

Nuclear Innovation Alliance. (2024). *Advanced nuclear reactor technology: A primer.* https://nuclearinnovationalliance.org/advanced-nuclear-reactor-technology-primer

Nuclear Newswire. (2025, June 17). *Trump administration begins overhaul of the NRC.* https://www.ans.org/news/2025-06-17/article-7116/trump-nrc-changes

NuScale. (2023, May 31). *NuScale power enhances case for small modular reactor applications in major industrial processes with new steam production estimates.* https://www.nuscalepower.com/press-releases/2023/nuscale-power-enhances-case-for-small-modular-reactor-applications-in-major-industrial-processes-with-new-steam-production-estimates

NYC Stands with Standing Rock. (2016). *Standing Rock syllabus.* NYC Stands with Standing Rock. https://nycstandswithstandingrock.wordpress.com/standingrocksyllabus

Nylander, F. (2020, September 8). *The legacy of colonialism: The shadow of French uranium mines.* African Apocalypse Film. https://africanapocalypsefilm.com/finding-a-way-from-french-uranium-mines-to-harnessing-the-power-of-the-sun/

Obando, S. (2024, September 13). *Phoenix GC breaks ground on $70M data center in Mesa, Arizona.* Construction Dive. https://www.constructiondive.com/news/phoenix-general-contractor-haydon-breaks-ground--data-center-mesa-arizona/727001

Obee, K. (2025, July 11). *Historic expansion of RECA passes in reconciliation bill.* Ploughshares. https://ploughshares.org/article/reca-passes-in-reconciliation-bill

Oe, M., Takebayashi, Y., Sato, H., & Maeda, M. (2021). Mental health consequences of the Three Mile Island, Chernobyl, and Fukushima nuclear disasters: A scoping review. *International Journal of Environmental Research and Public Health, 18*(14). https://doi.org/10.3390/ijerph18147478

Office of the Mayor, City of Atlanta. (2021, January 4). Administrative Order No. 2021-01. https://citycouncil.atlantaga.gov/home/showpublisheddocument/5332

Offshore Technology. (2024, March 8). *Nord Stream 2 pipeline, Russia and Germany.* https://www.offshore-technology.com/projects/nord-stream-2-pipeline

Okerlund, J., Klasky, E., Middha, A., Kim, S., Kleinman, M., & Parthasarathy, S. (2022). *What's in the chatterbox? Large language models, why they matter, and what we should do about them.* Science, Technology, and Public Policy Program, Ford School of Public Policy. https://stpp.fordschool.umich.edu/research/research-report/whats-in-the-chatterbox

Olick, D. (2024, October 16). *Amazon goes nuclear, to invest more than $500 million to develop small modular reactors.* CNBC. https://www.cnbc.com/2024/10/16/amazon-goes-nuclear-investing-more-than-500-million-to-develop-small-module-reactors.html

Omarova, A. (2023, November 8). What a national tragedy says about labor rights in Kazakhstan. *The Diplomat.* https://thediplomat.com/2023/11/a-national-tragedy-and-labor-rights-in-kazakhstan

Organization Designation Authorization Expert Review Panel. (2024). *Section 103 Organization Designation Authorizations (ODA) for Transport Airplanes Expert Panel.* Federal Aviation Administration. https://www.faa.gov/newsroom/Sec103_ExpertPanelReview_Report_Final.pdf

Organization for Economic Co-operation and Development - Nuclear Energy Agency. (2021). *Climate change: Assessment of the vulnerability of nuclear power plants and approaches for their adaptation* (No. NEA No. 7207). Nuclear Technology Development and Economics. https://www.oecd-nea.org/upload/docs/application/pdf/2021-11/nea7207_climate_change_adaptation.pdf

Osofsky, H. J., Osofsky, J. D., & Hansel, T. C. (2011). Deepwater Horizon oil spill: Mental health effects on residents in heavily affected areas. *Disaster Medicine and Public Health Preparedness, 5*(4), 280–286. https://doi.org/10.1001/dmp.2011.85

Ottinger, G. (2009). Buckets of resistance: Standards and the effectiveness of citizen science. *Science Technology & Human Values, 34*(2), 244–270. https://doi.org/10.1177/0162243909337121

Ottinger, G. (2013). *Refining expertise: How responsible engineers subvert environmental justice challenges.* NYU Press. https://nyupress.org/9780814762387/refining-expertise

Owen, J. R., Kemp, D., Lechner, A. M., Harris, J., Zhang, R., & Lèbre, É. (2023). Energy transition minerals and their intersection with land-connected peoples. *Nature Sustainability, 6,* 203–211. https://doi.org/10.1038/s41893-022-00994-6

O'Donovan, C. (2024, October 5). Fighting back against data centers, one small town at a time. *Washington Post.* https://www.washingtonpost.com/technology/2024/10/05/data-center-protest-community-resistance

Padhi, S. K., & Mankotia, R. (2019, October 6). *Why building sewage treatment plants in cities on the Ganga is a challenge.* Down To Earth. https://www.downtoearth.org.in/waste/why-building-sewage-treatment-plants-in-cities-on-the-ganga-is-a-challenge-67120

Paillere, H., & Donovan, J. (2021, March 11). *Nuclear power 10 years after Fukushima: The long road back.* International Atomic Energy Agency. https://www.iaea.org/newscenter/news/nuclear-power-10-years-after-fukushima-the-long-road-back

Palansamy, Y. (2025, February 7). *The growing e-waste crisis in Malaysia: What you need to know and how to act.* Malay Mail. https://www.malaymail.com/news/malaysia/2025/02/07/the-growing-e-waste-crisis-in-malaysia-what-you-need-to-know-and-how-to-act/164970

Palma, J. (2017, June 1). *Ecuador: Comunidad Amazónica denuncia escasez de peces y culpa a la mayor hidroeléctrica construida en el país [Ecuador: Amazonian community denounces fish shortage and blames the largest hydroelectric plant built in the country].* Mongabay. https://es.mongabay.com/2017/06/hidroelectricas-pueblos_indigenas-conflictos-rios-ecuador

Panchana, A. (2025, September 2). *Ecuador drops dam dispute with China, but project remains contentious.* Dialogue Earth. https://dialogue.earth/en/energy/ecuador-drops-dam-dispute-with-china-but-project-remains-contentious/

Pandey, N., de Coninck, H., & Sagar, A. D. (2022). Beyond technology transfer: Innovation cooperation to advance sustainable development in developing countries. *WIREs Energy and Environment, 11*(2). https://doi.org/10.1002/wene.422

Paris Agreement, United Nations Framework Convention on Climate Change, 3156 UNTS 79 (2015). https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en

Park, S., & Ewing, R. C. (2023). US legal and regulatory framework for nuclear waste from present and future reactors and their fuel cycles. *Annual Review of Environment and Resources, 48,* 713–736. https://doi.org/10.1146/annurev-environ-112621-064435

Parrish, W., & Levin, S. (2018, September 20). 'Treating protest as terrorism': US plans crackdown on Keystone XL activists. *The Guardian.* https://www.theguardian.com/environment/2018/sep/20/keystone-pipeline-protest-activism-crackdown-standing-rock

Parthasarathy, S. (2007). *Building genetic medicine: Breast cancer, technology, and the comparative politics of health care.* The MIT Press. https://doi.org/10.7551/mitpress/1686.001.0001

Parthasarathy, S. (2010). Assessing the social impact of direct-to-consumer genetic testing: Understanding sociotechnical architectures. *Genetics in Medicine, 12*(9), 544–547. https://doi.org/10.1097/GIM.0b013e3181e71c70

Patel, P. (2024). The case for nuclear cargo ships. *IEEE Spectrum.* https://spectrum.ieee.org/nuclear-powered-cargo-ship

Patel, R. (2012). The long Green Revolution. *The Journal of Peasant Studies, 40*(1), 1–63. https://doi.org/10.1080/03066150.2012.719224

Patel, S. (2012, April 1). Less-familiar generation III+ reactors make inroads. *POWER.* https://www.powermag.com/less-familiar-generation-iii-reactors-make-inroads

Patel, S. (2022, March 1). Sweden's government approves construction of spent nuclear fuel repository. *POWER.* https://www.powermag.com/swedens-government-approves-construction-of-spent-nuclear-fuel-repository

Patel, S. (2024a, December 2). Trial run at Finland's Onkalo repository sets stage for world's first spent nuclear fuel disposal. *POWER.* https://www.powermag.com/trial-run-at-finlands-onkalo-repository-sets-stage-for-worlds-first-spent-nuclear-fuel-disposal

Patel, S. (2024b, October 14). Google bets big on nuclear: Inks deal with Kairos Power for 500-MW SMR fleet to power data centers. *POWER Magazine.* https://live-powermag.pantheonsite.io/google-bets-big-on-nuclear-inks-deal-with-kairos-power-for-500-mw-smr-fleet-to-power-data-centers

Patel, S. (2024c, December 18). Another big data center win for nuclear: Oklo and Switch sign historic 12 GW deal. *POWER Magazine.* https://www.powermag.com/another-big-data-center-win-for-nuclear-oklo-and-switch-sign-historic-12-gw-deal

Pathak, V. M., Verma, V. K., Rawat, B. S., Kaur, B., Babu, N., Sharma, A., Dewali, S., Yadav, M., Kumari, R., Singh, S., Mohapatra, A., Pandey, V., Rana, N., & Cunill, J. M. (2022). Current status of pesticide effects on environment, human health and it's eco-friendly management as bioremediation: A comprehensive review. *Frontiers in Microbiology, 13.* https://doi.org/10.3389/fmicb.2022.962619

Pawariya, A. (2016, June 22). *Ganga action plan – How poorly planned sewage treatment plants led to overall plan failure.* Swarajyamag. https://swarajyamag.com/politics/ganga-action-plan-how-poorly-planned-sewage-treatment-plants-led-to-overall-plan-failure

Paz Cardona, A. J. (2020a, March 18). *Why did Ecuador's tallest waterfall suddenly disappear?* Mongabay. https://news.mongabay.com/2020/03/why-did-ecuadors-tallest-waterfall-suddenly-disappear

Paz Cardona, A. J. (2020b, August 11). *Ecuador races for emergency infrastructure as river's collapse threatens dam.* Mongabay. https://news.mongabay.com/2020/08/ecuador-races-for-emergency-infrastructure-as-rivers-collapse-threatens-dam

Public Broadcasting Service. (2020a). *Caught up in the war on communism: Norman Borlaug and the "Green Revolution."* PBS American Experience. https://www.pbs.org/wgbh/americanexperience/features/caught-war-on-communism-norman-borlaug-and-green-revolution

Public Broadcasting Service. (2020b, April 3). *The Green Revolution: Norman Borlaug and the race to fight global hunger.* PBS. https://www.pbs.org/wgbh/americanexperience/features/green-revolution-norman-borlaug-race-to-fight-global-hunger

Pécout, A. (2024, June 26). France's first small nuclear reactor project. *Le Monde.* https://www.lemonde.fr/en/economy/article/2024/06/26/france-s-first-small-nuclear-reactor-project_6675728_19.html

Pelcastre, J. (2024, June 28). *China's push into Ecuador.* Diálogo Américas. https://dialogo-americas.com/articles/chinas-push-into-ecuador/

Pellaud, B. (1994). Safeguards in transition: Status, challenges, and opportunities. *IAEA Bulletin, 36*(3). https://www.iaea.org/publications/magazines/bulletin/36-3/safeguards-transition-status-challenges-and-opportunities

Penn, I., & Lipton, E. (2021, May 6). The Lithium gold rush: Inside the race to power electric vehicles. *The New York Times.* https://www.nytimes.com/2021/05/06/business/lithium-mining-race.html

Penn, I., Elliott, R. F., & Rieser, J. (2024, September 30). U.S. ramps up hunt for uranium to end reliance on Russia. *The New York Times.* https://www.nytimes.com/2024/09/30/business/energy-environment/uranium-russia-united-states.html

Perkins, J. H. (1998). Wheat breeding and the exercise of American power, 1940-1970. In J. H. Perkins, *Geopolitics and the Green Revolution.* Oxford University Press. https://doi.org/10.1093/oso/9780195110135.003.0010

Perrons, R. K. (2013). Assessing the damage caused by Deepwater Horizon: Not just another Exxon Valdez. *Marine Pollution Bulletin, 71*(1), 20–22. https://doi.org/10.1016/j.marpolbul.2013.03.016

Phadke, R. (2002). Assessing water scarcity and watershed development in Maharashtra, India: A case study of the Baliraja Memorial Dam. *Science, Technology, & Human Values, 27*(2), 236–261. https://doi.org/10.1177/016224390202700203

Phillips, L. (2011, May 25). Europe divided over nuclear power after Fukushima disaster. *The Guardian.* https://www.theguardian.com/environment/2011/may/25/europe-divided-nuclear-power-fukushima

Pibida, F. (2022, May 6). China's nuclear-powered diplomacy in Argentina. Weekly Asado, *Wilson Center.* https://www.wilsoncenter.org/blog-post/chinas-nuclear-powered-diplomacy-argentina

Picot, W. (2024, February 23). Enhancing nuclear power production with Artificial Intelligence. *IAEA Bulletin.* https://www.iaea.org/bulletin/enhancing-nuclear-power-production-with-artificial-intelligence

Pierson, B. (2023, November 14). *Lawsuit claims UnitedHealth AI wrongfully denies elderly extended care.* Reuters. https://www.reuters.com/legal/lawsuit-claims-unitedhealth-ai-wrongfully-denies-elderly-extended-care-2023-11-14

Plumer, B. (2024, June 11). Nuclear power is hard. A climate-minded billionaire wants to make it easier. *The New York Times.* https://www.nytimes.com/2024/06/11/climate/bill-gates-nuclear-wyoming.html

Plumer, B. (2024, September 20). Three Mile Island plans to reopen as demand for nuclear power grows. *The New York Times.* https://www.nytimes.com/2024/09/20/climate/three-mile-island-reopening.html

Potter, B. (2023, May 1). *Why does nuclear power plant construction cost so much?* Institute for Progress. https://ifp.org/nuclear-power-plant-construction-costs

Prasad, S., Abdulla, A., Morgan, M. G., & Azevedo, I. L. (2015). Nonproliferation improvements and challenges presented by small modular reactors. *Progress in Nuclear Energy, 80,* 102–109. https://doi.org/10.1016/j.pnucene.2014.11.023

Pratt, T. (2023, June 9). Real cost of 'Cop City' under question after Atlanta approves $67m for project. *The Guardian.* https://www.theguardian.com/us-news/2023/jun/09/cop-city-cost-atlanta-city-council

Pratt, T. (2025, September 13). *Prosecutors' 'Cop City' case collapses as judge tosses Rico conspiracy charges.* The Guardian. https://www.theguardian.com/us-news/2025/sep/13/cop-city-case-georgia-prosecutors

Pray, C. E. (1981). The Green Revolution as a case study in transfer of technology. *The Annals of the American Academy of Political and Social Science, 458,* 68–80.

Presidential Commission on the Challenger Space Shuttle Challenger Accident. (1986). Chapter V: The contributing cause of the accident. In *Report to the President By the Presidential Commission On the Space Shuttle Challenger Accident* (pp. 83–120). https://www.nasa.gov/history/rogersrep/v1ch5.htm

Prioleau, T. (2003). *Environmental impact of the petroleum industry.* Hazardous Substance Research Centers/South & Southwest Outreach Program. https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.files/fileID/14522.

Priyashantha, A. K. H., Pratheesh, N., & Pretheeba, P. (2022). E-waste scenario in South-Asia: An emerging risk to environment and public health. *Environmental Analysis, Health and Toxicology, 37*(3). https://doi.org/10.5620/eaht.2022022

Prokip, A. (2020, April 24). Anniversary of Chernobyl finds European nuclear power at a crossroad. *Focus Ukraine, Wilson Center.* https://www.wilsoncenter.org/blog-post/anniversary-chernobyl-finds-european-nuclear-power-crossroad

Pruitt, S. (2020, November 10). *Broken treaties with Native American tribes: Timeline.* History.Com. https://www.history.com/news/native-american-broken-treaties

Pskowski, M. (2017, September 13). *Coca-Cola sucks wells dry in Chiapas, forcing residents to buy water.* Truthout. https://truthout.org/articles/coca-cola-sucks-wells-dry-in-chiapas-forcing-residents-to-buy-water

Puffert, D. J. (2000). The standardization of track gauge on North American railways, 1830-1890. *The Journal of Economic History, 60*(4), 933–960.

Quevenco, R. (2012, September 5). *UAE first "newcomer" In 27 years to start nuclear power plant construction.* International Atomic Energy Agency. https://www.iaea.org/newscenter/news/uae-first-newcomer-27-years-start-nuclear-power-plant-construction

Radde, K. (2023, March 11). *Autopsy reveals anti-'Cop City' activist's hands were raised when shot and killed.* NPR. https://www.npr.org/2023/03/11/1162843992/cop-city-atlanta-activist-autopsy

Radiation Exposure Compensation Act, Pub. L. No. 101–426, 42 U.S.C. (1990). https://www.congress.gov/bill/101st-congress/house-bill/2372/text/rh

Radio Prague International. (1998, January 1). Austrians maintain battle against Temelin. *Radio Prague International.* https://english.radio.cz/austrians-maintain-battle-against-temelin-8046306

Radomski, J. (2024a, April 10). *China, Ecuador and the Coca Codo Sinclair hydroelectric power plant.* Latinoamérica 21. https://latinoamerica21.com/en/china-ecuador-and-the-coca-codo-sinclair-hydroelectric-power-plant

Radomski, J. (2024b, August 21). The ongoing saga of a Chinese infrastructure project in Ecuador. *AULA Blog.* https://aulablog.net/2024/08/21/the-ongoing-saga-of-a-chinese-infrastructure-project-in-ecuador

Radtke, P. (2023, August 13). *Carbon-capture gold rush an 'insult' to locals in emissions-hit Louisiana.* The Guardian. https://www.theguardian.com/environment/2023/aug/13/louisiana-carbon-capture-emissions

Radtke, P. (2025, February 27). *Capturing CO2, sold as climate solution, rebranded as oil industry boost.* Floodlight. https://floodlightnews.org/capturing-co2-sold-as-climate-solution-rebranded-as-oil-industry-boost

Raj, C., Mukherjee, A., Caliskan, A., Anastasopoulos, A., & Zhu, Z. (2024). Breaking bias, building bridges: Evaluation and mitigation of social biases in LLMs via contact hypothesis. *Proceedings of the AAAI/ACM Conference on AI, Ethics, and Society, 7,* 1180–1189. https://doi.org/10.1609/aies.v7i1.31715

Ramana, M. V., & Mian, Z. (2014). One size doesn't fit all: Social priorities and technical conflicts for small modular reactors. *Energy Research & Social Science, 2,* 115–124. https://doi.org/10.1016/j.erss.2014.04.015

Ramana, M. V. (2015, April 27). The forgotten history of small nuclear reactors. *IEEE Spectrum.* https://spectrum.ieee.org/the-forgotten-history-of-small-nuclear-reactors

Rauf, T. (2016). The general framework of IAEA safeguards. In J. L. Black-Branch & D. Fleck (Eds.), *Nuclear Non-Proliferation in International Law: Volume II - Verification and Compliance* (pp. 11–21). T.M.C. Asser Press. https://doi.org/10.1007/978-94-6265-075-6_2

Ravitz, J. (2016, November 1). *The sacred land at the center of the Dakota pipeline fight.* CNN. https://www.cnn.com/2016/11/01/us/standing-rock-sioux-sacred-land-dakota-pipeline/index.html

Redvers, N., Aubrey, P., Celidwen, Y., & Hill, K. (2023). Indigenous Peoples: Traditional knowledges, climate change, and health. *PLOS Global Public Health, 3*(10). https://doi.org/10.1371/journal.pgph.0002474

Reta, M., & Gout, E. (2021, April 28). *Advancing equity through grid modernization.* Center for American Progress. https://www.americanprogress.org/article/advancing-equity-grid-modernization

Rettman, A. (2021, June 7). *Russia threatens to cut Ukraine gas over Donbas war.* EUobserver. https://euobserver.com/eu-and-the-world/ar617cfd0e

Reuters. (2018, February 12). Shell settles state, U.S. clean air violations at Louisiana plant. *Reuters.* https://www.reuters.com/article/business/environment/shell-settles-state-us-clean-air-violations-at-louisiana-plant-idUSKBN1FW2BY

Reuters. (2025, July 9). *Ecuador, Power China agree on process to drop hydroelectric plant arbitration.* https://www.reuters.com/sustainability/climate-energy/ecuador-power-china-agree-process-drop-hydroelectric-plant-arbitration-2025-07-09/

Ricchio, J. (2018). *Pesticide drift in the Midwest: 2010-2016* [University of Iowa]. https://iro.uiowa.edu/esploro/outputs/9983777110802771

Richter, J. (2009). The Navajo people and uranium mining. *The Oral History Review, 36*(1), 141–143. https://doi.org/10.1093/ohr/ohp025

Rico, R. J. (2023, January 29). *Protesters question circumstances surrounding 'Stop Cop City' activist's death.* PBS News. https://www.pbs.org/newshour/nation/protesters-question-circumstances-surrounding-stop-cop-city-activists-death

Rico, R. J. (2023, March 23). *Muddy clothes? 'Cop City' activists question police evidence.* AP News. https://apnews.com/article/cop-city-protest-domestic-terrorism-atlanta-6d114e109d489d316f588f51c7cab0cc

Rico, R. J. (2024, September 17). *Georgia prosecutors drop all 15 counts of money laundering against 3 'Cop City' activists.* AP News. https://apnews.com/article/atlanta-cop-city-charges-dropped-solidarity-fund-360fad48beddfb970b145fc6577cc113

Ridzuan, S. (2021). Inequality and water pollution in India. *Water Policy, 23*(4), 985–999. https://doi.org/10.2166/wp.2021.057

Riess, R., Andone, D., & Valencia, N. (2023, March 6). *23 face domestic terrorism charges after arrests in 'Cop City' protests at planned police training site in Atlanta.* CNN. https://www.cnn.com/2023/03/06/us/atlanta-cop-city-protests/index.html

Ro, C. (2022, September 16). Renewable energy costs have dropped much faster than expected, but there's a catch. *Forbes.* https://www.forbes.com/sites/christinero/2022/09/14/renewable-energy-costs-have-dropped-much-faster-than-expected-but-theres-a-catch

Robbins, J. (2024, April 4). *A nuclear power revival is sparking a surge in uranium mining.* Yale Environment 360. https://e360.yale.edu/features/us-uranium-mining-nuclear-power

Roberts, D. (2019, October 2). *Could squeezing more oil out of the ground help fight climate change?* Vox. https://www.vox.com/energy-and-environment/2019/10/2/20838646/climate-change-carbon-capture-enhanced-oil-recovery-eor

Robertson, C., & Krauss, C. (2014, September 4). BP may be fined up to $18 billion for spill in Gulf. *The New York Times.* https://www.nytimes.com/2014/09/05/business/bp-negligent-in-2010-oil-spill-us-judge-rules.html

Robinson, K. S. (2020). *The ministry for the future.* Orbit Books. https://www.hachettebookgroup.com/titles/kim-stanley-robinson/the-ministry-for-the-future/9780316300162

Rodraza, R. (1993). The FDA's response to AIDS: Paradigm shift in new drug policy? *Food and Drug Law Journal, 48*(3), 351–375.

Rodríguez Mega, E. (2015, June 5). *Maya ancestry may help explain the high risk of diabetes in Mexico.* Science. https://www.science.org/content/article/maya-ancestry-may-help-explain-high-risk-diabetes-mexico

Roecker, S. (2023). Nuclear power plants under attack: The legacy of Zaporizhzhia. *Arms Control Today, 53.* https://www.armscontrol.org/act/2023-04/features/nuclear-power-plants-under-attack-legacy-zaporizhzhia

Rogin, A., Corkery, A., & Edic, G. (2025, May 25). *The growing environmental impact of AI data centers' energy demands.* PBS News. https://www.pbs.org/newshour/show/the-growing-environmental-impact-of-ai-data-centers-energy-demands

Rojas, R., & Keenan, S. (2023, June 2). Georgia officials target bail fund in crackdown on 'Cop City' protests. *The New York Times.* https://www.nytimes.com/2023/06/02/us/cop-city-atlanta-protests.html

Rojas, R. (2023, September 30). In a 'city too busy to hate,' new attention to an overlooked race massacre. *The New York Times.* https://www.nytimes.com/2023/09/30/us/atlanta-race-massacre-1906.html

Rolls-Royce. (n.d.). *Rolls-Royce small modular reactors.* Retrieved October 10, 2024, from https://www.rolls-royce.com/innovation/small-modular-reactors.aspx

Romanian Energy Ministry. (2019, July 10). *5.000 de mineri din Valea Jiului vor fi pregătiți ca tehnicieni în sectorul producerii energiei eoliene și a distribuției electricității [5,000 miners from the Jiu Valley will be trained as technicians in the wind energy production and electricity distribution sector].* https://energie.gov.ro/5-000-de-mineri-din-valea-jiului-vor-fi-pregatiti-ca-tehnicieni-in-sectorul-producerii-energiei-eoliene-si-a-distributiei-electricitatii

Roose, K. (2024, October 23). Can A.I. be blamed for a teen's suicide? *The New York Times.* https://www.nytimes.com/2024/10/23/technology/characterai-lawsuit-teen-suicide.html

Rosatom. (2023). Small modular reactor—New nuclear trend. *Rosatom Newsletter.* https://rosatomnewsletter.com/2023/03/02/small-modular-reactor-new-nuclear-trend

Rosatom. (2024). First SMRs for export. *Rosatom Newsletter.* https://rosatomnewsletter.com/2024/06/28/first-smrs-for-export

Rossi, E. (2022, September 9). *Russia and China in the scramble for nuclear power in Africa.* Med-Or Foundation. https://www.med-or.org/en/news/la-russia-e-la-cina-nel-nucleare-africano

Rout, S. (2009). Revisiting the Baliraja Dam struggle: A study of an environmental movement in Maharashtra. *Sociological Bulletin, 58*(3), 69–89. https://doi.org/10.1177/0038022920090302

Rubin, G. T. (2021, May 14). Escape From Yucca Mountain: Biden administration promises progress on nuclear waste. *The Wall Street Journal.* https://www.wsj.com/articles/escape-from-yucca-mountain-biden-administration-promises-progress-on-nuclear-waste-11620984602

Rudzis, M. (2017). *WWI production poisoned CT "Radium girls."* Connecticut in World War 1. https://ctinworldwar1.org/wwi-production-poisoned-ct-radium-girls

Saha, M. (2013). The state, scientists, and staple crops: Agricultural "modernization" in pre–Green Revolution India. *Agricultural History, 87*(2), 201–223. https://doi.org/10.3098/ah.2013.87.2.201

Sahlman, W., Nanda, R., Lassiter III, J., & McQuade, J. (2012). *TerraPower.* Harvard Business School Case 813-108. https://www.hbs.edu/faculty/Pages/item.aspx?num=43679

Saidazimova, G., & Bigg, C. (2006, April 20). *Chornobyl 20 years after: Liquidators recall disaster, speak of life after.* Radio Free Europe-Radio Liberty. https://www.rferl.org/a/1067806.html

Sam, R., Sainati, T., Hanson, B., & Kay, R. (2023). Licensing small modular reactors: A state-of-the-art review of the challenges and barriers. *Progress in Nuclear Energy, 164.* https://doi.org/10.1016/j.pnucene.2023.104859

Sanchez-Lopez, M. D. (2023). Geopolitics of the Li-ion battery value chain and the lithium triangle in South America. *Latin American Policy, 14*(1), 22–45. https://doi.org/10.1111/lamp.12285

Sangaralingam, M. (2024, August 1). *Waste trade: A form of colonialism.* Break Free From Plastic. https://www.breakfreefromplastic.org/2024/08/01/waste-trade-a-form-of-colonialism/

Sapien, J. (2023, September 7). *The inside story of how the Navy spent billions on the "little crappy ship."* ProPublica. https://www.propublica.org/article/how-navy-spent-billions-littoral-combat-ship

Saric, I. (2024, March 25). *Boeing timeline: Tracking the fallout of the door plug blowout.* Axios. https://www.axios.com/2024/03/14/boeing-737-max-problems-timeline

Scarr, S., Kumar, V., Pal, A., & Cai, W. (2019, January 18). *The race to save the river Ganges.* Reuters. https://www.reuters.com/graphics/INDIA-RIVER/010081TW39P/index.html

Schacter, J. R. (2021). Delegating safety: Boeing and the problem of self-regulation. *Cornell Journal of Law and Public Policy, 30*(3), 637–670. https://community.lawschool.cornell.edu/wp-content/uploads/2024/09/Schacter-final-1.pdf

Schmid, S. D. (2021). From "inherently safe" to "proliferation resistant": New perspectives on reactor designs. *Nuclear Technology, 207*(9), 1312–1328. https://doi.org/10.1080/00295450.2020.1837584

Schmitt, B. (2021, June 14). Geopolitical weapon: Putin's pipeline nears completion. *Atlantic Council.* https://www.atlanticcouncil.org/blogs/ukrainealert/geopolitical-weapon-putins-pipeline-nears-completion

Schneider, M., & Froggatt, A. (2024). The world nuclear industry status report 2024. In J. W. Dash (Ed.), *World Scientific Encyclopedia of Climate Change* (Vol. 2, pp. 203–209). https://doi.org/10.1142/9789811213953_0021

Schneider, M., Froggatt, A., Hosokawa, K., Thomas, S., Yamaguchi, Y., & Hazemann, J. (2013). *World nuclear industry status report 2013.* World Nuclear Industry Status Report. https://www.worldnuclearreport.org/IMG/pdf/20130716msc-worldnuclearreport2013-lr-v4.pdf

Schroer, C. (2022, June 29). Host communities and nuclear energy: Benefits for some, risks for others. *Good Energy Collective.* https://www.goodenergycollective.org/resources/host-communities-and-nuclear-energy-benefits-for-some-risks-for-others

Schulman, S., & Ciesemier, K. (Hosts). (2023, October 19). *How ACT UP changed the face of AIDS and activism* [Audio Podcast Episode]. In At Liberty. ACLU. https://www.aclu.org/podcast/how-act-up-changed-the-face-of-aids-and-activism

Schulman, S. (2021). *Let the record show: A political history of ACT UP New York, 1987-1993.* Farrar, Straus and Giroux. https://us.macmillan.com/books/9780374185138/lettherecordshow

Science Museum. (2021, February 2). *Flushed away: Sewers through history.* https://www.sciencemuseum.org.uk/objects-and-stories/everyday-wonders/flushed-away-sewers-through-history

Seattle Times Business Staff. (2019, May 5). Timeline: A brief history of the Boeing 737 MAX. *The Seattle Times.* https://www.seattletimes.com/business/boeing-aerospace/timeline-brief-history-boeing-737-max

Sebastian, C. (2023, March 7). *Why the West hasn't gone after Russian nuclear energy.* CNN. https://www.cnn.com/2023/03/06/energy/russia-nuclear-industry-no-sanctions/index.html

Sebwenna-Painter, K., Beckstein, A., & Kraus, S. (2023). Psychological impacts of historic loss and current events surrounding American Indian boarding schools. *American Indian and Alaska Native Mental Health Research, 30*(2), 1–21. https://coloradosph.cuanschutz.edu/docs/librariesprovider205/journal_files/vol30/30_2_2023.pdf

Selin, C. (2011). Negotiating plausibility: Intervening in the future of nanotechnology. *Science and Engineering Ethics, 17*(4), 723–737. https://doi.org/10.1007/s11948-011-9315-x

Semenov, B. A. (1983). Nuclear power in the Soviet Union. *IAEA Bulletin, 25*(2). https://www.iaea.org/sites/default/files/25204744759.pdf

Shahshahani, A. (2023, September 15). Cop Cities in a militarized world. *Boston Review.* https://www.bostonreview.net/articles/cop-cities-in-a-militarized-world

Sharma, A. (2020). 'We do not want fake energy': The social shaping of a solar micro-grid in rural India. Science, *Technology and Society, 25*(2), 308–324. https://doi.org/10.1177/0971721820903006

Sharma, T. (2023, December 12). Addressing bias in large language models and its impact on non-native English speakers. *Esya Centre.* https://www.esyacentre.org/perspectives/2023/12/12/addressing-bias-in-large-language-models-and-its-impact-on-non-native-english-speakers

Shaw, A. (2024, September 5). *Chinese Linglong SMR internals put in place, reaching near completion.* Power Technology. https://www.power-technology.com/news/chinas-linglong-smr-internals-put-in-place

Shaw, G. C., & Kaczkowski, V. (2009, February 17). *St. Lawrence Seaway.* The Canadian Encyclopedia. https://www.thecanadianencyclopedia.ca/en/article/st-lawrence-seaway

Shebala, M. (2009, July 23). 1979 Church Rock spill a symbol for uranium dangers. *Navajo Times.* https://navajotimes.com/news/2009/0709/072309uranium.php

Shindondola-Mote, H. (2008). *Uranium mining in Namibia: The mystery behind "low level radiation."* Centre for Research on Multinational Corporations (SOMO). https://search.issuelab.org/resource/uranium-mining-in-namibia-the-mystery-behind-low-level-radiation

Shone, O. (2024, October 9). 5 key features and benefits of large language models. *The Microsoft Cloud Blog.* https://www.microsoft.com/en-us/microsoft-cloud/blog/2024/10/09/5-key-features-and-benefits-of-large-language-models

Shropshire, D. (2023, August 7). *Hold on! Did you know that microreactors were field deployed over 60 years ago?* Idaho National Laboratory. https://inl.gov/nuclear-energy/hold-on-did-you-know-that-microreactors-were-field-deployed-over-60-years-ago

Shultz, J. M., Walsh, L., Garfin, D. R., Wilson, F. E., & Neria, Y. (2015). The 2010 Deepwater Horizon oil spill: The trauma signature of an ecological disaster. *The Journal of Behavioral Health Services & Research, 42(*1), 58–76. https://doi.org/10.1007/s11414-014-9398-7

Sierra Club. (n.d.). *Nuclear power.* Retrieved October 10, 2024, from https://www.sierraclub.org/policy/energy/nuclear-power

Simon, M. (2023, March 14). *Cops and donuts go together more than you thought: The corporations funding Cop City in Atlanta.* Forbes. https://www.forbes.com/sites/morgansimon/2023/03/14/cops-and-donuts-go-together-more-than-you-thought-the-corporations-funding-cop-city-in-atlanta

Singh, M. (2024, January 23). *Alarm as first uranium mine in years opens near Grand Canyon.* The Guardian. https://www.theguardian.com/us-news/2024/jan/23/us-uranium-mine-grand-canyon

Slotkin, J. (2020, June 14). *Atlanta police shooting ruled a homicide; anti-racism protesters continue to rally.* NPR. https://www.npr.org/sections/live-updates-protests-for-racial-justice/2020/06/14/876762714/anti-racism-protests-outcry-after-shooting-in-atlanta-clashes-in-paris

Smith, A. (2004). Boarding school abuses, human rights, and reparations. *Social Justice, 31*(4 (98)), 89–102. https://www.jstor.org/stable/29768278

Smith, A. (2009). *Indigenous peoples and boarding schools: A comparative study.* United Nations. https://www.un.org/esa/socdev/unpfii/documents/E_C_19_2009_crp1.pdf

Sneath, S., & Laughland, O. (2023, April 20). They cleaned up BP's massive oil spill. Now they're sick – and want justice. *The Guardian.* https://www.theguardian.com/environment/2023/apr/20/bp-oil-spill-deepwater-horizon-health-lawsuits

SOCOTEC. (n.d.). *Water boards.* SOCOTEC Netherlands. Retrieved November 20, 2024, from https://www.socotec.nl/en/sectors/water-boards

Solis, J. (2019, May 15). *Western Shoshone step up resistance to Yucca project.* Nevada Current. https://nevadacurrent.com/2019/05/14/western-shoshone-step-up-resistance-to-yucca-project

Sommer, J. (2024, September 27). Nuclear power is the new A.I. trade. What could possibly go wrong? *The New York Times.* https://www.nytimes.com/2024/09/27/business/ai-nuclear-power-stocks.html?unlocked_article_code=1.N04.igHv.tUJRGAzHCjRA&smid

Son, P. (2018, November 27). Natural resource extraction and settler colonial infrastructures. *Society and Space.* https://www.societyandspace.org/articles/natural-resource-extraction-and-settler-colonial-infrastructures

Song, D. (2021). Small modular reactors (SMRs): The case of China. In D. T. Ingersoll & M. D. Carelli (Eds.), *Handbook of small modular nuclear reactors* (2nd ed., pp. 395–408). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-823916-2.00016-3

Sovacool, B. K., Carley, S., & Kiesling, L. (2024). Energy justice beyond the wire: Exploring the multidimensional inequities of the electrical power grid in the United States. *Energy Research & Social Science, 111.* https://doi.org/10.1016/j.erss.2024.103474

Spalding, M. (2022, June 12). *Paradigm shift or a perpetuation of injustice: The Atlanta Prison Farm and the South River Forest.* SaportaReport. http://saportareport.com/paradigm-shift-or-a-perpetuation-of-injustice-the-atlanta-prison-farm-and-the-south-river-forest/columnists/guestcolumn/derek

Spanne, A. (2021, August 6). *Green Revolution: History, technologies, and impact.* Treehugger. https://www.treehugger.com/green-revolution-history-technologies-and-impact-5189596

Stanford, G. S. (2013). *What is the IFR?* Argonne National Laboratory. https://www.ne.anl.gov/About/reactors/ifr/What%20Is%20the%20IFR.25.pdf

Stanway, D. (2021, August 12). *China launches first commercial onshore small reactor project.* Reuters. https://www.reuters.com/world/china/china-launches-first-commercial-onshore-small-reactor-project-2021-07-13

Steiner, R. (2006). *The public oven project* [Brown University]. https://static1.squarespace.com/static/61556cddcb335674e38fde8e/t/61558ac5e4d8546b8578c18f/1632996040172/The+Public+Oven+Project.pdf

Stephens, J., & Flaherty, P. (2010, June 29). Oil industry cleanup organization swamped by BP spill. *The Washington Post.* https://www.biologicaldiversity.org/news/center/articles/2010/washington-post-06-02-2010.html

Stirling, A. (2008). "Opening up" and "closing down": Power, participation, and pluralism in the social appraisal of technology. *Science Technology & Human Values, 3*3(2), 262–294. https://doi.org/10.1177/0162243907311265

Stocks, C. (2024, June 28). *Government investing in hydroelectric energy in eastern Ontario.* International Water Power. https://www.waterpowermagazine.com/news/government-investing-in-hydroelectric-energy-in-eastern-ontario

Stone, G. D. (2022). The Green Revolution and developing world farms. In *The agricultural dilemma: How not to feed the world* (pp. 162–193). Routledge. https://www-taylorfrancis-com.proxy.lib.umich.edu/reader/download/d22a49ec-cb25-4568-b2df-33eac1da2ec3/book/pdf?context=ubx

Stone, O. (Director). (2023, June 2). *Nuclear now* [Film]. https://www.nuclearnowfilm.com

Stover, D. (2024, December 19). AI goes nuclear. *Bulletin of the Atomic Scientists.* https://thebulletin.org/2024/12/ai-goes-nuclear

Sullivan, B. (2022). *Puerto Rico: There are still thousands without power 2 weeks after Fiona.* NPR. https://www.npr.org/2022/10/02/1126462352/puerto-rico-hurricane-fiona-luma-energy-power-outages

Sustainability Directory. (2025, April 22). *What are SMR's water consumption implications?* https://energy.sustainability-directory.com/question/what-are-smrs-water-consumption-implications

SwissInfo. (2019, January 21). *Historic nuclear accident dashed Swiss atomic dreams.* SwissInfo. https://www.swissinfo.ch/eng/banking-fintech/radioactive_historic-nuclear-accident-dashed-swiss-atomic-dreams/44696398

Szasz, F. M. (1992). The British mission at Los Alamos: The scientific dimension. In F. M. Szasz (Ed.), *British scientists and the Manhattan project: The Los Alamos years* (pp. 16–31). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-12731-3_2

Szulecki, K., & Overland, I. (2023). Russian nuclear energy diplomacy and its implications for energy security in the context of the war in Ukraine. *Nature Energy, 8*(4), 413–421. https://doi.org/10.1038/s41560-023-01228-5

Tan, C. (2024, June 14). *A new chapter in Kemmerer? TerraPower breaks ground.* Wyoming Public Media. https://www.wyomingpublicmedia.org/open-spaces/2024-06-14/a-new-chapter-in-kemmerer-terrapower-breaks-ground

Tan, E. (2024, October 29). A rural Missouri town fights Big Tech, and itself. *The New York Times.* https://www.nytimes.com/2024/10/29/technology/data-center-peculiar-missouri.html

Tanisho, Y., Shigemura, J., Kubota, K., Tanigawa, T., Bromet, E. J., Takahashi, S., Matsuoka, Y., Nishi, D., Nagamine, M., Harada, N., Tanichi, M., Takahashi, Y., Shimizu, K., Nomura, S., & Yoshino, A. (2016). The longitudinal mental health impact of Fukushima nuclear disaster exposures and public criticism among power plant workers: The Fukushima NEWS Project study. *Psychological Medicine, 46*(15), 3117–3125. https://doi.org/10.1017/S003329171600194X

Tao, M., & Chu, D. (2023, July 27). New nuclear technology sees vast export potential. *Global Times.* https://www.globaltimes.cn/page/202307/1295190.shtml

Teijlingen, K. V., & Hidalgo-Bastidas, J. P. (2022). A mine, a dam, and the Chinese-Ecuadorian politics of knowledge. In P. Amar, L. Rofel, F. Brancoli, M. A. Viteri, & C. Fernandez (Eds.), *The Tropical Silk Road* (pp. 233–244). Stanford University Press. https://doi.org/10.1515/9781503633810-018

Tennessee Valley Authority. (n.d.). *Advanced nuclear solutions.* Retrieved May 15, 2025, from https://tva.com/energy/technology-innovation/advanced-nuclear-solutions

Teplinsky, E., Lovering, J., & Buongiorno, J. (2022, February 8). *Nuclear power is critical for the world's climate crisis.* Bloomberg Law. https://news.bloomberglaw.com/environment-and-energy/nuclear-power-is-critical-for-the-worlds-climate-crisis

Teräväinen, T. (2019). Negotiating water and technology—Competing expectations and confronting knowledges in the case of the Coca Codo Sinclair in Ecuador. *Water, 11*(3), Article 3. https://doi.org/10.3390/w11030411

Terrell, M. (2024, October 14). New nuclear clean energy agreement with Kairos Power. *The Key Word, Google.* https://blog.google/outreach-initiatives/sustainability/google-kairos-power-nuclear-energy-agreement

The Associated Press. (2022, December 22). *After the Fukushima disaster, Japan swore to phase out nuclear power. But not anymore.* NPR. https://www.npr.org/2022/12/22/1144990722/japan-nuclear-power-change-fukushima

The Associated Press. (2024, July 8). *Key events in the troubled history of the Boeing 737 Max.* AP News. https://apnews.com/article/boeing-plea-737-max-crashes-b34daa014406657e720bec4a990dccf6

The House Committee on Transportation & Infrastructure. (2020). *Final committee report: The design, development, & certification of the Boeing 737 MAX.* https://democrats-transportation.house.gov/imo/media/doc/2020.09.15%20FINAL%20737%20MAX%20Report%20for%20Public%20Release.pdf

The National Native American Boarding School Healing Coalition. (2020). *Healing voices volume 1: A primer on American Indian and Alaska Native boarding schools in the U.S.* https://boardingschoolhealing.org/wp-content/uploads/2021/09/NABS-Newsletter-2020-7-1-spreads.pdf

The White House. (2021). *Fact sheet: The Bipartisan Infrastructure Deal.* https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2021/11/06/fact-sheet-the-bipartisan-infrastructure-deal

Thigpen, M. (2023, June 6). *Atlanta leaders just voted to approve 'Cop City' funding.* Capital B News. https://capitalbnews.org/cop-city-vote

Thoet, A. (2016, December 2). *Audio shows Standing Rock Sioux tribe objected to pipeline two years ago.* PBS News. https://www.pbs.org/newshour/nation/audio-shows-standing-rock-sioux-tribe-objected-pipeline-two-years-ago

Thomas-Blate, J. (2016, June 7). *Saving the St. Lawrence.* American Rivers. https://www.americanrivers.org/2016/06/saving-the-st-lawrence

Thompson, T., Epp, J., & Charlebois, P. (2008). *The past grievance final settlement agreement.* The People's Voice Archive. https://tpv.omeka.net/items/show/10

Tillerson, K. (2008). Explaining racial disparities in HIV/AIDS incidence among women in the U.S.: A systematic review. *Statistics in Medicine, 27*(20), 4132–4143. https://doi.org/10.1002/sim.3224

Tirone, J. (2023, February 14). Russia's Grip on Nuclear-Power Trade Is Only Getting Stronger. *Bloomberg.* https://www.bloomberg.com/news/features/2023-02-14/russia-s-grip-on-nuclear-power-trade-is-only-getting-stronger

Tiwari, S. (2021). China becomes third country to develop floating nuclear reactor; claims it can withstand the 'rarest of rare' storms. *The Eurasian Times.* https://www.eurasiantimes.com/china-becomes-third-country-to-develop-floating-nuclear-reactor

Tkacik, M. (2019, September 18). Crash course—How Boeing's managerial revolution created the 737 MAX disaster. *The New Republic.* https://newrepublic.com/article/154944/boeing-737-max-investigation-indonesia-lion-air-ethiopian-airlines-managerial-revolution

Tollefson, J. (2018). Sucking carbon dioxide from air is cheaper than scientists thought. *Nature, 558*(7709), 173–173. https://doi.org/10.1038/d41586-018-05357-w

Tong, S., Prior, J., McGregor, G., Shi, X., & Kinney, P. (2021). Urban heat: An increasing threat to global health. *The BMJ, 375.* https://doi.org/10.1136/bmj.n2467

Touran, N. (2008, September 8). *How much nuclear waste would you make if you got 100% of your electricity from nuclear power?* What Is Nuclear? https://whatisnuclear.com/calcs/how-much-nuclear-waste-per-capita.html

Touran, N. (2020, January 12). *Nuclear reactor development history.* What Is Nuclear? https://whatisnuclear.com/reactor-history.html

Touran, N. (2023, April 16). *What is an advanced reactor?* What Is Nuclear? https://whatisnuclear.com/advanced-reactors.html

Townsend, T. (2017, May 8). *Eric Schmidt said ATMs led to more jobs for bank tellers. It's not that simple.* Vox. https://www.vox.com/2017/5/8/15584268/eric-schmidt-alphabet-automation-atm-bank-teller

Trahan, A. (2025, August 18-21). *Safeguards considerations for fast reactors and associated fuel cycles.* IAEA Technical Meeting on Proliferation Resistance Features of Fast Reactors and Associated Fuel Cycles, Vienna, Austria. https://conferences.iaea.org/event/411/contributions/37624/attachments/20702/34978/A.%20Trahan%20Fast%20Reactor%20safeguards%20TM%20Aug2025-v2%20(1).pdf

Transport Canada, US Army Corps of Engineers, US Department of Transportation, The St. Lawrence Seaway Management Corporation, Saint Lawrence Seaway Development Corporation, Environment Canada, & U.S. Fish and Wildlife Service. (2007). *Great Lakes Seaway study.* https://www.seaway.dot.gov/sites/seaway.dot.gov/files/docs/Army%20Corps%20-%20Great%20Lakes%20Seaway%20Study.pdf

Treaty of Fort Laramie (1868). (2021, September 7). National Archives. https://www.archives.gov/milestone-documents/fort-laramie-treaty

Treaty on the Non-Proliferation of Nuclear Weapons, opened for signature July 1, 1968, 21 U.S.T. 483, 729 U.N.T.S. 161. https://treaties.unoda.org/t/npt

Tsukimori, O., & Sheldrick, A. (2016, December 21). *Japan pulls plug on Monju, ending $8.5 billion nuclear self-sufficiency push.* Reuters. https://www.reuters.com/article/markets/currencies/japan-pulls-plug-on-monju-ending-85-billion-nuclear-self-sufficiency-push-idUSKBN14A0UW

Tsukimori, O. (2016, November 28). *Fukushima nuclear decommission, compensation costs to almost double.* Reuters. https://www.reuters.com/article/world/fukushima-nuclear-decommission-compensation-costs-to-almost-double-media-idUSKBN13N03C

Tsutsui, Y., Ujiie, T., Takaya, R., Uchida, H., Odagiri, Y., Tominaga, M., & Takahara, M. (2024). 11-year trends of psychological impact on Fukushima mothers and children post-nuclear accident. *Journal of Applied Developmental Psychology, 95.* https://doi.org/10.1016/j.appdev.2024.101727

Tucker, B. (1998). Deaf culture, cochlear implants, and elective disability. *The Hastings Center Report, 28*(4), 6–14. https://doi.org/10.2307/3528607

Turk, V. (2023, October 10). How AI reduces the world to stereotypes. *Rest of World.* https://restofworld.org/2023/ai-image-stereotypes

Turkewitz, J., & León Cabrera, J. M. (2024, December 30). The rivers run dry and the lights go out: A warming nation's doom loop. *The New York Times.* https://www.nytimes.com/2024/12/30/world/americas/ecuador-hydropower-drought.html

Turman, A. (2021). Clear of conflict? Examining FAA certification and conflict preemption in light of the 737 MAX. *Houston Law Review, 58*(3). https://houstonlawreview.org/article/19363-clear-of-conflict-examining-faa-certification-and-conflict-preemption-in-light-of-the-737-max

Turner, M. (2011, September 26). *Clamshell Alliance campaigns against Seabrook Nuclear Power Plant, New Hampshire, 1976-1989.* Global Nonviolent Action Database. https://nvdatabase.swarthmore.edu/content/clamshell-alliance-campaigns-against-seabrook-nuclear-power-plant-new-hampshire-1976-1989

Turp-Balazs, C. (2021, February 22). *Why Romania's miners make the country's government anxious.* Emerging Europe. https://emerging-europe.com/analysis/the-explainer-romanias-miners

Tyler, R. S., & Summerfield, Q. A. (1996). Cochlear implantation: Relationships with research on auditory deprivation and acclimatization. *Ear and Hearing, 17*(3), 38S.

Union of Concerned Scientists. (2009, July 18). *Fissile materials basics.* https://www.ucsusa.org/resources/fissile-materials-basics

Union of Concerned Scientists. (2022, March 23). *Nuclear frontline communities.* https://www.ucsusa.org/resources/nuclear-frontline-communities

Union of Concerned Scientists. (2023). *A brief history of nuclear accidents worldwide.* https://www.ucsusa.org/resources/brief-history-nuclear-accidents-worldwide

United Nations. (2007). Declaration on the Rights of Indigenous Peoples [Resolution 61/295]. (A/RES/61/295) . https://documents.un.org/doc/undoc/gen/n06/512/07/pdf/n0651207.pdf

United Nations. (2024a, April 15). *Prospect of nuclear accident 'dangerously close' at Zaporizhzhia Power Plant in Ukraine, International Atomic Energy Agency chief warns security council.* [Meeting coverage, Security Council]. https://press.un.org/en/2024/sc15662.doc.htm

United Nations. (2024b, September 26). *Nuclear arms race 'heading in wrong direction,' United Nations chief warns, as General Assembly marks day for their total elimination* [Meetings coverage, General Assembly]. https://press.un.org/en/2024/ga12636.doc.htm

United Nations Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, June 25, 1998, 2161 U.N.T.S. 417. https://treaties.un.org/doc/Treaties/1998/06/19980625%2008-35%20AM/Ch_XXVII_13p.pdf

United Nations Environment Programme. (2025, March 11). *As electronic waste surges, countries look for answers.* https://www.unep.org/news-and-stories/story/electronic-waste-surges-countries-look-answers

United Nations Human Rights. (2018, August 16). *Japan: Fukushima clean-up workers, including homeless, at grave risk of exploitation, say UN experts.* https://www.ohchr.org/en/press-releases/2018/08/japan-fukushima-clean-workers-including-homeless-grave-risk-exploitation-say

United Nations Office for Disarmament Affairs. (n.d.). *Treaty on the Prohibition of Nuclear Weapons.* Retrieved October 13, 2025, from https://disarmament.unoda.org/en/our-work/weapons-mass-destruction/nuclear-weapons/treaty-prohibition-nuclear-weapons

UN Office of the High Commissioner for Human Rights. (2017, May 12). *UN expert calls on Mexico to urgently expand and improve water and sanitation provision for all* [Press Release]. https://www.ohchr.org/en/press-releases/2017/05/un-expert-calls-mexico-urgently-expand-and-improve-water-and-sanitation

Urmee, T., & Gyamfi, S. (2014). A review of improved cookstove technologies and programs. *Renewable and Sustainable Energy Reviews, 33,* 625–635. https://doi.org/10.1016/j.rser.2014.02.019

U.S. Census Bureau. (2022a). *American community survey 5-year estimates. Retrieved from Census Reporter Profile page for Braidwood, IL.* Census Reporter. http://censusreporter.org/profiles/16000US1707770-braidwood-il

U.S. Census Bureau. (2022b). *American community survey 5-year estimates. Retrieved from Census Reporter Profile page for Delta borough, York County, PA.* Census Reporter. http://censusreporter.org/profiles/06000US4213318800-delta-borough-york-county-p

U.S. Centers for Disease Control and Prevention. (2001). HIV and AIDS --- United States, 1981—2000. *Morbidity and Mortality Weekly Report, 50*(21), 430–434. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5021a2.htm

U.S. Congress, Office of Technology Assessment (Ed.). (1991). Case Study: Nuclear powerplant control room operators. In *Biological rhythms: Implications for the worker: New developments in neuroscience* (pp. 143–155). U.S. Government Printing Office. https://www.princeton.edu/~ota/disk1/1991/9108/9108.PDF

U.S. Department of Defense. (2024, September 24). *DoD breaks ground on Project Pele: A mobile nuclear reactor for energy resiliency.* https://www.defense.gov/News/Releases/Release/Article/3915633/dod-breaks-ground-on-project-pele-a-mobile-nuclear-reactor-for-energy-resiliency/

U.S. Department of Energy. (2021). *DOE announces $30 million for research to secure domestic supply chain of critical elements and minerals.* https://www.energy.gov/articles/doe-announces-30-million-research-secure-domestic-supply-chain-critical-elements-and

U.S. Department of Energy, Office of Nuclear Energy. (n.d.-a). *Advanced reactor demonstration program.* U.S. Department of Energy. Retrieved November 7, 2024, from https://www.energy.gov/ne/advanced-reactor-demonstration-program

U.S. Department of Energy, Office of Nuclear Energy. (n.d.-b). *Advanced small modular reactors (SMRs).* Retrieved May 14, 2025, from https://www.energy.gov/ne/advanced-small-modular-reactors-smrs

U.S. Department of Energy, Office of Nuclear Energy. (n.d.-c). *Enhanced safety of advanced reactors.* Energy.Gov. Retrieved November 8, 2024, from https://www.energy.gov/ne/enhanced-safety-advanced-reactors

U.S. Department of Energy, Office of Nuclear Energy. (2019, July 9). *TRISO particles: The most robust nuclear fuel on Earth.* https://www.energy.gov/ne/articles/triso-particles-most-robust-nuclear-fuel-earth

U.S. Department of Energy, Office of Nuclear Energy. (2020, June 23). 3 ways nuclear is more flexible than you might think. *Office of Nuclear Energy Blog, U.S. Department of Energy.* https://www.energy.gov/ne/articles/3-ways-nuclear-more-flexible-you-might-think

U.S. Department of Energy, *Office of Nuclear Energy.* (2021, February 26). What is a nuclear microreactor? U.S. Department of Energy. https://www.energy.gov/ne/articles/what-nuclear-microreactor

U.S. Department of Energy, Office of Nuclear Energy. (2022a, June). 3 reasons why nuclear is clean and sustainable. *Energy.Gov.* https://www.energy.gov/ne/articles/3-reasons-why-nuclear-clean-and-sustainable

U.S. Department of Energy, Office of Nuclear Energy. (2022b, October 3). *5 fast facts about spent nuclear fuel. Office of Nuclear Energy Blog, U.S. Department of Energy.* https://www.energy.gov/ne/articles/5-fast-facts-about-spent-nuclear-fuel

U.S. Department of Energy, Office of Nuclear Energy. (2023a). *NRC certifies first U.S. small modular reactor design.* U.S. Department of Energy. https://www.energy.gov/ne/articles/nrc-certifies-first-us-small-modular-reactor-design

U.S. Department of Energy, Office of Nuclear Energy. (2023b). *The ultimate fast facts guide to nuclear energy.* https://www.energy.gov/ne/articles/ultimate-fast-facts-guide-nuclear-energy

U.S. Department of Energy, Office of Nuclear Energy. (2023c, August 2). Beyond Oppenheimer: How nuclear weapons and nuclear reactors are different. *U.S. Office of Nuclear Energy Blog, U.S. Department of Energy.* https://www.energy.gov/ne/articles/beyond-oppenheimer-how-nuclear-weapons-and-nuclear-reactors-are-different

U.S. Department of Energy, Office of Nuclear Energy. (2024a). *Coal-to-nuclear transitions: An information guide.* Office of Nuclear Energy. https://www.energy.gov/sites/default/files/2024-05/Coal-to-Nuclear%20Transitions%20An%20Information%20Guide.pdf

U.S. Department of Energy, Office of Nuclear Energy. (2024b). *The ultimate fast facts guide to nuclear energy.* https://www.energy.gov/ne/articles/ultimate-fast-facts-guide-nuclear-energy

U.S. Department of Energy, Office of Nuclear Energy. (2024c, September 30). *Department of Energy launches $100 million nuclear safety training and workforce development program.* U.S. Department of Energy. https://www.energy.gov/ne/articles/department-energy-launches-100-million-nuclear-safety-training-and-workforce

U.S. Department of Energy, Office of Nuclear Energy. (2025, July 1). *Energy Department announces first microreactor experiments in DOME test bed.* Energy.Gov. https://www.energy.gov/ne/articles/energy-department-announces-first-microreactor-experiments-dome-test-bed

U.S. Department of Energy, Office of Resource Sustainability. (n.d.). *Enhanced oil recovery.* Energy.Gov. Retrieved January 10, 2025, from https://www.energy.gov/fecm/enhanced-oil-recovery

U.S. Department of Justice, Office of Public Affairs. (2015, May 1). *U.S. will pay $13.2 million for cleanup evaluation of 16 abandoned uranium mines on the Navajo Nation* [Press Release]. https://www.justice.gov/opa/pr/us-will-pay-132-million-cleanup-evaluation-16-abandoned-uranium-mines-navajo-nation

U.S. Department of Justice, Office of Public Affairs. (2021, January 7). *Boeing charged with 737 Max fraud conspiracy and agrees to pay over $2.5 billion* [Press Release]. https://www.justice.gov/opa/pr/boeing-charged-737-max-fraud-conspiracy-and-agrees-pay-over-25-billion

U.S. Department of State, Office of the Spokesperson. (2022, December 15). *The United States of America and the Republic of Kenya sign a memorandum of understanding concerning strategic civil nuclear cooperation* [Press Release]. https://2021-2025.state.gov/the-united-states-of-america-and-the-republic-of-kenya-sign-a-memorandum-of-understanding-concerning-strategic-civil-nuclear-cooperation

U.S. Department Of The Army. (2016). *Nuclear and chemical weapons and materiel: Army reactor program:* Defense Technical Information Center. https://apps.dtic.mil/sti/pdfs/ADA403304.pdf

U.S. Department of Transportation, Office of Inspector General. (n.d.). *The Great Lakes-St. Lawrence Seaway system.* Great Lakes St. Lawrence Seaway Development Corporation. Retrieved December 19, 2024, from https://www.seaway.dot.gov/about/great-lakes-st-lawrence-seaway-system

U.S. Department of Transportation, Office of Inspector General. (2020). *Timeline of activities leading to the certification of the Boeing 737 MAX 8 aircraft and actions taken after the October 2018 Air Lion incident* (FAA Report No. AV2020037). https://www.oig.dot.gov/sites/default/files/FAA%20Oversight%20of%20Boeing%20737%20MAX%20Certification%20Timeline%20Final%20Report.pdf

U.S. Environmental Protection Agency. (n.d.). *Radioactive waste from uranium mining and milling* [Overviews and Factsheets]. Retrieved October 10, 2024, from https://www.epa.gov/radtown/radioactive-waste-uranium-mining-and-milling

U.S. Environmental Protection Agency. (2020, October 22). *DeKalb County, Georgia Clean Water Act settlement modified to further address sanitary sewer overflows.* https://19january2021snapshot.epa.gov/newsreleases/dekalb-county-georgia-clean-water-act-settlement-modified-further-address-sanitary

U.S. Environmental Protection Agency. (2022, July). *Annual progress update: Federal actions to address uranium contramination on Navajo Nation.* https://www.epa.gov/system/files/documents/2022-11/ten-year-plan-annual-progress-update-nnaum-2022-07.pdf

U.S. Environmental Protection Agency. (2024a, April 29). *Nuclear submarines and aircraft carriers.* https://www.epa.gov/radtown/nuclear-submarines-and-aircraft-carriers

U.S. Environmental Protection Agency. (2024b, July 24). *How to report a pesticide incident involving exposures to people.* https://www.epa.gov/pesticide-incidents/how-report-pesticide-incident-involving-exposures-people

U.S. Environmental Protection Agency. (2024c, October 7). *EPA decides on cleanup plans for seven abandoned uranium mine sites in Navajo Nation.* https://www.epa.gov/newsreleases/epa-decides-cleanup-plans-seven-abandoned-uranium-mine-sites-navajo-nation

U.S. Environmental Protection Agency. (2025a, May 7). *Abandoned Mines Cleanup* (Southwest, Arizona, New Mexico, Utah). https://www.epa.gov/navajo-nation-uranium-cleanup/aum-cleanup

U.S. Environmental Protection Agency. (2025b, May 29). *Case summary: $600 million settlement to clean up 94 abandoned uranium mines on the Navajo Nation.* https://www.epa.gov/enforcement/case-summary-600-million-settlement-clean-94-abandoned-uranium-mines-navajo-nation

U.S. Government Accountability Office. (2004). *Aviation Safety: FAA Needs to Strengthen the Management of Its Designee Programs* (GAO-05-40). https://www.globalsecurity.org/security/library/report/gao/d0540.pdf

U.S. Government Accountability Office. (2015). *Technology assessment: Nuclear reactors: Status and challenges in development and deployment of new commercial concepts* (GAO-15-652). https://www.gao.gov/products/gao-15-652

U.S. Government Accountability Office. (2020). *Environmental liabilities: DOE needs to better plan for post-cleanup challenges facing sites* (GAO-20-373). https://www.gao.gov/products/gao-20-373

U.S. Government Accountability Office. (2023). *Nuclear Power: NRC Needs to Take Additional Actions to Prepare to License Advanced Reactors* (GAO-23-105997). https://www.gao.gov/assets/d23105997.pdf

U.S. Government Accountability Office. (2024a). *NRC should take actions to fully consider the potential effects of climate change* (No. GAO-24-106326). https://www.gao.gov/assets/gao-24-106326.pdf

U.S. Government Accountability Office. (2024b). *Nuclear waste cleanup: Changes needed to address current and growing shortages in mission-critical positions* (GAO-24-106479). https://www.gao.gov/products/gao-24-106479

U.S. Nuclear Regulatory Commission. (n.d.). *NRC Licensing Process for Operators.* NRC. Retrieved October 11, 2024, from https://www.nrc.gov/docs/ML2114/ML21144A141.pdf

U.S. Nuclear Regulatory Commission. (2011). *Responsibilities and functions of the regulatory body.* (Module 3 of Integrated Regular Review Service Mission to the United States). https://www.nrc.gov/docs/ML1125/ML112510375.pdf

U.S. Nuclear Regulatory Commission. (2021). *NRC Reactor Operator Exam.* NRC. https://www.nrc.gov/docs/ML2200/ML22007A312.pdf

U.S. Nuclear Regulatory Commission. (2022). *Backgrounder on nuclear power plant licensing process.* https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/licensing-process-fs.html

U.S. Nuclear Regulatory Commission. (2023a, May 15). *Reprocessing.* https://www.nrc.gov/materials/reprocessing.html

U.S. Nuclear Regulatory Commission. (2023b). *Licensing Process for Operators.* NRC. https://www.nrc.gov/reactors/operator-licensing/licensing-process.html

U.S. Nuclear Regulatory Commission. (2024). *Backgrounder on radioactive waste.* https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html

U.S. Nuclear Regulatory Commission. (2025, March 4). *Advanced reactors.* https://www.nrc.gov/reactors/new-reactors/advanced.html

Usher, A. D. (2021). A beautiful idea: How COVAX has fallen short. *The Lancet, 397*(10292), 2322–2325. https://doi.org/10.1016/S0140-6736(21)01367-2

UW Center for Cooperatives. (n.d.). *Rural telephone cooperatives | Research on the Economic Impact of Cooperatives.* Retrieved October 10, 2024, from https://reic.uwcc.wisc.edu/telephone

Vallejo, M. C., Espinosa, B., Venes, F., López, V., & Anda, S. (2018). Evading sustainable development standards: Case studies on hydroelectric projects in Ecuador. *Global Development Policy Center.* https://www.bu.edu/gdp/files/2018/10/GEGI_GDP-Ecuador-WP.pdf

Van Dam, D., & Brink, H. (2021, September 18). *'Hotlanta' is even more sweltering in these neighborhoods due to a racist 20th-century policy.* CNN. https://www.cnn.com/2021/09/18/weather/extreme-urban-heat-environmental-racism-climate/index.html

van Wagtendonk, A. (2014, August 15). *How the Panama Canal helped make the U.S. a world power.* PBS News. https://www.pbs.org/newshour/world/panama-canal-helped-make-u-s-world-power

Varas, E., & Paz y Miño, E. (2023, April 20). *Todas las fisuras de Coca Codo Sinclair.* GK. https://gk.city/2023/04/20/todas-las-fisuras-coca-codo-sinclair-hidroelectrica

Vaughan, D. (1996). *The Challenger launch decision: Risky technology, culture, and deviance at NASA* (1st ed.). University of Chicago Press.

Velastegui-Montoya, A., García-Romero, J. A., Chuizaca-Espinoza, I. A., Quevedo, R. P., Santana-Cunha, C., Ochoa-Brito, J. I., & Arias-Hidalgo, M. (2024). Assessing regressive erosion effects: Unveiling riverside land use land cover changes post hydroelectric project construction. *Environmental Challenges, 15.* https://doi.org/10.1016/j.envc.2024.100882

Venable, K. (2020, January 25). *State finds evidence of UCC Seadrift discharging plastics into Victoria Barge Canal.* The Victoria Advocate. https://www.victoriaadvocate.com/news/environment/state-finds-evidence-of-ucc-seadrift-discharging-plastics-into-victoria-barge-canal/article_a301854c-3ebe-11ea-8c4a-f7c97901d06c.html

Verma, P. (2024, December 23). In the shadows of Arizona's data center boom, thousands live without power. *The Washington Post.* https://www.washingtonpost.com/technology/2024/12/23/arizona-data-centers-navajo-power-aps-srp

Vidal, J. (2014, April 1). Norman Borlaug: Humanitarian hero or menace to society? *The Guardian.* https://www.theguardian.com/global-development/poverty-matters/2014/apr/01/norman-borlaug-humanitarian-hero-menace-society

Vidalon, D. (2022, December 8). *EDF, Fortum agree to study nuclear newbuild in Finland and Sweden.* Reuters. https://www.reuters.com/business/energy/edf-fortum-agree-study-nuclear-newbuild-finland-sweden-2022-12-08

Villegas, A., & Scheyder, E. (2023, April 21). *Chile plans to nationalize its vast lithium industry.* Reuters. https://www.reuters.com/markets/commodities/chiles-boric-announces-plan-nationalize-lithium-industry-2023-04-21/

Vinca, A., Emmerling, J., & Tavoni, M. (2018). Bearing the cost of stored carbon leakage. *Frontiers in Energy Research, 6.* https://doi.org/10.3389/fenrg.2018.00040

von Hippel, F. (2021, January 27). Biden can rescue the Nuclear Regulatory Commission from industry capture. *Bulletin of the Atomic Scientists.* https://thebulletin.org/2021/01/biden-can-rescue-the-nuclear-regulatory-commission-from-industry-capture

Walker, J. S., & Wellock, T. R. (2024). *A short history of nuclear regulation, 1946–2024* (Revision 3). Nuclear Regulatory Commission. https://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0175/index

Wallace, J., Paris, C., & Malsin, J. (2025, February 2). Moscow has $2 billion stuck at JPMorgan. The U.S. isn't sure what to do with it. *Wall Street Journal.* https://www.wsj.com/politics/policy/moscow-has-2-billion-stuck-at-jpmorgan-the-u-s-isnt-sure-what-to-do-with-it-b0669584

Waltz, E. (2024, December 10). Big tech embraces nuclear power to fuel AI and data centers. *IEEE Spectrum.* https://spectrum.ieee.org/nuclear-powered-data-center

Wang, Q., & Chen, X. (2012). Regulatory transparency—How China can learn from Japan's nuclear regulatory failures? *Renewable and Sustainable Energy Reviews, 16*(6), 3574–3578. https://doi.org/10.1016/j.rser.2012.03.001

Wang, Y., Zhao, L., Otto, A., Robinius, M., & Stolten, D. (2017). A review of post-combustion CO 2 capture technologies from coal-fired power plants. *Energy Procedia, 114,* 650–665. https://doi.org/10.1016/j.egypro.2017.03.1209

Wang, Z., Rodriguez Morales, M. M., Husak, K., Kleinman, M., & Parthasarathy, S. (2021). *In communities we trust: Institutional failures and sustained solutions for vaccine hesitancy.* Science, Technology, and Public Policy Program, Ford School of Public Policy. https://stpp.fordschool.umich.edu/research/research-report/communities-we-trust-institutional-failures-and-sustained-solutions

Ward, M. H., Lubin, J., Giglierano, J., Colt, J. S., Wolter, C., Bekiroglu, N., Camann, D., Hartge, P., & Nuckols, J. R. (2006). Proximity to crops and residential exposure to agricultural herbicides in Iowa. *Environmental Health Perspectives, 114*(6), 893–897. https://doi.org/10.1289/ehp.8770

Watson, N., & Ashton, L. (2022, April 14). *Towards a just energy transition: Nuclear power boasts best paid jobs in clean energy sector.* IAEA. https://www.iaea.org/newscenter/news/towards-a-just-energy-transition-nuclear-power-boasts-best-paid-jobs-in-clean-energy-sector

Watts, E. J. (1973). The police in Atlanta, 1890-1905. *The Journal of Southern History, 39*(2), 165–182. https://doi.org/10.2307/2205612

Weaver, G. (2023, November 22). *The role of nuclear weapons in a Taiwan crisis.* Atlantic Council. https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/the-role-of-nuclear-weapons-in-a-taiwan-crisis

Weber, J. (2012). The evolving interstate highway system and the changing geography of the United States. *Journal of Transport Geography, 25,* 70–86. https://doi.org/10.1016/j.jtrangeo.2012.07.012

Weingroff, R. F. (1996). Federal-Aid Highway Act of 1956: Creating the interstate system. *Public Roads, 60*(1). https://trid.trb.org/View/469739

Weingroff, R. F. (1996). Federal-Aid Highway Act of 1956: Creating the interstate system. *Public Roads, 60*(1). Retrieved November 26, 2024, from https://highways.dot.gov/public-roads/summer-1996/federal-aid-highway-act-1956-creating-interstate-system

Weitzdörfer, J., & Djokić, D. (2021, March 11). Highly enriched shareholders mean disasters down the line: Why utilities like TEPCO need new corporate governance. *Bulletin of the Atomic Scientists.* https://thebulletin.org/2021/03/highly-enriched-shareholders-mean-disasters-down-the-line-why-utilities-like-tepco-need-new-corporate-governance

Wellerstein, A. (2020, August 4). Counting the dead at Hiroshima and Nagasaki. *Bulletin of the Atomic Scientists.* https://thebulletin.org/2020/08/counting-the-dead-at-hiroshima-and-nagasaki

Wells, K. (2023, June 9). *An eating disorders chatbot offered dieting advice, raising fears about AI in health.* NPR. https://www.npr.org/sections/health-shots/2023/06/08/1180838096/an-eating-disorders-chatbot-offered-dieting-advice-raising-fears-about-ai-in-hea

Wendel, W. B. (2023). Malice or snafu? Punitive damages and organizational culture defects. *DePaul Law Review, 72*(2), 457–494. https://via.library.depaul.edu/law-review/vol72/iss2/12

Wendling, M. (2023, June 6). *Atlanta 'Cop City': Money approved for controversial training centre*. BBC News. https://www.bbc.com/news/world-us-canada-65772507

Westfall, C. (2004). *Vision and reality: The EBR-II story.* Argonne National Laboratory. https://www.ne.anl.gov/About/reactors/EBR2-NN-2004-2-2.pdf

Wetlands International. (2023, March 22). World Water Day: The water impacts of lithium extraction. *Wetlands International Europe.* https://europe.wetlands.org/blog/world-water-day-the-water-impacts-of-lithium-extraction

White, J. A., & Foxall, W. (2016). Assessing induced seismicity risk at CO2 storage projects: Recent progress and remaining challenges. *International Journal of Greenhouse Gas Control, 49,* 413–424. https://doi.org/10.1016/j.ijggc.2016.03.021

White, P., & Lutz, B. (2024). *Nuclear reactor licensing 101.* Nuclear Innovation Alliance. https://nuclearinnovationalliance.org/index.php/nuclear-reactor-licensing-101

Wilde-Ramsing, J., de Haan, E., & Scheele, F. (2011). *Uranium from Africa.* WISE and SOMO. https://www.somo.nl/uranium-from-africa

Winde, F., Brugge, D., Nidecker, A., & Ruegg, U. (2017). Uranium from Africa – An overview on past and current mining activities: Re-appraising associated risks and chances in a global context. *Journal of African Earth Sciences, 129,* 759–778. https://doi.org/10.1016/j.jafrearsci.2016.12.004

Wingender, P., Yao, J., Zymek, R., Carton, B., Cerdeiro, D., & Weber, A. (2024). *Europe's shift to EVs amid intensifying global competition (IMF Working Paper No. 2024/218).* International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2024/10/11/Europes-Shift-to-EVs-Amid-Intensifying-Global-Competition-556285

Winner, L. (1980). Do artifacts have politics? *Daedalus, 109*(1), 121–136.

Wiwoho, J., Trinugroho, I., Kharisma, D. B., & Suwadi, P. (2024). Cryptocurrency mining policy to protect the environment. *Cogent Social Sciences, 10*(1). https://www.tandfonline.com/doi/abs/10.1080/23311886.2024.2323755

Wollff, I. (2023). Coal resources, production, and use in Indonesia. In D. Osborne (Ed.), *The Coal Handbook (Second Edition)* (2nd ed., Vol. 2, pp. 361–430). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-824327-5.00008-9

Woolford, A. (2015). Chapter 3: Framing the Indian as a problem. In *This benevolent experiment: Indigenous boarding schools, genocide, and redress in Canada and the United States.* U of Nebraska Press. https://www.nebraskapress.unl.edu/nebraska/9780803276727/this-benevolent-experiment/

Woolley, S. M., Youk, A. O., Bear, T. M., Balmert, L. C., Talbott, E. O., & Buchanich, J. M. (2015). Impact of coal mining on self-rated health among Appalachian residents. *Journal of Environmental and Public Health, 2015*(1). https://doi.org/10.1155/2015/501837

Work, R. O. (2013). *The littoral combat ship: How we got here, and why* (p. 65). Defense Technical Information Center. https://apps.dtic.mil/sti/citations/ADA594372

World Health Organization. (2021). *Vaccine equity declaration.* https://www.who.int/campaigns/vaccine-equity/vaccine-equity-declaration

World Health Organization. (2023, October 12). *Climate change.* https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

World Nuclear Association. (n.d.). *Are there different types of nuclear reactor?* Retrieved May 14, 2025, from https://world-nuclear.org/nuclear-essentials/are-there-different-types-of-reactor

World Nuclear Association. (2013). *Licensing and project development of new nuclear plants.* https://world-nuclear.org/our-association/publications/working-group-reports/licensing-and-project-development-of-new-nuclear-p

World Nuclear Association. (2021a, April 1). *Advanced nuclear power reactors.* https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/advanced-nuclear-power-reactors

World Nuclear Association. (2021b, June 17). *What is nuclear waste, and what do we do with it?* https://world-nuclear.org/nuclear-essentials/what-is-nuclear-waste-and-what-do-we-do-with-it

World Nuclear Association. (2023, December 13). *High-assay low-enriched uranium (HALEU).* https://world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/high-assay-low-enriched-uranium-haleu

World Nuclear Association. (2024a). *Asia's nuclear energy growth.* https://world-nuclear.org/information-library/country-profiles/others/asias-nuclear-energy-growth

World Nuclear Association. (2024b). *Chernobyl accident 1986.* https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident

World Nuclear Association. (2024c). *Radioactive waste – Myths and realities.* https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-wastes-myths-and-realities

World Nuclear Association. (2024d). *Safety of nuclear power reactors.* https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors

World Nuclear Association. (2024e). *Uranium mining overview.* https://world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/uranium-mining-overview

World Nuclear Association. (2024f). *Fukushima Daiichi accident.* https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident

World Nuclear Association. (2024g, May 16). *World uranium mining production.* https://world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production

World Nuclear Association. (2024h, August 23). *Processing of used nuclear fuel.* https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel

World Nuclear Association. (2024i, December 3). *Nuclear organisations in China.* https://world-nuclear.org/information-library/appendices/nuclear-power-in-china-appendix-1-government-struc

World Nuclear Association. (2025a, February 4). Nuclear-powered ships. https://world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships

World Nuclear Association. (2025b, December 3). *Nuclear Power in Russia.* https://world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power

World Nuclear News. (2022). *Construction starts on Russia's next floating nuclear power plant.* https://world-nuclear-news.org/articles/construction-starts-on-russia-s-next-floating-nucl

World Nuclear News. (2023, December 6). *China's demonstration HTR-PM enters commercial operation.* https://world-nuclear-news.org/articles/chinese-htr-pm-demo-begins-commercial-operation

World Nuclear News. (2024a, January 8). *UK to launch HALEU production programme.* https://world-nuclear-news.org/articles/uk-to-launch-haleu-production-programme

World Nuclear News. (2024b, September 19). *Czech Republic selects Rolls-Royce SMR for small reactors project.* https://world-nuclear-news.org/articles/czech-republic-selects-rolls-royce-smr-for-small-reactors-project

World Nuclear News. (2024c, October 18). *DOE selects HALEU enrichment providers.* https://world-nuclear-news.org/articles/doe-selects-haleu-enrichment-providers

World Resources Institute. (2024, February 29). *Electric vehicle measures in US climate policy.* https://www.wri.org/us-climate-policy-implementation/sectors/electric-vehicles

Wu, F., & Butz, W. P. (2004). The Green Revolution. In *The Future of Genetically Modified Crops* (1st ed., pp. 11–38). RAND Corporation. https://www.jstor.org/stable/10.7249/mg161rc.11

Wu, X. (2020). Technology, power, and uncontrolled great power strategic competition between China and the United States. *China International Strategy Review, 2*(1), 99–119. https://doi.org/10.1007/s42533-020-00040-0

Wynne, B. (1992). Misunderstood misunderstanding: Social identities and public uptake of science. *Public Understanding of Science, 1*(3), 281–304. https://doi.org/10.1088/0963-6625/1/3/004

Xiao, T., & Liang, Y. (2024). Analysis on the development of modern rural power grids with low carbon serving rural revitalization from the perspective of scientific and technological innovation. *International Journal of Low-Carbon Technologies, 19,* 1445–1452. https://doi.org/10.1093/ijlct/ctae075

Xinhua News Agency. (2021, May 12). *Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035.* (Promulgated by the National People's Congress.). (Center for Security and Emerging Technology, Trans.). https://cset.georgetown.edu/publication/china-14th-five-year-plan

Xue, X., & Tang, K. (2024, May 16). *China's plan to float nuclear reactors in South China Sea seen as risky.* Voice of America. https://www.voanews.com/a/china-s-plan-to-float-nuclear-reactors-in-south-china-sea-seen-as-risky/7614953.html

Yadav, N. (2025, February 13). *India and France plan to develop small modular nuclear reactors.* BBC. https://www.bbc.com/news/articles/cvg8yge40eqo

Yale Law Journal. (1975). AT&T and the antitrust laws: A strict test for implied immunity note. *Yale Law Journal, 85*(2), 254–279. https://openyls.law.yale.edu/handle/20.500.13051/15705

Yañez-Barnuevo, M. (2025, June 25). *Data centers and water consumption.* Environmental and Energy Study Institute. https://www.eesi.org/articles/view/data-centers-and-water-consumption

Yauri, G. (2024, November 19). *Ecuador grapples with 14-hour blackouts, climate change, and alleged corruption* (R. Glass, Trans.). Global Voices. https://globalvoices.org/2024/11/19/ecuador-grapples-with-14-hour-blackouts-climate-change-and-alleged-corruption/

Yeung, P. (2025, January 8). 'Forgotten': How one Mexican city struggles against big industry for water. *Al Jazeera.* https://www.aljazeera.com/news/longform/2025/1/8/forgotten-how-one-mexican-city-struggles-against-big-industry-for-water

Yogarajan, V., Dobbie, G., & Keegan, T. T. (2025). Debiasing large language models: Research opportunities. *Journal of the Royal Society of New Zealand, 55*(2), 372–395. https://doi.org/10.1080/03036758.2024.2398567

Yousif, N. (2024, November 13). *Why Canada could become the next nuclear energy "superpower."* BBC News. https://www.bbc.com/news/articles/c5yjnkgz0djo

Yu, Z. J. (2023, October 10). *What did Ecuador's largest hydropower project bring to the country?* China Global Dialogue. https://chinaglobaldialogue.com/2023/10/10/environment-2/

Zehner, O. (2012). *Green Illusions: The Dirty Secrets of Clean Energy and the Future of Environmentalism.* University of Nebraska Press. https://doi.org/10.2307/j.ctt1d9nqbc

Zweifel, T. D., & Vyas, V. (2021). Crash: Boeing and the power of culture. *Journal of Intercultural Management and Ethics, 4*(4), 13–25. https://jime.csesm.org/index.php/JIME/article/view/200

Appendix: Further Reading on Advanced Nuclear Reactors

Carelli, M. D., & Ingersoll, D. T. (Eds.). (2020). Handbook of small modular nuclear reactors (2nd ed.). Woodhead Publishing. https://doi.org/10.1016/C2019-0-00070-2

Gen IV International Forum. (n.d.). Generation IV goals, technologies and GIF R&D roadmap. Retrieved February 19, 2025, from https://www.gen-4.org/generation-iv-criteria-and-technologies

Gonzales, V., & Dunlap, L. (2021, March 26). Advanced nuclear reactors 101. Resources for the Future. https://www.rff.org/publications/explainers/advanced-nuclear-reactors-101

Idaho National Laboratory. (n.d.). Advanced small modular reactors. Retrieved June 16, 2025, from https://inl.gov/trending-topics/small-modular-reactors

Ingersoll, D. T. (2016). Small modular reactors: Nuclear power fad or future? Woodhead Publishing. https://doi.org/10.1016/C2014-0-02850-X

International Atomic Energy Agency, Division of Nuclear Power, & Nuclear Power Technology Development Section. (2020). Advances in small modular reactor technology developments. A supplement to: IAEA advanced reactors information system (ARIS). 2020 Edition (INIS-XA--20K0995; p. 354). https://aris.iaea.org/Publications/SMR_Book_2020.pdf

Liou, J. (2023, September 13). What are small modular reactors (SMRs)? International Atomic Energy Agency. https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs

Nuclear Energy Agency. (2024). The NEA small modular reactor dashboard: Second edition. https://www.oecd-nea.org/jcms/pl_90816/the-nea-small-modular-reactor-dashboard-second-edition

Nuclear Innovation Alliance. (2024). Advanced nuclear reactor technology: A primer. https://nuclearinnovationalliance.org/advanced-nuclear-reactor-technology-primer

Nuclear Innovation Alliance. (n.d.). Advanced nuclear. https://nuclearinnovationalliance.org/advanced-nuclear-0

Touran, N. (2023, April 16). What is an Advanced Reactor? What Is Nuclear? https://whatisnuclear.com/advanced-reactors.html

U.S. Government Accountability Office. (2015). Technology assessment: Nuclear reactors: Status and challenges in development and deployment of new commercial concepts (GAO-15-652). https://www.gao.gov/products/gao-15-652

U.S. Department of Energy. (2024, September). Pathways to commercial liftoff: Advanced nuclear. Internet Archive Wayback Machine. Retrieved June 19, 2025, from https://web.archive.org/web/20250206065309/http://liftoff.energy.gov/wp-content/uploads/2024/10/LIFTOFF_DOE_AdvNuclear-vX7.pdf

World Nuclear Association. (2021, April 1). Advanced nuclear power reactors. https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/advanced-nuclear-power-reactors

World Nuclear Association. (2024, April 30). Generation IV nuclear reactors. https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/generation-iv-nuclear-reactors

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