Chapter 3

The Geopolitics of Nuclear Energy in Africa: What, Who, and Why?

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3.1 Introduction

Debates about which energy resource will power twenty-first century national economies continue to rage. Such debates, for the most part vociferous and highly partisan in nature, currently raging in a host of countries, ranging from the United States of America (USA), the United Kingdom (UK), Germany, Taiwan, Australia, Japan, South Korea to South Africa, and within and across international organisations such as the World Bank and the International Atomic Energy Agency (IAEA) (cf. Gattie & Hewitt 2023:1; McFarlane & Gattie 2021; Comins 2024:4–5; McGillis & Oung 2022; McGillis 2024; Nordquist & Merrifield 2023; Donovan 2022; Paraskova 2023). At the extremes, these debates are often framed in terms of those who advocate for an increase in, and greater reliance, on civilian nuclear energy and, conversely, those who are vehemently opposed to the nuclear option and making a case for the efficacy of renewable energy sources. In the main, these debates—and the divergent positions taken—view energy as primarily a market commodity in which factors of price and affordability predominate, or as a solution to climate change through the reduction of CO_2 emissions, or as a mix of both (Gattie & Hewitt 2023:1; Gattie 2024).

These debates do not only rage within countries, but also between them, insomuch that energy and climate issues, and how best to address both, are central to contemporary geopolitics. Accordingly, under the Biden-Harris administration, the US has elevated global climate change to the centre of American foreign policy and national security (Gattie & Hewitt 2022a), with an unprecedented restructuring of the US economy and industrial base underway with an almost exclusive focus on addressing climate change (Gattie 2023a). In a joint US-EU Energy Council statement during 2022, the group of countries appealed to global leaders "to ensure robust decarbonization efforts, a swift, just and socially inclusive energy transition to a climate-neutral figure, and to address energy poverty, including in Africa" (quoted in Gattie & Hewitt 2022a). In this quest to decarbonize national economies, the US and its allies have generally been loath to endorse civilian nuclear energy as a prominent technology to address energy poverty and reach global climate change objectives. Yet, while the US was, until recently, bent on restructuring its economy away from fossil fuels and towards renewable energy, China, ostensibly the champion for renewable energy, "is expanding its economy and diversifying its industrial base to displace America as the world's most influential superpower" and is doing all of this by ramping up its reliance on fossil fuels (Gattie 2023a). In Chinese President Xi Jinping's "Report to the 20th National Congress of the Communist Party of China", he made reference to climate change only twice, emphasising further that "based on China's energy and resource endowment, we [i.e., China] will advance initiatives to reach peak carbon emissions in a well-planned and phased way in line with the principle of building the new before discarding the old" (quoted in Gattie 2002). In fact, as David Gattie (quoted in Lund 2024) notes, China and Russia "do not get up in the morning worried about their CO_2 emissions. They are working to reshape the international order that they feel has been biased in favor of the west for too long". From Beijing's point of view, climate change policy is nothing more than a pawn on China's geopolitical chessboard (Gattie 2023b; cf. also Royal 2021). Importantly, too, while the US and its allies are mostly predisposed to a future without civilian nuclear technology, China and Russia are investing heavily in nuclear energy technology and exports.

For China, Russia, and the US (and any other state, for that matter), energy is the lifeblood of the national economy. Beyond clearly commercial or industrial reasons, access to reliable energy is also indispensable for a country's ability to provide for its self-defence and defend its vital interests—in short, a country's survival (Gattie & Massey 2020:122; McGillis & Oung 2022; McFarlane 2021). On this score, Robert McFarlane is emphatic in stating that sovereign control over clean, stable and abundant energy constitutes "the sine qua non of a nation's survival and the leading measure of its national security" (cf. also Fox and McFarlane 2021). Moreover, in a globalized, interdependent world, having access to and abundance supplies of energy—whether coal, oil, natural gas, or nuclear—provide their possessors with geopolitical advantages that less endowed countries lack (Gattie & Massey 2020:122). While geopolitical competition over access to fossil fuel reserves are not new, there is today—not unlike during the Cold War—a resurgence among, principally, authoritarian China and Russia in using civilian nuclear energy projects as weapons in service of their geopolitical interests—i.e., refashioning world order in accordance with *their* interests and values, and forging decades-long strategic alliances through civilian nuclear energy projects. US academics are likewise urging that country's government to step up its civilian nuclear energy base to rein in Chinese and Russian dominance in this sector, with the goal—similar to that of China and Russia—of fashioning a world order amenable to *their* interests and values. In this unfolding geopolitical competition, a host of African states, each desperate to escape the scourge of energy poverty and looking towards civilian nuclear energy as solution, are becoming—unwittingly, for the most part—engulfed by the (rival) interests and visions of world order of the twenty-first century's great powers, with possibly dire implications for African agency. As before in history, Africa will not be spared from great-power geopolitical competition, with civilian nuclear energy projects constituting one more tool—or weapon—in the foreign policy toolbox of the great powers.

The primary goal of this chapter is to unpack and explain the unfolding geopolitical competition in respect of civilian nuclear energy projects across developing (and, by implication, African) economies, emphasising that African states must remain wary of the geopolitical baggage that accompanies such projects. The first section of this chapter considers the developmental factors propelling developing economies—and African states in particular—to consider or pursue civilian nuclear energy. In the second section, I consider the geopolitics of civilian nuclear energy – and the dominance of Chinese and Russian state-owned enterprises (SOEs) in this sector. Next, I explain what drives this new wave of geopolitical competition and what it could—or perhaps more importantly, should—suggest to African states and African agency. The concluding section urges African states to approach civilian nuclear energy projects with eyes wide open.

3.2 Energy poverty, or the (African) case for nuclear energy

Whatever the merits of the case for or against nuclear energy by nuclear advocates or detractors, the important point is that African countries and their leaders have continued to express interest in it. Although South Africa remains the sole operator of a nuclear power plant in Africa, construction of Egypt's El Dabaa nuclear power plant is proceeding swiftly (World Nuclear Association 2024a; World Nuclear Association 2024b; Lorenzini 2023). In general, at least two dozen African states are considering, planning, or have expressed an interest in pursuing a nuclear future (World Nuclear Association 2024b). There also appears to be increased interest in commercial Small Modular Reactors (SMRs) among African states, with Nuclear Power Ghana and Regnum Technology having recently signed a deal to deploy a NuScale VOYGR-12 SMR (World Nuclear News 2024). Globally, interest in civilian nuclear energy remains high, with some 30 countries considering, planning, or initiating civilian nuclear energy programmes (World Nuclear Association 2024b). As Niko McMurray and David Gattie (2024) note, global demand for clean nuclear energy is at an all-time high.

African interest in civilian nuclear energy must be read against the backdrop of two other trends that have historically posed, and will continue to pose, acute challenges—but also remarkable opportunities— to humanity, namely population growth in emerging economies and urbanisation (McFarlane & Gattie 2021:73). According to the United Nations' World Population Prospects, the global population will reach a staggering 10 billion people by 2060, peaking at 10.3 billion by 2084 (Ritchie & Rodés-Guirao 2024). Importantly, that growth will predominantly occur in developing economies, with Africa destined to be a key engine of global economic growth. Large-scale migration to cities is likely to follow, and as a result there will be a need to construct a vast and intricate network of industrial and social services. Rapidly urbanising cities will require access to clean, reliable electricity, clean water, and nutritious food, a plight that some commentators have heralded as "the largest and most intense developmental challenge in human history" (McFarlane & Gattie 2021:73).

More particularly, African cities will be subject to rapid urbanisation, with six cities—Luanda, Dar es Salaam, Cairo, Kinshasa, Lagos, and Greater Johannesburg—estimated to have populations exceeding 10 million people by 2035 (Savage 2024). By this date, more than half of Africa's citizens, roughly 1 billion people, will have moved to cities and towns (Savage 2024). Over the next three decades or so, forecasts indicate that Africa's population will double, reaching a staggering 2.2 billion people (Savage 2024). Marked by increased migration and population growth, African populations and states will require access to a host of social and industrial services, among which clean, reliable electricity will be paramount. Tellingly, as Robert McFarlane and David Gattie (2021:73) have noted, "reliably electricity" will constitute the "most urgent need in these regions". In fact, "energy sovereignty" will constitute the twenty-first century's Westphalian principle, a principle fuelled by "the need for abundant, baseload and clean energy" (Gattie 2022).

Several of Africa's rapidly urbanising cities are marked by inveterate issues of "overcrowding, informal settlements, high unemployment, poor public services" and, with reference to the concerns of this chapter, "stretched utility services and exposure to climate change" (Savage 2024). Reliable electricity is not, however, the only issue facing developing economies, particularly developing African economies. Clean—i.e., environmentally friendly—electricity is paramount, especially in light of the increased desire and necessity of meeting global climate objectives, mitigating the deleterious effects of global climate change (Gattie 2020:9). Accordingly, reliable baseload electricity under low-carbon constraints is considered the desideratum for African states—and central to energy sovereignty. Renewables such as wind and solar (which currently account for about 2% of total energy production in Africa) have a role to play in providing "household electricity through off- and mini-grid applications in rural areas". Yet these will not be sufficient to address the continent's baseload requirement (Cilliers 2025).

Nuclear energy presents perhaps the most realistic trade-off for addressing the demand for baseload electricity, while also addressing the emissions problem. When probed about their interest in, or decision to pursue, nuclear energy projects, African leaders have often cited challenges related to Africa's "increasing energy requirements" for socio-economic development and the volatility of fossil fuel prices (World Nuclear Association 2024b). There is also an emerging realization, among both African leaders and leading international organisations, that reaching net zero goals will require "nuclear power capacity" to "double by 2050", making energy security amid decarbonization goals of overriding importance (Donovan 2022; Nordquist & Merrifield 2023; Gardner 2024). The case for nuclear energy—globally but in Africa in particular—is aptly presented and summarized by Kelvin Kemm, a nuclear physicist and chief executive of Stratek, a South African company specializing in SMRs, who notes that nuclear power "is the cleanest, greenest, safest, cheapest, electricity that exists. Over a half century of nuclear power in the world has proven that" (quoted in Comins 2024:5). For their part, Robert McFarlane and David Gattie (2021:74) note that nuclear energy, particularly in the form of SMRs, is capable "of not only providing abundant baseload power but also meeting industrial applications ranging from desalination to process heat and power for the production of hydrogen for use in hybrid systems" (cf. also McFarlane 2021).

3.2.1 The debate on conventional nuclear energy

Nuclear energy is, of course, often lambasted, with its appeal far from universal. Arguments against nuclear energy have predominantly turned on issues of cost, necessity, safety (i.e., nuclear accidents and nuclear waste concerns) and proliferation[1] (Gattie & Hewitt 2023:11; Gattie & Massey 2020:127; Holt 2019:1). In considering these issues, a sharp distinction must be drawn between conventional (predominantly light water reactors (LWRs)) and advanced nuclear reactors. The latter has variously been defined as "a nuclear fission reactor with significant improvements over the most recent generation of nuclear fission reactors"; nuclear fission reactors; or radioisotope power systems (Gattie 2023:5; Holt 2019:1). Given the predominance of nuclear fission processes and designs, it is also worth considering what advanced fission reactors entail. These reactors, compared to current LWR designs, have been described by *inter alia* the US Congress as "a nuclear fission reactor, including a prototype plant [...], with significant improvements compared to reactors operating on 27 December 2020", with these improvements geared toward the following: "additional inherent safety features; lower waste yields; improved fuel and material performance; increased tolerance to loss of fuel cooling; enhanced reliability or improved resilience; increased proliferation resistance; increased thermal efficiency; reduced consumption of cooling water and other environmental impacts; the ability to integrate into electric appliances and non-electric applications; modular sizes to allow for deployment that corresponds with the demand for electricity or process heat; and operational flexibility to respond to changes in demand for electricity or process heat and to complement integration with intermittent renewable energy or energy storage" (quoted

1 Proliferation concerns and the spectre of nuclear terror are addressed in greater detail in Coetzee (2023a; 2023b; 2021). In the main, such concerns are much exaggerated.

in Gattie 2023:5). A reactor design boasting some or other combination of these improvements would be considered an advanced nuclear reactor (Gattie 2023:5). While the current fleet of conventional reactors constitute "Generation III" or, in cases of more recently constructed reactors, "Generation III+" reactors, advanced reactors are referred to as "Generation IV" nuclear technologies (Holt 2019:3). As will be argued below, many—if not most—of the concerns raised by detractors of nuclear energy are allayed by advanced nuclear reactors.

In the case of the current fleet of *conventional* nuclear reactors, cost is indeed a contentious issue, especially when compared to (subsidized) renewables like wind and solar and, importantly, when assessing cost through a short-term lens. While the low-carbon and reliability benefits of conventional nuclear energy accrue almost immediately, the reality is that large-scale nuclear projects are capital-intensive, prone to cost overruns, and require a long-term investment horizon (Gattie 2024). When considering Lazard's 2024 Levelized Cost of Energy (LCOE)[2] Report, it is evident that renewables fare significantly better compared to conventional nuclear energy: utility scale solar photovoltaic, $29–$92 per MWh; utility scale solar photovoltaic plus storage, $60–$210 per MWh; (US) nuclear, $142–$222 per MWh (Lazard 2024:9). However, as Gattie and Hewitt (2023:11) aptly note, LCOE is geared towards calculations related to the amortization period but fails to account for "the technical lifetime of a power plant". Indeed, the comparative economic benefits of conventional nuclear energy projects only accrue over the long term, given that the operational life of a conventional nuclear power plant (more than sixty years) is two to three times greater than that of other technologies (Gattie 2024). Practically, this means that while a nuclear power plant enters the second half of its expected lifetime, "recapitalization" will inevitably follow to address the lost power generation from other power plants that have "reached their technical end of life, but prior to the nuclear plant reaching its technical end of life" (Gattie & Hewitt 2023:11). Moreover, although high construction

2 LCOE refers to "the average revenue required per unit of electricity to recover the cost of constructing and operating a power plant" (Gattie & Hewitt 2023:10).

costs and cost overruns have tarnished conventional nuclear energy's reputation, it is not altogether evident, as is often claimed, that renewable energy is always cheaper energy (Lund 2024). The cases of France and Germany are instructive, the former being heavily reliant on conventional nuclear energy and the latter undertaking an extensive renewables (wind and solar) experiment (Cumins 2024:5). As Kelvin Kemm notes, decades of real-world experience show that "the German electricity price is way higher than the French price" and, ironically, Germany's CO_2 footprint is significantly higher than that of France (quoted in Cumins 2024:5). Ultimately, reaping the full value of conventional nuclear energy requires a long-term horizon, as this technology will find it extremely difficult to compare favourably "with the short-term marginal prices of low-cost natural gas and subsidized renewables" (Gattie & Hewitt 2023:11; Gattie & Hewitt 2022a).

If issues of cost are contentious in the debate on conventional nuclear energy, so are issues related to necessity. While some argue for the desirability and efficacy of relying exclusively on wind and solar for power generation (i.e., we only need solar and wind), several scholars have cast doubt on the validity of this claim (Gattie 2024; Gattie & Hewitt 2022a). In fact, some scholars contend outright that the need for abundant and consistent baseload energy cannot be provided by wind and solar alone (Lund 2024; Fox & McFarlane 2021; Gattie 2020:7). While renewables are undoubtedly central to ensuring a diverse energy mix and to addressing global climate change objectives, it is worth mentioning that "renewable energy has limits" (Gattie 2020:11). To foster a developing industrial base, reliable, baseload energy is required, a requirement that cannot be met due to the intermittent nature of wind and solar energy generation (Lund 2024; Gattie 2020:7). Nuclear energy is uniquely suited to this task given the fact it is a very high-density energy resource, dispatchable and, importantly, it constitutes the power generation technology with the highest capacity factor (i.e., "the percentage of round-the-clock delivery of design capacity") (Gattie & Hewitt 2023:12; McGillis & Oung 2022; McFarlane 2021).

Besides meeting a (developing) state's electricity needs, twenty-first century energy systems must meet a host of additional needs unique to each country, ranging from district heating, desalination, process heat, and the development of alternative energy sources (McFarlane 2021). The operation of and cutting-edge operations required by data-centres is today adding a new dimension to be met by modern energy systems. Nuclear energy can meet all these needs—and without any onsite carbon emissions. Gradually (and, for some, grudgingly), a consensus is emerging that the goals of net-zero carbon emissions cannot be reached "without a significant increase in nuclear capacity". To this end, some 20 countries attending the 2023 United Nations Climate Change Conference (COP28) in Dubai pledged to triple their nuclear power capacity by 2050 (International Atomic Energy Agency 2024a). The tide against nuclear energy seems to be turning.

As mentioned above, arguments against civilian nuclear energy on the grounds of safety mostly relate to fears about nuclear accidents and the management (disposal) of radioactive waste, both of which are key concerns of Jo-Ansie van Wyk's chapter in this volume. While fears about nuclear accidents are understandable, the historical record on nuclear safety gives us pause for thought. As Todd Royal (2023) has pointed out, over six decades of nuclear energy have resulted in some 200 casualties, with these numbers inclusive of the most infamous nuclear accidents (i.e., Chernobyl, Three Mile Island, and Fukushima). When factoring in cancer diagnoses among those exposed to radiation following these accidents, such calculations must be weighed against the harmful effects of natural-gas-fired power plants in the form of coal pollution or methane emissions, with nuclear energy emerging as the clear winner when all things are considered (Royal 2023). Managing spent nuclear fuel has, however, been a far more inveterate problem, especially in regard to the environmental effects of radioactive waste and the attendant cost of long-term storage solutions (Lorenzini 2023).

Attempts at sustainable nuclear waste management have proliferated in recent years. Finland's Onkalo project is a case in point. Hailed by the International Atomic Energy Agency (IAEA) as a "game-changer in nuclear waste management", Onkalo comprises "an expansive underground repository" capable of storing 5,500 tonnes of waste and constitutes the world's first permanent nuclear waste storage site (African Commission on Nuclear Energy 2024). Other technological developments in nuclear waste management, notably those related to molecular crystal development (in which such crystals serve to capture one of the most prevalent radioactive fission products, iodine) and waste-eating bacteria, have likewise been deemed game-changers (African Commission on Nuclear Energy 2024; Khan 2023). Along with such game-changing technologies, developments in advanced reactors—in particular, SMR development—promise to address not only concerns related to nuclear safety but almost all the fears related to conventional nuclear reactors.

3.2.2 Nuclear energy resurrected: The case for advanced nuclear reactors

SMRs refer to a class of advanced nuclear reactors that are small (compared to the size of traditional conventional nuclear reactors), modular (factory-assembled and transportable), use nuclear fission, and typically produce around 20–300 MW(e) per unit (International Atomic Energy Agency 2024a:8; Gattie & Hewitt 2023:19; Liou 2021). According to the IAEA's Advanced Reactors Information System (ARIS) database, there are currently some 68 active[3] SMR designs in different stages of research, development, and deployment. In China and Russia, some units are already deployed; in the US, the expected deployment date for that country's first SMR—NuScale's VOYGR design—is likely no earlier than 2027 (International Atomic Energy Agency 2024a:8; Coetzee 2024). Although advanced nuclear reactors are not restricted to SMRs or micro-reactors (a subset of SMRs), these reactors have the potential to improve the economics of nuclear energy projects (Gattie &

3 "Active" refers to designs "confirmed by their designers to the IAEA" (International Atomic Energy Agency 2024a). Globally, there are more than 80 SMR designs and concepts (International Atomic Energy Agency 2024b).

Hewitt 2023:2). They constitute, in the words of IAEA Director General Rafael Mariano Grossi, a "more affordable option" for energy-hungry developing countries, especially given that their upfront capital costs are likely to be significantly lower than conventional nuclear power plants (quoted in International Atomic Energy Agency 2024a; Mining Review Africa 2024; Royal 2023). SMRs can be factory-produced, then shipped and assembled on site, thus offering significant savings in terms of cost and construction time and reducing the overall risk profile of the project (International Atomic Energy Agency 2024a:8; Liou 2021; Clifford 2022; Gattie & Hewitt 2022). This flexibility in the construction, transportation, and assembly of SMRs, together with the transportability of micro-reactors once assembled (which can thus service areas considered inaccessible to large conventional nuclear power plants), means that these reactors can be harnessed to "achieve a level of decentralization by locating highly reliable generation in near proximity to high demand centers" (Gattie & Hewitt 2023:5; Liou 2024; Royal 2023). SMRs are also scalable (i.e., adaptable to changing energy demands of the communities in which they are deployed), which also eases challenges related to financing, and can be designed to integrate alongside renewables such as wind and solar (International Atomic Energy Agency 2024a:8; Royal 2023). Besides being capable of providing around-the-clock baseload and dispatchable power generation, SMRs and micro-reactors can be harnessed for industrial processes, ranging from desalination, district heating, process heat, power for developing alternative energy sources, and hard rock mining (Gattie & Hewitte 2023:2, 19; McFarlane & Gattie 2021:74; McFarlane 2021). In what is likely to be a strong demand signal and key to building a book of business, artificial intelligence (AI) data-intensive centres are increasingly turning to and investing in SMRs to meet their ever-expanding electricity demands, thus aligning SMR development with attempts to address twenty-first century energy needs (Lawson 2024).

In addition to the benefits outlined above, SMRs and micro-reactors are primed to play an indispensable role in meeting net-zero carbon emissions goals. According to IAEA projections, reaching net-zero carbon emissions will require a tripling of nuclear capacity by 2050, and SMRs are expected to produce at least a quarter of that capacity (International Atomic Energy Agency 2024a). In producing abundant and consistent baseload energy and a host of other benefits, SMRs and micro-reactors will do so without any onsite carbon emissions (Fox & McFarlane 2021). Some SMR designs also boast enhanced safety and operational characteristics—e.g., passive fail-to-safe features (in which a system automatically reverts back to a safe position after failure detection) or, in the case of a promising micro-reactor design, negative feedback features, passive heat removal, and "an independent emergency rod shutdown" (Gattie & Hewitt 2023:19; McGillis & Oung 2022). The impressive benefits of SMRs and micro-reactors are, however, offset (though scarcely so) by the fact that they have made little headway in reducing radioactive nuclear waste, with some studies focused on three SMRs with different reactor and fuel technologies (i.e., VOYGR, Natrium, and Xe-100) concluding that SMR waste will be "comparable" with conventional nuclear reactors (Singer 2022). The net result will be, as Kim, Boing, and Dixon (2024:1106) have noted, that managing SMR waste would pose "no major challenges" compared to those of conventional nuclear reactors. Most SMRs are likely to use high-assay, low-enriched uranium (HALEU) fuel, thus adding to the amount of radioactive nuclear waste. As the discussion above has indicated, some headway in addressing the challenges and fears related to radioactive nuclear waste has been made, though much more research and development is required. One promising development is the use of thorium as a fuel source, a naturally occurring radioactive element but one that produces "less toxic and shorter-lived radioactive waste". Tellingly, China is set to begin construction of the world's first thorium molten salt nuclear power station in 2025 (Kajal 2024).

All things considered, there is a strong case to be made that nuclear energy—in particular, advanced nuclear technology—can and should be harnessed to address the critical energy needs of developing economies, constituting an energy source that is safe, environmentally friendly, indispensable for net-zero carbon emission goals, and capable of providing consistent and reliable baseload energy.

3.3 From Russia and China with "love": The geopolitics of civilian nuclear energy projects

Escaping energy poverty is central to the plans and objectives of developing economies, with several African countries turning to nuclear energy to meet their critical and expanding energy needs or, at the very least, signalling their intention to do so in the future. The story of Africa's and other developing economies' turn to nuclear energy is, however, one that will be written against the backdrop of the rapidly unfolding geopolitical competition between, on the one hand, the US and a host of liberal democratic allies and, on the other hand, authoritarian and revisionist powers China and Russia. In this twenty-first century geopolitical struggle, nuclear energy projects are unlikely to constitute a politically neutral activity and, much less so, a purely market commodity. Instead, as Robert McFarlane and David Gattie (2021:73) note, nuclear energy constitutes "a weapon in an arena where state-owned enterprises are the competing gladiators". Nuclear energy projects constitute "arms" or extensions of states' foreign policies, with suppliers gaining military basing rights in strategically important areas in return for the shipment of nuclear fuel to these new sites (McFarlane & Gattie 2021:73). Accordingly, nuclear energy has emerged as a particularly powerful geopolitical tool in the foreign policy toolbox of this century's great or major powers[4].

3.3.1 Civilian nuclear energy and geopolitics: an old story

The geopolitics of nuclear energy and the use of nuclear energy projects as springboards for projecting national interests are nothing new. In fact, the national security value-added proposition of civilian nuclear energy is as old as the nuclear age itself, with nuclear energy deeply enmeshed within the geopolitics of the Cold War. The harnessing and application of nuclear fission to military weaponry—the crowning achievement of the Manhattan Project—afforded the US with a strategically vital first-mover advantage in nuclear energy, while at the same time sparking fears over how best to control

4 The question of whether Russia constitutes a great or major power is beyond the scope and concern of this chapter.

the proliferation of nuclear weapons and nuclear technology (Gattie 2024; Gattie & Hewitt 2023:12). Importantly, such fears reflected US concerns about losing its competitive advantage vis-à-vis the Soviet Union. National security concerns, primarily those related to providing stewardship to the growing nuclear fuel and technology ecosystem, informed the establishment of the US-based Atomic Energy Commission (AEA) in 1946 and, in 1957, the IAEA (Gattie & Hewitt 2023:12). The US's lead and competitive advantage in nuclear technology came to an abrupt end with the Soviet detonation of a nuclear device in 1949 (Gattie 2024). Against the backdrop of the rapidly intensifying geopolitical competition, the US National Security Council advanced its original principles of US civilian nuclear power policy in 1955, which were directed towards not only controlling the weaponisation of nuclear energy but (importantly for our purposes) harnessing and advancing "nuclear science, technology, and engineering" with a view to suppressing any Soviet effort to utilise civilian nuclear energy to foster enduring alliances with other countries (Gattie & Hewitt 2023:12). Notice the express national security objectives of these principles and the utilisation of civilian nuclear energy as a weapon in the unfolding Cold War great-power competition:

> *In the interests of national security, U.S. programs for the development of the peaceful uses of atomic energy should be directed toward:*
>
> *a. Maintaining U.S. leadership in the field, particularly in the development and application of atomic power;*
>
> *b. Using such U.S. leadership to promote cohesion within the free world and to forestall successful Soviet exploitation of the peaceful uses of atomic energy to attract the allegiance of the uncommitted peoples of the world;*
>
> *c. Increasing progress in developing and applying the peaceful uses of atomic energy in free nations abroad;*
>
> *d. Assuring continued U.S. access to foreign uranium and thorium supplies;*

> *e. Preventing the diversion to non-peaceful uses of any fissionable materials provided to other countries.* (Quoted in Gattie 2024; Gattie & Hewitt 2023:12)

Consequently, US civilian nuclear energy policy was from the outset deeply infused with national security considerations, fearing that the Soviet Union could exploit civilian nuclear energy to sway uncommitted countries—hence, buy influence and foster enduring alliance partnerships—and thus tilt the balance of power against the US, while at the same time inscribing in policy the strategic use of civilian nuclear energy in service of US geopolitical interests (Gattie 2024). The Soviet Union, of course, likewise recognised the strategic value of civilian nuclear energy. Accordingly, both states came to recognise that a relative advantage in nuclear technology is likely to engender a commensurate advantage in global influence, with civilian nuclear energy to be harnessed as extensions of each state's larger geopolitical goals (Gattie 2020:9; Gattie & Hewitt 2023:13). Against this backdrop, the US endeavoured—with great success, one must add—to establish itself as the twentieth-century's dominant power in civilian nuclear energy projects and technology (Gattie 2024).

3.3.2 Old, yet ever new: twenty-first century nuclear energy geopolitics

That was the world of the twentieth century, however. Today, US dominance in civilian nuclear energy is a distant memory, the US having lost its competitive advantage to China and Russia, the twenty-first century's leading powers in civilian nuclear projects and partnerships. Heavily subsidised Chinese and Russian state-owned enterprises are wasting no time in capitalising on the demand for nuclear power and, concurrently, the vacuum left by the atrophy of the US civilian nuclear energy industry. Tellingly, of the 60 nuclear projects currently underway in some 16 countries, the US is not leading in any (World Nuclear Association 2024c). When it comes to the number of reactors that have been connected to the grid and under construction since 2000, China and Russia are outpacing the US—and China is outpacing both (International Atomic Energy Agency 2024c). Previously, between 1960–1999, the US accounted for a large global share of the nuclear reactors connected to the grid: 130 as against Russia's 33 and China's 0 (Gattie 2024). Since 2000, however, China has connected 53 nuclear reactors to the grid (and has 29 under construction), Russia has connected 13 (and has four under construction), and the US has connected three (and has none under construction) (International Atomic Energy Agency 2024c; International Atomic Energy Agency 2024d; International Atomic Energy Agency 2024e). Moreover, since 2017, 27 out of 31 nuclear reactors under construction have been based on Russian and Chinese designs (Shats & Singer 2022). Besides this, while the US civilian nuclear energy sector was enjoying its slumber over the past three decades, China and Russia "have established mature, reliable, and increasingly domestically-sourced supply chains" by means of which they have ascended to global leadership in the construction and deployment of nuclear reactors (Gattie & Hewitt 2023:17).

Although China is leading the pack in terms of nuclear reactors under construction and grid connections, Russia remains dominant in the nuclear export market. From 2009 to 2018 alone, Russia obtained 23 out of 31 contracts for nuclear reactor exports (Li, Liu & Yu 2023:2; cf. also Lorenzini 2023 for Rosatom's dominance). At the time of writing, Russia had some 20 nuclear reactors "confirmed or planned for export construction", while China had but two (World Nuclear Association 2024d; World Nuclear Association 2024e). Russian dominance is not restricted to nuclear reactor exports, however. Russia also boasts the world's largest uranium conversion and enrichment industries (around 43% of global enrichment capacity), making that country a major player in nuclear fuel exports (Cohen 2024; Clarke 2023; Gilbert & Bazillian 2022). Moreover, Russian facilities provide around 40% of the world's uranium fuel supply (Luria & Freed 2023) and Russia, together with China, is actively investing in and forming strategic partnerships with key supplier states of yellowcake, so much so that observers now conclude that "dependence on Russia for nuclear fuel" poses an acute strategic vulnerability (Clarke

2023). Interestingly, while Russia has endured a relentless sanctions campaign due to its war on Ukraine, "global reliance on Russian nuclear reactors, equipment, fuels, and services has only increased" (Luria & Freed 2023; Dolzikova 2023:1). When looking to the future, the looming arrival of a host of SMR designs are likely to strengthen Russian dominance over the nuclear fuel cycle, especially given that many designs will use high assay low HALEU fuel. Although HALEU is produced in Russia and the US, the only commercially operational facility is currently located in Russia (International Atomic Energy Agency 2024a).

While Russian dominance in civilian nuclear energy is set to continue in the short to medium term, China is poised to become the twenty-first century's leading power in civilian nuclear energy. China certainly harbours ambitions to rapidly increase its nuclear footprint across the globe and become "the twenty-first-century's steward of civilian nuclear" (Gattie & Hewitt 2022b; Li, Liu & Yu 2023:1). Some observers note that China is destined to be become "the world's leading nuclear-power producer" by as early as 2030. Chinese policymakers have begun to realize the economic and geopolitical utility of nuclear exports, with Zhang Guobao, former director of the National Energy Administration, noting that "exporting one nuclear power plant is equivalent to exporting one million Volkswagen Santana sedans" (quoted in Liu 2022). Likewise, China's Thirteenth Five-Year Plan pointed towards (advanced) nuclear technologies as central to development and commercialization (Gattie 2020:9) China is already outcompeting the rest in the number of nuclear reactors connected to the grid and under construction and, crucially, boasts self-reliance in reactor design, construction and the nuclear fuel cycle (World Nuclear Association 2024e; Azman 2024; Shats & Singer 2022). Today, as during the Cold War, civilian nuclear energy is inextricably tied to the larger geopolitical ambitions and interests of the leading powers of the day. Once more, civilian nuclear energy constitutes a weapon to be utilised in service of the unfolding twenty-first century geopolitical competition. Recognising that "energy sovereignty" will constitute "the Westphalian Principle" of this century (Gattie & Hewitt 2022a), China has come to see nuclear energy, along with energy projects in general, as an important lever to further its geopolitical ambitions and interests.

Russian and Chinese interest in civilian nuclear energy projects as extensions of their countries' foreign policy has long-term potential to shape and then entrench this century's geopolitical landscape. If and where successful, such projects will result in the creation of alliances "that will shape geopolitics for the next sixty to one hundred years—the life of these plants, including decommissioning" (McFarlane & Hewitt 2021:73). Consider the case of Egypt. From the entering into force of the Egyptian government's contracts with Rosatom in 2017 to the fourth reactor's end of service life around 2110, Egypt will have locked themselves in a contractual relationship with Russia for well-near a century, an estimation that excludes the plant's decommissioning phase (Lorenzini 2023). This, in turn, will afford Russia significant leverage over an infrastructure asset critical to Egypt's energy security, "with potential geopolitical repercussions that may be felt beyond Egypt's borders" (Lorenzinin 2023). One such repercussion is already evident in several Sub-Saharan countries, where Russian provision of nuclear technology is fuelling diplomatic support for Russian policies in international fora, especially in the United Nations General Assembly (Gabriel 2024:4). In bringing civilian nuclear energy to energy-hungry African states, China and Russia are buying geopolitical influence and leverage and creating dependencies, while exporting their ideological preferences (Gattie 2024). Thus, whoever leads in addressing the soaring energy needs of developing economies will not only make a whopping profit but will also gain significant geopolitical leverage with these economies, which will be critical in shaping the twenty-first-century world order (Gattie & Hewitt 2022b).

3.4 Decoding the Chinese and Russian strategic playbook—and its implications for Africa

In considering China's interest in expanding its nuclear footprint across the globe, careful attention must be given to a strategy known in China's highest circles as "unrestricted warfare"—but which has publicly and euphemistically been labelled as the Belt and Road Initiative (BRI). The strategy aims to outflank the US and its allies, reducing their competitive and geopolitical influence, and affording China victory in this unfolding geopolitical competition "without ever firing a shot" (Gattie & Hewitt 2022b). This strategy is underpinned by three core objectives: one, capturing and controlling the world's strategic resources; two, taking critical terrain (such as Suez, Malacca and Gibraltar); and three, monopolising key markets (McFarlane and Gattie 2021:71). Consider the outworking of this strategy and its glaring success. Today, China owns much of the Democratic Republic of the Congo's industrial mines and about 60% of that country's cobalt; it owns much of Chile's lithium (used for *inter alia* electric vehicles, semiconductors, and specialized batteries, with China the world's top producer of refined lithium); and it owns or operates nearly 100 ports spread across 50 countries (e.g., in Sri Lanka, Greece, and Italy), some of which are located in strategically vital areas for maritime trade or potential military use (McFarlane and Gattie 2021:71; Fox and McFarlane 2021; African Defense Forum 2023; Sly & Ledur 2023). China's share in global solar panel manufacturing exceeds 80%, with the world's top 10 suppliers of solar PV manufacturing equipment located in that country (International Energy Agency 2023:15). Chinese strategic investments in mines supplying lithium, uranium, cobalt, graphite, nickel and other critical minerals are continuing apace (Wald 2024; Clarke 2023). In fact, Chinese companies account for 60% of worldwide production of global critical minerals and 85% of processing capacity (Benabdalla 2024). With specific reference to Africa, Lina Benabdallah (2024) warns that "China has emerged as a major player in Africa's mining sector" with Chinese companies securing "significant stakes in various mining operations" across the continent.

Russia seems to be operating from a similar playbook, with four large nuclear power reactors in Egypt under construction, thus positioning the Russian navy to utilise the plants as refuelling bases (Fox & McFarlane 2021). Russian SOE Rosatom is also involved in building four nuclear reactors in Turkey and one in Slovakia (both of which are NATO countries), with Russia's venture on the Turkish coast likely to grant its navy a dominant role in the Suez Canal and in the Eastern Mediterranean where Russia already boasts a naval base at the Syrian coastal town of Tartus (Cohen 2024; McFarlane & Gattie 2021:73; Fox & McFarlane 2021; International Atomic Energy Agency 2024f; International Atomic Energy Agency 2024g). As with China, Russia is increasing its strategic allocation of critical minerals (especially in relation to energy), with Moscow pursuing "preferential access to rare earth and uranium mines" in Africa, South America and elsewhere (McFarlane & Gattie 2021:73; Fox & McFarlane 2021; Clarke 2023; Gabriel 2024:3).

In the case of both China and Russia, these strategic initiatives are themselves building blocks of far grander geopolitical ambitions. Civilian nuclear energy projects constitute but one of several levers (albeit an important one) to pull in service of Chinese and Russian geopolitical ambitions. Using civilian nuclear energy projects as springboard to advance geopolitical interests is, of course, hardly a novelty, neither is the proposition that states are likely to avail themselves of every available lever to pull in service of their larger geopolitical ambitions. This is simply what great powers do. When great powers attempt to advance their geopolitical interests, they do so purposively. At the heart of much of Chinese and Russian geopolitical ambition is to dismantle the post-1945 Western liberal international order and replace it with "a new world order" that suits "their own authoritarian interests" (Gattie & Hewitt 2022a). The rallying cry behind constructing a new world order is not to create a more just, inclusive, liberal and peaceful world (notwithstanding the rhetoric coming from Beijing and Moscow) but, ultimately, to fashion an international order reflective of the values, rules, norms and interests of China and Russia. China, in particular, is bent on creating an international order wholly at odds with the post-1945 liberal international order, with Xi Jinping often brazenly expressing his desire to change the world (Easton 2022:26). This new world order, as Ian Easton (2022) notes, is predicated on the destruction of the free and open post-1945 liberal international order and "replacing it with a centralized regime made in its [i.e., China's] own image".

A war of ideas and for the hearts and minds of peoples and states is playing out before our eyes, with Xi Jinping indicating in no uncertain terms that the new international order will be Chinese-made and Chinese-inspired: "We will resolutely use Marxism to observe the age, understand this age, and lead this age. We will use modern China's vitality and rich experience to push forward the progress of Marxism … We will increasingly spread modern Chinese Marxism and Marxism in the twenty-first century!" (Easton 2022:51). It is, Xi Jinping noted on 1 January 2020, the "long-term strategic mission" of every member of Chinese society to disseminate ideas about the superiority of China's Marxist state system and state governance system, all of which will powerfully contribute to "the China Dream of realizing the great Chinese resurgence" (quoted in Easton 2022:56). In the global battle for the hearts and minds of people, exporting China's "unique communist system" to tear down and replace the Western liberal international order is a Chinese strategic imperative (Easton 2022:55). The lynchpin of Chinese foreign policy is not the BRI. It is also not "unrestricted warfare". Both of these are merely means to an end, with China's foreign policy being guided by the all-encompassing concept of a Community of Common Destiny for All Mankind. At its core, this concept is "a manifestation of China, as a world power, playing its role as protector of all humankind's shared values" (quoted in Easton 2022:61). Tellingly, these shared values will be shaped by China's conception of *its* interest and values, as the textbook on Xi Jinping Thought clearly elucidates: "The Community of Common Destiny for All Mankind will mold the interests of the Chinese people and those of the world together so they are one and the same" (quoted in Easton 2022:63). Much as in the Cold War competition, China's grand geopolitical ambitions and interests—not benevolence towards developing economies—informs its foreign policy.

Feverish attempts to fashion the unfolding international order according to the likes and preferences of the leading powers of the system are not unusual in world affairs. Instead, in considering the striking continuity of great-power behaviour throughout the ages, we are led to appreciate the contemporaneity of the dictum "that those who are ignorant of the past are condemned to repeat it" (Hazlitt 1979:10), a prescient warning for those developing economies increasingly under China's and Russia's orbit. Understanding the larger geopolitical ambitions undergirding Chinese and Russian foreign policy and, by implication, civilian nuclear energy projects is vital for prudent decision-making by African countries. The point here is not that Chinese and Russian SOEs are harnessing lucrative civilian nuclear energy projects to augment their geopolitical interests while Western liberal states would be loath to do the same (Coetzee 2024). On the contrary, commentators have over the last decade or so urged Western liberal states to get their house in order with the goal of outcompeting Chinese and Russian SOEs in civilian nuclear energy and to ensure cohesion among liberal states and, as a corollary, the longevity of the liberal international order (Gattie 2024). Great powers of all stripes and colours are likely to harness civilian nuclear energy projects in service of *their* geopolitical interests and in constructing an international order amenable to *their* values and interests.

For African states, accordingly, the key takeaway is to remain extremely vigilant of the geopolitical baggage accompanying prospective civilian nuclear energy partners and to chart a course that serves the interests of African states and *their* vision for the future (Coetzee 2024). Beyond trapping energy-hungry African states in long-term alliances with authoritarian partners, attractive civilian nuclear energy projects carry the additional danger of increasing African countries' exposure to debt risk, especially where such projects are predicated on conventional nuclear reactor designs (Lorenzini 2023). With their governments bankrolling their operations, Chinese and Russian SOEs are well positioned to provide enticing financing terms to developing economies desperate for nuclear energy yet lacking the means to fund it (Luria & Freed 2023; Liu 2022; Lorenzini 2023; McFarlane & Gattie 2021:71). Again, the contention is *not* that African countries should distance themselves from Chinese or Russian nuclear power plants while buying exclusively from Western vendors. Instead, whomever African states decide to buy from, political influence will be part and parcel of such projects. What is at stake in signing on the dotted line—i.e., in formalising long-term agreements with foreign powers to construct nuclear power plants in African countries—is the very notion of African agency. In essence, it really boils down to what—or more pertinently, whom—African states are willing to live with. Whether China, Russia, or the US, African states will not escape the geopolitical influence of their prospective nuclear energy partners (Coetzee 2024). Having another state supply critical nuclear infrastructure constitute a trade-off, not a solution. In such cases, African leaders must carefully weigh the gains and losses likely to accrue from long-term alliances with foreign civilian nuclear energy partners, with the losses sensibly defined as the depth and form of foreign political influence African states are willing to live with. Unfortunately, this estimation of losses cannot (and should not) be separated from the question of the type of society African states envision for themselves and their neighbours and, more broadly, the future of international order. This might sound very extravagant, but in reality it is not. Nothing short of the future of international order and the ability of African states to chart their own future are at stake in this iteration of the age-old saga of great-power competition.

3.5 Conclusion

This chapter set out to explore the geopolitics of civilian nuclear energy projects across the developing world, with a particular emphasis on African states. Nuclear energy—especially *advanced* nuclear reactors—presents an attractive, affordable, climate-friendly, and safe energy source for African states that are desperate to address their increasing energy needs. Several African leaders have come to view civilian nuclear energy as a long-term solution for achieving energy security, and Russian and Chinese SOEs have been more than willing to partner with African states. In offering nuclear deals to African countries desperate for energy security, Russian and Chinese nuclear vendors are hardly acting out of benevolence. They, not unlike the great powers during the Cold War, have come to realize and harness the strategic utility of civilian nuclear power projects. Beyond a mere market commodity, civilian nuclear energy projects provide have once again become weapons wielded by the great powers of the day and in service of their geopolitical interests and their conception of the future of international order. Chinese and Russian ambitions are geared towards redefining the twenty-first century's international order, with the former country earnestly contending to construct a world mirroring its own image. Again, this is simply what great powers have done historically and will continue to do. This geopolitical game is, however, directed at African states, with the potential of stripping African countries of their agency and entrapping them in long-term alliances with revisionist and authoritarian states. As mentioned above, African leaders are not encouraged to discard non-Western energy projects in favour of Western ones; instead, a keen appreciation of the long-term geopolitical baggage that comes with any prospective nuclear supplier must be paramount, an estimation that cannot be divorced from larger questions relating to the future of the international order and the type of society that African states envision for themselves and their neighbours.

References

African Commission on Nuclear Energy (AFCONE). 2024. Finland is on the verge of an incredible human-made alteration deep beneath the Earth: 'They'll hold a total of 5,500 tonnes of waste'. 1 April. Available at: https://www.afcone.org/finland-is-on-the-verge-of-an-incredible-human-made-alteration-deep-beneath-the-earth-theyll-hold-a-total-of-5500-tonnes-of-waste/

African Defense Forum (ADF). 2023. Chinese Mining 'Wrecking Lives' in DRC. 3 October. Available at: https://adf-magazine.com/2023/10/chinese-mining-wrecking-lives-in-drc/

Azman, F. 2024. The geopolitics of nuclear energy: partnerships, progress, and prospects. *Energy Focus.* 7 June. Available at: https://energyfocus.the-eic.com/nuclear/geopolitics-nuclear-energy-partnerships-progress-and-prospects.

Benabdallah, L. 2024. China's Role in Africa's Critical Minerals Landscape: Challenges and Key Opportunities. *African Policy Research Institute.* 6 September. Available at: https://afripoli.org/chinas-role-in-africas-critical-minerals-landscape-challenges-and-key-opportunities#:~:text=China's%20dominance%20in%20global%20critical,within%20the%20African%20mining%20industry.

Bosman, I., Lapenko, O. & Kachur, D. 2024. From Koeberg to Chernobyl: The Challenge of Nuclear Safety in SA and Ukraine. *South African Institute of International Affairs.* 4 November. Available at: https://saiia.org.za/research/from-koeberg-to-chernobyl-the-challenge-of-nuclear-safety-in-sa-and-ukraine/

Clarke, N. 2023. The UK Needs to Confront the Weaponisation of the Nuclear Supply Chain. *RUSI.* 9 June. Available at: https://www.rusi.org/explore-our-research/publications/commentary/uk-needs-confront-weaponisation-nuclear-supply-chain.

Cilliers, J. 2025. Africa's nuclear energy future. *ISS.* 23 January. Available at: https://issafrica.org/iss-today/africa-s-nuclear-energy-future

Clifford, C. 2022. Russian and Chinese designs dominate nuclear reactors, warns IEA chief. *CNBC.* 1 July. Available at: https://www.cnbc.com/2022/07/01/russian-and-chinese-designs-in-87percent-of-new-nuclear-reactors-iea-chief.html

Coetzee, E. 2021. Iran, the bomb and the spectre of (nuclear) terror. In Solomon, H. (ed.). *Directions in International Terrorism: Theories, Trends and Trajectories.* Singapore: Palgrave MacMillan, pp. 219–241. https://doi.org/10.1007/978-981-16-3380-5_10

Coetzee, E. 2023a. The specter of nuclear terror in Africa: another look. In Kostelyanyets, S. & Solomon, H. (eds). *Between Promise and Peril: African Security in the 21st Century.* Moscow: Russian Academy of Sciences, pp. 154–173.

Coetzee, E. 2023b. The prospects for nuclear and radiological terrorism in Africa. In Solomon, H. & Barlow, E. (eds). *The Future of War in Africa.* Amazon Publishing, pp. 98–111.

Coetzee, E. 2024. The Geopolitics of Civilian Nuclear Energy Projects in Africa. *RUSI Newsbrief.* 18 October. Available at: https://rusi.org/explore-our-research/publications/rusi-newsbrief/geopolitics-civilian-nuclear-energy-projects-africa

Cohen, A. 2024. China And Russia Now Dominate The Global Nuclear Trade. *Forbes.* 7 June. Available at: https://www.forbes.com/sites/arielcohen/2024/06/07/china-and-russia-now-dominate-the-global-nuclear-trade/

Comins, L. 2024. Power battle over nuclear 'solution' for South Africa's energy crisis. *Mail & Guardian.* 8–15 August, pp. 4–5.

Dolzikova, D. 2023. Atoms for Sale: Developments in Russian Nuclear Energy Exports. *RUSI.* 14 Februrary. Available at: https://rusi.org/explore-our-research/publications/special-resources/atoms-sale-developments-russian-nuclear-energy-exports

Donovan, J. 2022. 'Nuclear is making a strong comeback', IEA's Birol Tells IAEA Director General Grossi at IAEA COP27 Event. 9 November. Available at: https://www.iaea.org/newscenter/news/nuclear-is-making-a-strong-comeback-ieas-birol-tells-iaea-director-general-grossi-at-iaea-cop27-event

Easton, I. 2022. *The Final Struggle: Inside China's Global Strategy.* Manchester: Eastbridge Books.

Fox, L. & McFarlane, R. 2021. China wants to get a stranglehold on our vital energy supplies – but we CAN stop them. *Daily Mail.* 7 August 2021. Available at: https://www.dailymail.co.uk/news/article-9872359/China-wants-stranglehold-energy-supplies-LIAM-FOX-ROBERT-MCFARLANE.html

Gabriel, J. P. N. 2024. Russian Nuclear Diplomacy in the Global South, and How to Respond to It. *IAI Commentaries.* 13 March. Available at: https://www.iai.it/sites/default/files/iaicom2413.pdf

Gardner, T. 2024. Ghana signs agreement to build small NuScale nuclear reactor. *Reuters.* 29 August. Available at: https://www.reuters.com/markets/deals/ghana-signs-agreement-build-small-nuscale-nuclear-reactor-2024-08-29/.

Gattie, D. K. 2020. U.S. energy, climate and nuclear power policy in the 21st century: The primacy of national security. *The Electricity Journal.* 33 (1), pp. 1–14. https://doi.org/10.1016/j.tej.2019.106690

Gattie, D. K. 2022. Energy Sovereignty Will Be the Westphalian Principle of the 21st Century. *The National Interest.* 22 February. Available at: https://nationalinterest.org/feature/energy-sovereignty-will-be-westphalian-principle-21st-century-200724

Gattie, D. K. 2023. US hyperfocus on decarbonization creates geopolitical blind spots. *The Hill.* 3 July. Available at: https://thehill.com/opinion/energy-environment/3887287-us-hyperfocus-on-decarbonization-creates-geopolitical-blind-spots/

Gattie, D. K. 2024. Competitive Advantage as a National Security Objective for US Civilian Nuclear Power Policy. *Georgetown Journal of International Affairs.* 3 June. Available at: https://gjia.georgetown.edu/2024/06/03/competitive-advantage-as-a-national-security-objective-for-us-civilian-nuclear-power-policy/

Gattie, D. K. & Hewitt, M. 2022a. Energy Sovereignty Will Be the Westphalian Principle of the 21st Century. *The National Interest.* 22 February. Available at: https://nationalinterest.org/feature/energy-sovereignty-will-be-westphalian-principle-21st-century-200724

Gattie, D. K. & Hewitt, M. 2022b. The U.S. Can't Lose the Global Nuclear Energy Race. *The National Interest.* 17 December. Available at: https://nationalinterest.org/feature/us-can%E2%80%99t-lose-global-nuclear-energy-race-206032

Gattie, D. K. & Hewitt, M. 2023. National Security as a Value-Added Proposition for Advanced Nuclear Reactors: A U.S. Focus. *Energies.* 16 (17), pp. 1–26. https://doi.org/10.3390/en16176162

Gattie, D. K. & Massey, J. N. K. 2020. Twenty-First-Century US Nuclear Power: A National Security Imperative. *Strategic Studies Quarterly.* 14 (3), pp. 122–143.

Gilbert, A. & Bazillian, M. 2022. Russia's energy clout doesn't just come from oil and gas – it's also a key nuclear supplier. *The Conversation.* 18 March. https://doi.org/10.64628/AAI.7gy7mcwfk4

Hazlitt, H. 1979. *Economics in One Lesson.* New York: Currency.

Holt, M. 2019. Advanced Nuclear Reactors: Technology Overview and Current Issues. *Congressional Research Service Report*. No. R45706. CRS: Washington.

International Atomic Energy Agency (IAEA). 2024a. Small modular reactors: Advanced in SMR Developments. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/p15790-PUB9062_web.pdf

International Atomic Energy Agency (IAEA). 2024b. Small modular reactors. Available at: https://www.iaea.org/topics/small-modular-reactors

International Atomic Energy Agency (IAEA). 2024c. Power Reactor Information System – China, People's Republic of. Available at: https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=CN

International Atomic Energy Agency (IAEA). 2024d. Power Reactor Information System – Russian Federation. Available at: https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=RU

International Atomic Energy Agency (IAEA). 2024e. Power Reactor Information System – United States of America. Available at: https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=US

International Atomic Energy Agency (IAEA). 2024f. Power Reactor Information System – Türkiye, Republic of. Available at: https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=TR

International Atomic Energy Agency (IAEA). 2024g. Power Reactor Information System – Slovak Republic. Available at: https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=SK

International Energy Agency (IEA). 2023. The State of Clean Technology Manufacturing: An Energy Technology Perspectives Special Briefing. Available at: https://iea.blob.core.windows.net/assets/0a421001-6157-436d-893c-c37eeab54967/TheStateofCleanTechnologyManufacturing.pdf

Kajal, K. 2024. China to launch world's first thorium molten salt nuclear power station in 2025. *Interesting Engineering.* 26 July. Available at: https://interestingengineering.com/energy/china-world-first-molten-salt

Khan, R. 2023. Unlocking the power of molecular crystals: a possible solution to nuclear waste. *University of Houston.* 19 July. Available at: https://uh.edu/news-events/stories/2023/july-2023/07192023-molecular-crystals-solution-nuclear-waste.php

Kim, T. K., Boing, L. & Dixon, B. 2024. Nuclear waste attributes of near-term deployable small modular reactors. *Nuclear Engineering and Technology.* 56 (3), pp. 1100–1107. https://doi.org/10.1016/j.net.2024.01.046

Lawson, A. 2024. Google to buy nuclear power for AI datacentres in 'world first' deal. *The Guardian.* 15 October. Available at: https://www.theguardian.com/technology/2024/oct/15/google-buy-nuclear-power-ai-datacentres-kairos-power

Lazard. 2024. Lazard Levelized Cost of Energy+. June. Available at: https://www.lazard.com/media/xemfey0k/lazards-lcoeplus-june-2024-_vf.pdf

Li, A., Liu, Y. & Yu, Z. 2023. China's nuclear exports: Understanding the dynamics between domestic governance reforms and international market competition. *Energy Research & Social Science.* 103 (September), pp. 1–11. https://doi.org/10.1016/j.erss.2023.103230

Liou, J. 2021. What are Small Modular Reactors (SMRs)? *International Atomic Energy Agency.* 13 September. Available at: https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs

Liu, Z. Z. 2022. Renewing America's Leadership in the Global Civil Nuclear Energy Market. *Council on Foreign Relations.* 22 June. Available at: https://www.cfr.org/blog/renewing-americas-leadership-global-civil-nuclear-energy-market.

Lorenzini, M. 2023. Why Egypt's new nuclear plant is a long-term win for Russia. *Bulletin of the Atomic Scientists.* 20 December. Available at: https://thebulletin.org/2023/12/why-egypts-new-nuclear-plant-is-a-long-term-win-for-russia/

Lund, J. 2023. Hoodwinked: How China is using clean energy policy against the United States. *Wisconsin Energy Cooperative News.* 20 December. Available at: https://wecnmagazine.com/article/hoodwinked/

Luria, E. & Freed, J. 2023. The global nuclear energy market is a geopolitical battleground. Defense News. 29 March. Available at: https://www.defensenews.com/opinion/commentary/2023/03/29/the-global-nuclear-energy-market-is-a-geopolitical-battleground/

McFarlane, R. 2021. How American Can Counter China in the Energy Competition. *The National Interest.* 11 July. Available at: https://nationalinterest.org/feature/how-america-can-counter-china-energy-competition-189500

McFarlane, R. & Gattie, D. 2021. Nuclear Affairs. *The National Interest.* November/December, pp. 69–75.

McGillis, J. & Oung, A. 2022. Taiwan's Nuclear Option. *The Breakthrough Institute.* 19 December. Available at: https://thebreakthrough.org/journal/no-18-fall-2022/taiwans-nuclear-option

McGillis, J. 2024. Taiwan's Lai needs to rethink nuclear shutdown plan. *Nikkei Asia.* 22 April. Available at: https://asia.nikkei.com/Opinion/Taiwan-s-Lai-needs-to-rethink-nuclear-shutdown-plan

Mining Review Africa. 2024. Mining Indaba 2024: South Africa leads in Small Modular Reactor development. 7 February. Available at: https://www.miningreview.com/news/mi24-south-africa-pioneering-small-modular-reactor-development/.

McMurray, N. & Gattie, D. 2024. Building the Global Nuclear Energy Order Book. *RealClear Energy.* 22 May. Available at: https://clearpath.org/our-take/building-the-global-nuclear-energy-order-book-realclear-energy/

Nordquist, D. J. & Merrifield, J. S. 2023. The World Needs More Nuclear Power: Why the World Bank Needs to Get in the Game. *Foreign Affairs.* 12 January. Available at: https://www.foreignaffairs.com/world/the-world-needs-more-nuclear-power

Paraskova, T. 2023. South Korea bets big on nuclear energy at the expense of renewables. *Oilprice.com*. 12 January. Available at: https://oilprice.com/Latest-Energy-News/World-News/South-Korea-Bets-Big-On-Nuclear-Energy-At-The-Expense-Of-Renewables.html

Ritchie, H. & Rodés-Guirao, L. 2024. Peak global population and other key findings from the 2024 UN World Population Prospects. 11 July. Available at: https://ourworldindata.org/un-population-2024-revision

Royal, T. 2021. Why Climate Change Panic Is Unfounded Hysteria. *The National Interest.* 4 April. Available at: https://nationalinterest.org/feature/why-climate-panic-unfounded-hysteria-181741

Royal, T. 2023. Nuclear Power is the Answer to Global and Environmental Energy Woes. *The National Interest.* 21 April. Available at: https://nationalinterest.org/feature/nuclear-power-answer-global-and-environmental-energy-woes-206418

Savage, R. 2024. Rapidly urbanising Africa to have six cities with populations above 10m by 2035. *The Guardian.* 22 August. Available at: https://www.theguardian.com/world/article/2024/aug/22/rapidly-urbanising-africa-to-have-six-cities-with-populations-above-10m-by-2035

Shats, D. & Singer, P. W. 2022. The Balance of Power Is Shifting Among Nuclear-Energy Titans. *Defense One.* 5 October. Available at: https://www.defenseone.com/ideas/2022/10/balance-power-shifting-among-nuclear-energy-titans/378067/

Singer, S. 2022. Managing NuScale, other SMR waste will be 'roughly comparable' with conventional reactors, DOE labs find. *Utility Dive.* 23 November. Available at: https://www.utilitydive.com/news/smr-modular-reactor-nuclear-waste-doe-stanford-study-nuscale/637185/

Sly, L. & Ledur, J. 2023. China has acquired a global network of strategically vital ports. *The Washington Post.* 6 November. Available at: https://www.washingtonpost.com/world/interactive/2023/china-ports-trade-military-navy/

Wald, E. 2024. The US wants to end its reliance on Chinese lithium. Its policies are doing the opposite. *Atlantic Council.* 23 January. Available at: https://www.atlanticcouncil.org/blogs/new-atlanticist/the-us-wants-to-end-its-reliance-on-chinese-lithium-its-policies-are-doing-the-opposite/

World Nuclear Association. 2024a. Nuclear Power in Egypt. 25 April. Available at: https://world-nuclear.org/information-library/country-profiles/countries-a-f/egypt

World Nuclear Association. 2024b. Emerging Nuclear Energy Countries. 26 April. Available at: https://world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries#africa

World Nuclear Association. 2024c. Reactor Database. Available at: https://world-nuclear.org/nuclear-reactor-database/summary

World Nuclear Association. 2024d. Nuclear Power in Russia. Available at: https://world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power#export-of-nuclear-reactors

World Nuclear Association. 2024e. Nuclear Power in China. Available at: https://world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power#nuclear-technology-exports

World Nuclear News. 2024. US, Ghanian firms sign commercial agreement for SMR deployment. 30 August. Available at: https://world-nuclear-news.org/Articles/US,-Ghanaian-firms-sign-commercial-agreement-for-S