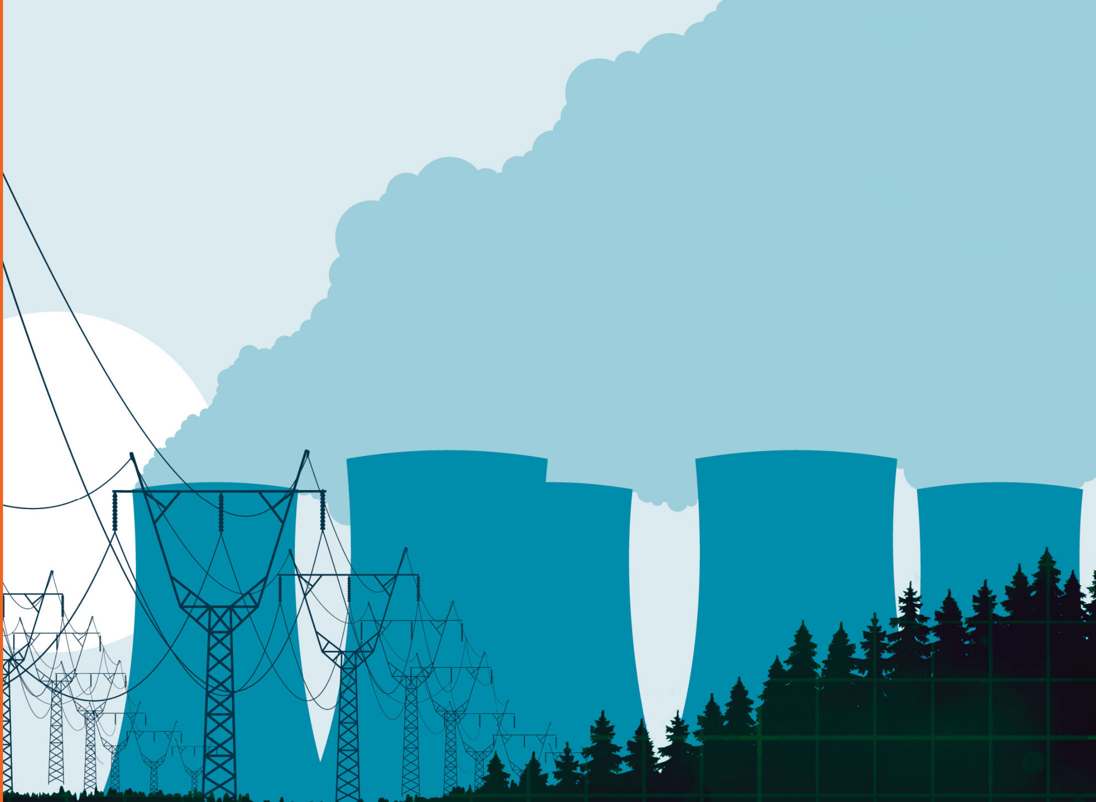

The Politics of Nuclear Energy in Africa

Opportunities, Fears and Constraints

Eben Coetzee (ed)

UNIVERSITY
OF
JOHANNESBURG

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UJ Press

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Published by UJ Press
University of Johannesburg
Library
Auckland Park Kingsway Campus
PO Box 524
Auckland Park
2006
https://ujpress.uj.ac.za/

First published 2025

https://doi.org/10.64449/9781997468714
978-1-997468-70-7 (Paperback)
978-1-997468-71-4 (PDF)
978-1-997468-72-1 (EPUB)
978-1-997468-73-8 (XML)

This publication had been submitted to a rigorous double-blind peer-review process prior to publication and all recommendations by the reviewers were considered and implemented before publication.

Proofreading: David Oldert
Cover design: Hester Roets, UJ Graphic Design Studio
Typeset in 9/13pt Merriweather Light

Contents

Foreword & Acknowledgements

This book stems from a longstanding interest in nuclear affairs. Although the scholars in this volume hold divergent views about the significance and consequences of the nuclear revolution for national and international politics, we all share the view that nuclear issues and challenges have been, and will continue to be, central to the security and development agendas of states and communities. Moreover, we are united in our desire for a world that is prosperous, peaceful, safe, and just. Whether nuclear energy is a force for good (or not) in the world of the present and future and a useful cog in the process of realizing this world, I leave to the reader to decide. Ultimately, if this book serves to kindle interest in the world of nuclear affairs, it will have served its purpose.

I would like to express my sincere thanks and appreciation to the contributors of this volume. Truly, without you this book would not be possible, and it was a privilege to exchange ideas with you. Your contributions have not only enriched this book but will greatly strengthen the academic discourse about the topic of this volume.

On a personal note, I would like to express my sincere thanks to my wife for her unceasing support. During difficult times, you have been a source of inspiration and encouragement, and you have supported me in ways of which you might not have always been aware. Finally, I can only attest and, with a grateful heart, echo the words of one of my favourite hymns: "I owe it all to Jesus" – everything.

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Editorial Foreword

Sven Botha
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"Now, I am become Death, the destroyer of worlds." J Robert Oppenheimer, known as the 'father of the atomic bomb', uttered these words after witnessing the Trinity test, the first detonation of a nuclear weapon, on 16 July 1945. There have been well over 2,000 nuclear tests since then.[1] As remote instruments of death, the ability of these weapons to spread enmity, discord, destruction and fear is extensive.

Despite key international instruments being implemented to curb nuclear non-proliferation – such as the Nuclear Non-Proliferation Treaty (NPT) (1968), the Comprehensive Nuclear-Test-Ban Treaty (1996), the United Nations General Assembly's declaration of the International Day Against Nuclear Tests (2009), and the Treaty on the Prohibition of Nuclear Weapons (TPNW) (2021) – nuclear weapons remain an obstacle to international peace and security. It is an obstacle that has intensified as the international community enters a time of great uncertainty.

This air of uncertainty is cultivated by leadership styles that are best characterised as unpredictable and fluid. Such approaches to world leadership make it difficult to predict choices and outcomes. This stark reality is concerning when one considers that the world's two largest nuclear arsenals are under the custodianship of President Vladimir Putin of Russia and the US's President Donald Trump. While President Putin has demonstrated his preference for war over diplomacy with the invasion of Ukraine in 2022, President Trump has maintained an ambivalent stance on nuclear weapons. During

1 Kimbell, D. 2025. The Nuclear Testing Tally. Washington, DC: Arms Control Association [November 2025]. https://www.armscontrol.org/factsheets/nuclear-testing-tally

his first term (2017 – 2021) as president, he dismantled the Iran Nuclear Deal and continues to threaten Iran following Operation 'Midnight Hammer' on the 22nd of June 2025. Likewise, via his Department of Government Efficiency, President Trump stripped the National Nuclear Security Administration of key human resources – thereby undermining the US's ability to safely maintain its nuclear arsenal – while also recently deploying two nuclear submarines following Russian antagonism, which was fuelled by ultimatums President Trump had made to Moscow over a ceasefire with Ukraine in August 2025, an escalation that the world has not seen since the Cuban Missile Crisis.

In light of this ardent posturing on nuclear issues, it's difficult to imagine President Trump opting for nuclear disarmament. Nonetheless, this is what occurred in February 2025 when he proclaimed that the three leading nuclear weapons states (Russia, the US and China) were spending "too much" on their nuclear weapon arsenals, and subsequently proposed that they trim their defence budgets by cutting back on these arsenals. While President Trump's track record is questionable, the business-savvy nature of this proposal may compel him to make a sincere effort at its attainment. It remains to be seen whether this proposal will stagnate or proliferate in its own right.

Regardless of the decision the US president opts for, nuclear non-proliferation and disarmament are tarnished by two additional factors. Firstly, the continued rise of far-right political parties undermines non-proliferation and disarmament commitments. This is because these political leaders have a preference for turning their policy focus inward, resulting in disengagement and, sometimes, withdrawal from key multilateral forums.[2] Moreover, far-right political leaders appeal to the emotions of the electorate, often resulting in the adoption of a hands-on stance on issues of defence and security. Nuclear weapons and associated technologies fall within this discourse. This suggests that governments where far-right political parties

2 Meler, O and Vieluf, M. 2021. Upsetting the Nuclear Order: How the Rise of Nationalist Populism Increases Nuclear Dangers. *The Nonproliferation Review*, 28(1-3): 13-35.

are present would prefer to maintain nuclear stockpiles for the sake of deterrence.

Secondly, the world continues to see rapid technological innovation, and the emergence of artificial intelligence (AI) and associated technologies is no exception. In his book *Leadership: Six Studies in World Strategy*, prior to his death, former US Secretary of State Henry Kissinger warned of this phenomenon. He wrote that AI would enable weapons "to launch themselves based on their own calculations."[3] Turning to such weapons (or even entertaining the threat of them) with relative ease creates the potential to "turn a crisis into a war or transform a limited war into a nuclear one through unintended or uncontrollable escalation."[4]

As the world ponders the future of (in)security and (un) predictability, it is important to keep an eye on the 2026 NPT and TPNW Review Conferences, where states that are party to these treaties will meet to assess their implementation and progress. South Africa will chair the latter Review Conference. Citizens must carefully consider their own agency within this discourse by reflecting on how their political choices could have a direct impact on the international security landscape. Similarly, political parties that are now in opposition and seek political power must recommit themselves to a world free of nuclear weapons, and find ways to understand and address the needs that fuel the politics of emotion on the far-right.

Present circumstances could result in nuclear weapons becoming more commonplace. One nuclear weapon going astray could cause hundreds of thousands of deaths in populated areas and would have a detrimental environmental impact on future generations. Future policy discourses must address the issue of political trust, the regulation of technology for weapons purposes and the quality of political leadership.

Amidst all of this uncertainty, Coetzee's volume provides us with an opportunity to reflect on Africa's position within the nuclear politics discourse. Essential here is Africa's position as

3 Kissinger, H. 2024. *Leadership: Six Studies in World Strategy.* New York: Penguin, 410.

4 Ibid.

the world's latest nuclear weapons-free zone. The absence of nuclear weapons leaves the continent free to explore its hand at nuclear energy to meet its energy needs. This volume brings together an insightful cohort of emerging and established scholars who grapple with many of the contemporary debates pertaining to Africa's nuclear energy domain including: nuclear energy as a driver for regional development, the complimentary roles of the non-proliferation and peaceful use regimes, geopolitical murmurs, untapped nuclear desires, and nuclear governance.

While this volume underpins the importance of African agency in the nuclear energy debate, readers are also reminded of the limits of such agency which have come to include untapped nuclear desires, political instability, and poor governance. This realistic account of Africa's position vis-à-vis nuclear politics does not only provide a comprehensive overview of the 'state of play', but also serves as launch pad to further research and debate.

Introduction

The Politics of Nuclear Energy – A Debate Renewed

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Few words evoke more passionate debate and reveal such widely divergent views as the word "nuclear". Whether in reference to "nuclear weapons", "nuclear energy", or "nuclear terrorism", nuclear-related questions and issues continue to garner the attention or suffer the opprobrium of scholars, decision-makers, and international and regional organisations. Ever since the nuclear genie was let out of the bottle, fears of impending nuclear disaster—whether in the form of all-out nuclear war or nuclear terrorism—have gripped the attention of policy makers and scholars (for a recent restatement of these fears, cf. Niemeyer 2023; Jacobsen 2024; Karam 2021; Narang & Sagan 2022). As Robert Gates, the former United States (US) Secretary of Defence, noted, every high-ranking government official is kept awake at night by the spectre of a nuclear-armed terrorist group inflicting unimaginable destruction on society (quoted in Coetzee 2020:371). Also, in the wake of the Russian invasion of Ukraine in February 2022, frequent Russian nuclear sabre-rattling has reignited fears about an all-out nuclear blowout, while the safety of nuclear power plants during this war has remained a very real concern (Williams 2024). The prospect of a nuclear-armed Iran and how that development could (but not necessarily would) lead to a nuclear cascade in the Middle East also looms large (Coetzee 2021). At the same time, Chinese modernisation of its nuclear forces continues apace, while nuclear-armed North Korea's rambunctious behaviour persists (Kristensen *et al.* 2024). Uncertainty about its external security situation is constraining South Korea, a country historically at odds with nuclear weapons possession, to begin contemplating or, at the very least, publicly discussing the merits and demerits of a South Korean nuclear weapons programme (Kelly & Kim 2024; Cha 2024:1). In the context of the unfolding bipolar or, as some contend, multipolar world, fears about the stability of nuclear deterrence have proliferated. Disruptive technologies, ranging from artificial intelligence (AI), cyber warfare, hypersonic weapons, to quantum computing, ostensibly pose insurmountable risks to deterrence stability, especially in relation to the survivability of second-strike nuclear forces and nuclear command and control systems (Lieber & Press 2017; Lieber & Press 2018; Coetzee 2021).

We also recognise and appreciate that consideration of nuclear issues cannot be wholly reduced to the dangers of nuclear Armageddon or nuclear terrorism. For more than seven decades, nuclear fission has been harnessed in service of improving the lot of the ordinary person, whether in the form of electricity generation (and the benefits accruing from it) or in pursuit of a range of industrial purposes. Accordingly, civilian nuclear energy has proven to be a reliable, (relatively) safe, mature technology, capable of providing abundant baseload and clean energy. This, of course, is only one half of the story. The other half can best be described as an unveiling of the dark side of civilian nuclear energy. In this unveiling, attention is focused on probing the intentional or unintentional effects accruing from the construction and operation of nuclear power plants, the management of radioactive nuclear waste, preventing nuclear accidents and responding to them when they do occur, and exposing the prevalence of nuclear sacrifice zones in which entire communities remain locked in the harmful effects accruing from their exposure or proximity to civilian or military applications of nuclear technology. Belatedly, there is also a growing recognition that today, as during the Cold War, civilian nuclear energy projects are weapons in the foreign policy toolboxes of nuclear exporters through which such states export their ideological preferences and advance their geopolitical interests.

As evident from the above, the contestation over civilian nuclear energy—what this book calls the 'politics of nuclear energy'—remains unusually salient, and more so given several assessments that the future of civilian nuclear energy looks much rosier than what would have been predicted a few decades ago (cf. Tirone 2024; Azman 2024; Donovan 2022). Increased interest in civilian nuclear energy across the developing world and, by extension, in African countries have soared, as these countries attempt to fight and overcome the scourge of energy poverty, betting that nuclear energy can provide a long-term solution. Some countries that have turned their backs on civilian nuclear energy have restarted debates about returning to nuclear power, with Germany and Taiwan constituting but two cases (McGillis 2024; DW 2024; McGillis & Oung 2022). Whatever the outcome of these debates, the crucial point is that appetite for civilian nuclear energy remains strong and, in fact, growing and that the arrival of a new generation of advanced nuclear reactors (inclusive of small modular reactors (SMRs) and micro-reactors) could further entrench the upward trajectory of civilian nuclear energy. With the future of civilian nuclear energy looking bright, debate on and the politics of civilian nuclear energy is likely to remain central to national and international politics.

The idea and rationale for this book stem from humble beginnings. In November 2022, a small group of scholars (mostly from South Africa) presented papers at an online webinar titled "The Politics of Nuclear Energy in Africa". This engagement emerged against the backdrop of two discernible realities: one, an increased reliance on or, at the very least, expression of interest in nuclear energy by African countries to address their energy needs; two, the need to create a community of scholars (located in Africa and concerned with the continent's future) with specialist knowledge about (African) nuclear affairs and, concomitantly, critical engagement by such an expanding community with Africa's increasing nuclear footprint. Research by African scholars on *African* nuclear affairs, though not altogether absent, remains scant and, unfortunately, piecemeal.

Formerly, with Africa standing largely (though, of course, not completely) aloof of nuclear-related issues, no real need or scholarly appetite for nuclear-related research focusing on the continent existed. Where engagement did occur, it almost invariably focused on the South African case—i.e., South Africa's nuclear weapons programme or the continent's only nuclear power station located at Koeberg, South Africa. While such engagement, especially with reference to the safety and longevity of Koeberg, remains pertinent, Africa's increasing nuclear footprint is necessitating wide-ranging, persistent and critical engagement about how best to understand and manage the continent's nuclear future (and the sprawling range of issues accompanying civilian nuclear energy projects), the pitfalls to avoid, the constraints to be faced and, importantly, the opportunities to embrace. This edited volume attempts to fill this gap, emphasising that there are significant benefits *and* risks, opportunities *and* constraints, associated with Africa's nuclear future.

The plan of the book

With several African states turning to civilian nuclear energy or, at the very least, expressing their intentions to do so, mapping the benefits and pitfalls of civilian nuclear energy (projects) are crucial, as is finding the best pathways through the complexities constitutive of the nuclear energy landscape. It stands to reason that increased reliance on nuclear energy in Africa (and, for that matter, across developing economies) brings with it a host of issues, challenges, fears, constraints and, importantly, opportunities and benefits. Wherever the prospect of civilian nuclear energy emerges, we must be leery of exaggerating the drawbacks while neglecting the benefits, a proposition that cuts both ways. At best, civilian nuclear energy presents a trade-off, not a solution. Some of these fears, challenges and constraints—e.g., the spectre of nuclear terror and nuclear proliferation—are perhaps exaggerated, with the concomitant consequence of possibly dampening the enthusiasm for nuclear energy among some African states, especially those as yet uncommitted or undecided about civilian nuclear energy; other issues and fears, such as those relating to nuclear waste management, nuclear sacrifice zones and the safety of existing nuclear power plants on the continent (notably, the Koeberg Nuclear Power Station in South Africa), are under-explored, and in dire need of critical engagement. Beyond these issues and fears, there is also the stark realisation that nuclear energy, and increased reliance on it by African countries, is unlikely to be a politically neutral activity. In fact, Africa's future nuclear footprint plays itself out against the backdrop of an intense geopolitical competition, one very much reminiscent of the Cold War powers' utilisation of civilian nuclear energy projects to spread and entrench their ideological preferences and further their geopolitical interests. That there are also real benefits to accrue from Africa's turn to civilian nuclear energy is undeniable. Moreover, some of these benefits could multiply (and some of the enduring concerns might be placated) by the arrival of SMRs and micro-reactors.

In short, Africa's increased nuclear footprint holds both promise and pitfalls, with long-term consequences—good and bad—for African agency, development, and security. Against this backdrop, the primary aim of this book is to analyse, explore, and evaluate the unfolding nuclear landscape of African states—in short, the 'politics of nuclear energy in Africa'. More specifically, the book has the following objectives, namely to:

- Describe the unfolding African nuclear landscape, with due emphasis on the increased reliance on nuclear energy to meet the soaring energy demands of African states and societies;
- Consider the costs and benefits to African states and societies accruing from an increased reliance on nuclear energy;
- Emphasise the significance and indispensability of international law and non-proliferation regimes and organisations to Africa's nuclear future;
- Describe, foreground, and address possible challenges related to managing nuclear power plants; and
- Describe and explain the larger geopolitical context in which African's nuclear future will unfold and the attendant consequences for African agency, development, and security.

Structure of the book

The authors of this volume attempt to probe the most pertinent issues related to Africa's increasing nuclear footprint, while noting that the issues covered here are not exhaustive of the complex issues part and parcel of the nuclear energy landscape. The contributors of this volume included scholars from the University of Johannesburg, South Africa—Prof. Anna-Mart van Wyk and Wandile Shezi; from the University of South Africa—Prof. Jo-Ansie van Wyk; from the South African Institute of International Affairs—Isabel Bosman; from the University of Leeds, the United Kingdom—Dr Tom Vaughan; from the University of the Western Cape, South Africa—Prof. Joelien Pretorius; and the University of the Free State, South Africa—Prof. Eben Coetzee.

Although the chapters of this volume speak to different aspects of the politics of nuclear energy, there is wide agreement that, for better or worse, nuclear energy stands central to the past, present and future of international politics—and, importantly, the future of Africa. Extensive and deep differences concerning the benefits (if any) and drawbacks (if any) of nuclear energy are, accordingly, discernible among the authors of this volume. These differences and open debate about them are something to be welcomed, celebrated and, with a view to the future, encouraged. In much the same vein, the book's chapters reflect different research goals (description and explanation or some combination of the two), different types of theories (problem-solving and critical and/or postcolonial theory), and different methods (empirical-analytical, interpretive and critical). Again, this tremendous diversity is a boon, itself reflective of the diversity of ways of understanding Africa's nuclear future and the need for open debate across scholars holding different ontologies, epistemologies, theories, and methods. Some chapters in this volume (see, especially, Chapters 1–3) are far more optimistic than others about the potential benefits of nuclear energy for the continent. Others (see, especially, Chapter 6) cast doubt on the presumed indispensability of nuclear energy to power national grids. Although no pretension is made in this book about a proverbial golden thread running nicely through it, the chapters are structured with a view towards illuminating, on one end of a continuum, those who emphasize the overriding benefits of civilian nuclear energy (cf. Chapter 1), those who cast doubt on the indispensability of nuclear energy for powering national grids on its other end (Chapter 6), those emphasizing that nuclear energy constitute a trade-off with the benefits outweighing the drawbacks (Chapters 2 and 3), and, finally, those showcasing the dark side of nuclear energy and how the drawbacks of nuclear energy overshadows its real or potential benefits (Chapters 4 and 5). Ultimately, the structure of the book allows for the reader to approach each chapter as a standalone chapter, while sufficient continuity exists for the reader wishing to peruse and consume every page of the volume.

In Chapter 1, "The Potential Role of Nuclear Energy in Promoting Regional Economic Development in SADC", Wandile Shezi and Prof. Anna-Mart van Wyk make a case for energy as the indispensable foundation of modern-day society and industry. As the world moves towards cleaner energy initiatives, they argue, governments should embrace new technology to mitigate the effects of global warming. The over-reliance on coal as a source of energy continues to negatively affect the climate, and member states of the Southern African Development Community (SADC) continue to experience challenges in accessing sustainable energy in the region. As a result, the region has experienced lower economic growth prospects and challenges with industrial strategy. South Africa, the region's dominant energy generator, plays a significant role in ramping up energy supply to the region via the Southern African Power Pool (SAPP). In the chapter, a case for nuclear energy programmes (in the form of small modular reactors (SMRs)) is presented as a possible mitigation strategy for the region's energy crisis, with South Africa being poised to play a leading role in this strategy owing to its decades-long success in operating civilian nuclear energy programmes. Civilian nuclear energy is one of the most low-carbon-emitting energy sources in the world and is presented in this chapter as a key solution to addressing the twin challenges of global warming and energy poverty.

In Chapter 2, "Advancing Nuclear Energy: Why Peaceful Uses Need the Non-Proliferation and Disarmament Regimes," Isabel Bosman notes that the benefits accruing from the peaceful application of nuclear science and technology (of which electricity production is only one) cannot and should not be separated from the development and entrenchment of a robust legal framework. Such a framework is not only indispensable for the safety and security of nuclear power plants but is also critical for creating a security environment in which nuclear installations are protected in times of conflict and, more importantly, where the authority of these legal instruments is respected. An increasing number of African states have expressed interest in including nuclear power in their energy mix to extend electricity access to their populations and to combat the effects of climate change. Africa has relied on the law to establish its territory as a nuclear weapons-free zone through the Treaty of Pelindaba, which *inter alia* provides the legal basis for the peaceful uses of nuclear energy on the continent and contains articles relating to the physical protection of nuclear installations and preventing armed attacks against them. The Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the cornerstone of the nuclear non-proliferation regime, was born out of the need to prevent an increasing number of states from acquiring nuclear weapons. In addition, the peaceful use of nuclear energy is one of the treaty's three core principles. Drawing on the links apparent from the Treaty of Pelindaba and the NPT, among others, between peaceful uses, non-proliferation, and disarmament, the chapter explores the notion that discussions about the peaceful application of nuclear energy and non-proliferation should not occur in isolation. Instead, such discussions should be seen as complementary and linked by a crucial element: the law.

In Chapter 3, "The Geopolitics of Nuclear Energy in Africa: What, Who, and Why?", Prof. Eben Coetzee examines the weaponisation of nuclear energy projects in service of the geopolitical interests of this century's leading great powers. The chapter first sets out to provide a case for civilian nuclear energy—especially in the form of advanced nuclear reactors (inclusive of SMRs and micro-reactors)—as an important means by which African states can and should address their soaring energy needs. However, civilian nuclear energy, whether in the form of conventional or advanced nuclear technology, presents at best a trade-off. During the Cold War, the leading powers of the era quickly recognised the strategic utility of civilian nuclear energy projects, with each great power harnessing—or, at the very least, attempting to harness—these projects in service of creating an international order reflective of *their* interests and values. Today, much like during the Cold War, China and Russia are using civilian nuclear energy projects to create decades-long alliances in strategically vitally areas of the world, a strategic endeavour amounting to nothing less than an attempt to refashion the international order in accordance with *their* values and interests. The behaviour is typical of how great powers usually behave. In considering these projects, the chapter probes the debilitating consequences for African agency, especially given the fact that collaboration in civilian nuclear energy projects is likely to lock African states in decades-long strategic alliances with authoritarian states. Once again, African states are unwittingly caught in the crosshairs of great-power competition.

"Unfulfilled Desire, Impossible Futures: The Contradictions of African Regional Nuclear Ordering", written by Dr Tom Vaughan and Prof. Joelien Pretorius, is the focus of Chapter 4. There is a drive, the authors contend, to expand the nuclear regime complex in Africa at the meso level through regional cooperative arrangements, such as the African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA), the African Commission for Nuclear Energy (AFCONE), and the Forum of Nuclear Regulatory Bodies in Africa (FNRBA). At face value, a regional layer of the nuclear regime complex is seen as a common-sense good to take ownership of ordering nuclear matters in Africa, and to map a path to development in Africa amidst climate change through nuclear energy. There is also no doubt that these well-intentioned organisations pursue regime expansion to give Africa a louder voice in the global nuclear order, however there is reason to look more critically at the performative agency of these nuclear organisations.

Governance through regime complexes may serve interests and power relations that are not always evident in the goals set out in founding documents and work plans. The critical framework that the chapter brings to the table draws on the work of Gabrielle Hecht, Shampa Biswas, Itty Abraham and Sidra Hamidi and allows the authors to reveal some of the trade-offs and power relations at work.

In Chapter 5, Prof. Jo-Ansie van Wyk explores "The Necropolitics of Africa's Nuclear Sacrifice Zones". Nuclear sacrifice zones have been described as radioactive landscapes of risk that have typically resulted from uranium mining or nuclear waste disposal. The communities in these socio-political landscapes often display unique pathologies associated with anger, danger, risk and death. By utilising the work of Foucault and Mbembe on biopolitics and necropolitics, the contribution explores and compares the necropolitical nature of selected nuclear sacrifice zones in Africa and the implications thereof. The chapter's object is to identify challenges to and opportunities for the continent's peaceful use of nuclear energy.

Chapter 6, Prof. Anna-Mart van Wyk's "Koeberg Controversies", sheds light on Africa's lone nuclear power station, Koeberg, situated 30 kilometres north of Cape Town, South Africa. The plant has two French-supplied reactor units, which combined contribute 1,849 MW of power to South Africa's national grid—roughly 5% of the country's electricity. Over the years, but particularly during the last decade, the plant has been embroiled in controversy, ranging from extensive issues and delays related to the renewal of its operational licence for another 20 years to the identification of several issues by the International Atomic Energy Agency (IAEA) related to management, safety, revalidation, environmental qualifications, electromagnetic compatibility, and an appropriate monitoring system for the containment structure. In addition, senior managers have resigned or have been suspended. The primary aim of this chapter is to track Koeberg's operations and controversies since the plant's activation in 1984 and assess whether the life extension project is feasible or at risk of collapsing completely, which would be detrimental to

South Africa's energy generation given the continuous load-shedding that has plagued South Africa and to which Eskom (the state-owned electricity utility) has been unable to provide workable solutions.

Taken together, this book's six chapters provide a timely engagement with the unfolding nuclear landscape in Africa, emphasising that substantial issues, risks, constraints, challenges, opportunities, and benefits will likely mark the continent's turn to nuclear energy.

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Chapter 1

The Potential Role of Nuclear Energy in Promoting Regional Economic Development in SADC

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Johannesburg South Africa

1.1 Introduction

The concepts of baseload, peak load, and medium load are fundamental to understanding power generation dynamics. Baseload represents the minimum level of electricity generation that is consistently required over a 24-hour period to satisfy continuous demand. Meanwhile, medium and peak loads pertain to the supplementary power produced in excess of the baseload; however, this additional generation may not always be required at all times (NEMA 2024). A state's capability to produce sustainable baseload energy ensures that the industrialisation process occurs without energy limitations on growth. For centuries, coal-fired energy, a carbon-intensive resource, has championed the Industrial Revolution periods and served as a baseload technology (Unger 2013:5; Jonsson 2012:5). However, an alternative baseload source is required in a world that increasingly seeks environmentally friendly and green energy initiatives. Arguably, there is no such thing as a benign energy project when considering sustainability and the environment; however, the future of energy generation requires more eco-friendly alternative technology.

Sustainable development is significantly hampered when limited access to energy is experienced as a result of socio-economic development being affected. The leading causes contributing to energy issues in developing and emerging regions include overpopulation, excessive consumption, poor power distribution systems, inadequate infrastructure, and ongoing delays in the commissioning of power plants, all of which are interconnected to the impacts of climate change. Climate change amplifies these issues by putting additional stress on already fragile systems. The unprecedented weather patterns associated with climate change strain energy production, particularly in systems reliant on hydropower, while increasing the energy demand from cooling and irrigation. Numerous efforts to establish sustained electricity generation in Africa have failed, leading to an energy crisis that cripples the continent (Mulugetta, Hagan & Kammen 2019). This is also true of the member states of the Southern African Development Community (SADC). In recent decades, SADC has experienced a significant disturbance in sustainable electricity supply characterised by frequent power outages, load curtailment, and load-shedding. As a result, SADC states have experienced a lower prospect of economic growth, which has implications for the region's industrialisation strategy. SADC's mandate requires a structural transformation that seeks to industrialise, modernise, and improve the region and bring about greater regional integration (Mapuva & Muyengwa-Mapuva 2014:28; Muller 2018:7; Eskom 2020).

South Africa's parastatal power utility, Eskom, supplies electricity to seven states in the SADC region. This makes South Africa the dominant electricity generator in the region—an important role, especially given the state's dominant economic status in the region (Nare 2018). However, Eskom continues to struggle with meeting electricity demand. Over the past decade, it has tried to alleviate the situation by building new coal-fired power stations in order to produce relatively low-cost energy for its customers. However, the demand far exceeds the supply, and both the new and old coal-fired power stations have been wracked with continual problems. Eskom's continued energy-generation struggle negatively affects the entire Southern African region (Booth & Therkildsen 2012; International Business Publication 2015:79).

This chapter argues that integrating an extended nuclear energy capability into South Africa's energy mix is a no-regret option. Nuclear energy has been an indispensable component of the state's energy framework for several decades. The growing demand for nuclear energy, which is known for its low-carbon emissions and efficiency as a baseload power source, reflects the increasing urgency of addressing climate change. This trend is driven by the global imperative to achieve net zero carbon emissions by 2050, and this further underscores the role of nuclear energy in transitioning to sustainable energy systems (Vásquez-Maignan, Richards & Konig 2024). As highlighted in the state's 2019 Integrated Resource Plan (IRP2019), decision 8 indicates that the state may proceed with preparations for a new nuclear build programme of the order of 2,500 megawatts (MW). This ensures that nuclear energy remains part of the state's energy mix and part of the future; it is indispensable to the achievement of energy sovereignty in the state (Comins 2024; DoE 2019: 48). The technology is poised to create exponential opportunities for socio-economic development in the country while also alleviating the existing energy crisis, meeting sustainable development goals, and bolstering economic development in the SADC region. This is because the importance of the peaceful use of nuclear technology—particularly civil nuclear technology—as a low-carbon-emitting energy development pathway is gradually growing in importance, despite the heightened concerns around the risks of nuclear energy following the 1986 Chernobyl and 2011 nuclear accidents in Ukraine and Japan, respectively (Olutola 2018b). But the good thing about technology is that it is constantly evolving. Over the decades, conventional nuclear power plants, generating 700+ MW of electricity, have been dominant. However, in recent years, advanced nuclear reactors for electricity generation have emerged that are designed to address some of the challenges of conventional nuclear power plants (Sweatman & Schroer 2024).

The decreased use of nuclear energy in developed states such as the United States of America (USA), Germany, and France, owing to, among other things, the need to replace ageing nuclear plants, has raised concerns about the disruption of energy output. Nevertheless, the desire to include nuclear energy in the energy mix remains strong in some regions, especially in developing states (IAEA 1987; Olutola 2018c). Indeed, as development continues, and with global warming fast becoming a problem, the manner in which baseload energy is generated needs to become cleaner, more effective, less carbon-emitting, and sustainable. Civil nuclear technology should be considered in this regard, as it produces low-carbon-emitting energy, thus making it one of the key solutions for mitigating global warming and ensuring energy security.

1.2 The importance of regionalism and regional economic development

Regional economic development is a key objective of SADC. Söderbaum and Granit (2014) describe regionalism as a set of values, identities, and common objectives that lead to forming regions and regional cooperation within a given geographical area. It fosters the creation and development of government frameworks and regional institutions to shape and regulate collective action. Regionalism takes place in many parts of the world, for instance, in forming multipurpose regional organisations such as the European Union (EU) or African Union (AU). In the case of Southern Africa, regionalism is evident through the formation of specialised organisations, such as the Transboundary Water Management Organisation, or specialised networks, such as the Southern African Power Pool (SAPP) (Söderbaum & Granit 2014).

Regional integration has always focused on access to markets (African Development Bank Fund 2019). Regional cooperation has been important and has attracted attention on several fronts, while the increase in the physical links across the African continent has spread environmental externalities beyond national jurisdictions (African Development Bank Fund 2019). Beyond other existing regionalisation initiatives and the eight regional economic communities in Africa, most regional initiatives deal with regional public goods. For example, five deal with energy, fifteen with the management of rivers and lakes, three with peace and security, and one with the environment (African Development Bank Fund 2019). Several regional integrations in Africa also stem from its geopolitical economy. Such geopolitical economies indicate that the integration of the economic, political, and military dynamics between states occurs in a manner that takes cognizance not only of international relations but also of the international political economy of the state (Kurecic 2017:318). Economic regionalism occurs when neighbouring states coordinate the opportunities and limitations that arise from interaction between states. It is an international institutional measure for facilitating the free trade of goods and services (Van Houten 2013). Different facets exist in economic regionalism, such as economic unions, customs unions, common markets, and free-trade areas. In the twentieth century, regionalism was characterised by a preference for tariffs, whereas in the twenty-first century regional trade agreements (RTAs) are different, their primary focus being on preferential market access (Amineh & Grin 2003).

The integration of economies in SADC remains an imperative process. Economic policies ought to complement each other to ensure mutual success. Therefore, existing tariff restrictions between each state must be abolished and come to terms with a single cohesive tariff policy for non-member states. The idea is to ensure mutually exclusive benefits by decreasing the cost of living (Madyo 2008:39; Mapuva & Muyengwa-Mapuva 2014). According to liberal economic theory, free trade entails that trade will exponentially increase member states' welfare. The static effects of regional economic integration are often found in the form of production efficiency and consumer welfare. Static welfare effects are evident when tariff barriers of member states of the trade bloc are decreased or abolished (Madyo 2008:40).

SADC mostly engages in cross-border, sector-specific projects such as the SAPP and regional development corridors.

It adopts an explicit market-related integration agenda, with the Regional Indicative Strategic Development Plan (RISDP) 2020–2030 and the SADC Vision 2050 being two strategic plans that provide a guiding framework for implementing regional integration and the developmental agenda (SADC 2020). Even though the RISDP is not legally binding, it enjoys a significant amount of political legitimacy (NEPAD 2015:20). Also, SADC has Vision 2027, aimed at the region's major infrastructure development challenge. Intra-regional trade is limited by inadequate infrastructure, which increases the cost of doing business and makes the region unattractive to investors. The revitalised focus on regional integration ought to emphasise infrastructure development (Dube 2013), which Vision 2027, also known as the Regional Infrastructure Development Master Plan (RIDMP), aims to do. This is a guide to developing and implementing priority infrastructure projects for the region. The RIDMP identifies six priority sectors for development: energy, transport, tourism, information and communication technologies, meteorology, and transboundary water (Dube, 2013). However, the challenge is that, despite SADC having designed various development programmes for integration, the lack of political will for implementing the various treaties and protocols has limited the organisation's success (Oloruntoba 2015).

Africa's integration efforts have failed to yield pleasing results as compared with other regions beyond the continent that have improved their economic welfare through integration mechanisms. The challenge facing Africa's regional economic integration has been its continued reliance on the old model of regionalism—an ideological paradigm of Pan-Africanism with its focus on politics rather than the economy. Moreover, African elites tend to focus on the wrong set of priorities, which do not ensure that state policies include regional development. This is often coupled with too little commitment towards a developed Africa (Qobo 2007). Therefore, for nuclear energy to flourish within SADC, it is imperative to harmonise standards related to nuclear safety, security, and non-proliferation. This would mitigate the risks associated with regulatory discrepancies. Establishing a unified framework through the SADC Energy

Protocol would be advantageous to facilitating the development of national nuclear energy programs under a cohesive regulatory and oversight structure. Furthermore, regional institutions, such as the SAPP, can play a crucial role in coordinating the deployment of nuclear energy across the region, thus ensuring alignment with comprehensive strategies that address regional energy demand and supply dynamics (Velichkov 2021).

1.3 The nexus of energy and development

Industrial development is part of the core developmental integration agendas of SADC. Access to sustainable energy plays an important role in achieving this and is reflected by the prominence of energy issues in recent regional, continental, and global processes. This includes the UN's 2030 Agenda for Sustainable Development, its 17 Sustainable Development Goals (SDGs), the AU's Agenda 2063, and the RISDP. Agendas 2030 and 2063 share several objectives and principles pertaining to sustainable development, poverty, environmental sustainability, and clean, sustainable energy. Both agendas emphasise the need for inclusive growth, human development, and the protection of the planet. In this regard, about 20 of Agenda 2063's goals are strategically aligned with Agenda 2030. For instance, Agenda 2063's Goal 1 (a high standard of living, quality of life, and well-being for all citizens) is linked with Agenda 2030's SDGs 1, 2, 8 and 11 (African Union 2015; The Economic, Social & Cultural Council and African Union 2023). Similarly, the RISDP 2020–2030 is a successor to the previous RISDP, which was a 15-year blueprint that provided a strategic direction for SADC's long-term social and economic goals. The inclusion of peace, security, and governance is a much-needed innovation that recognises the foundational importance of ensuring the necessary preconditions for achieving other priorities. In the long run, the objective of the RISDP 2020–2030 is to increase the region's manufacturing capacity, competitiveness, and trade capacity in order to achieve sustainable economic development. The revised RISDP 2020–2030 aligns with the following UN SDGs: 8—decent work and economic growth; 16—peace, justice, and strong institutions; and 17—partnerships for the goals (SADC 2020;

United Nations 2023). For the respective goals to be achieved in each agenda, national development plans, regional plans such as the RISDP, and continental strategies such as Agenda 2063 must be revised and aligned with the global UN SDGs. Integrating the SDGs into national policies, programmes, and strategies ensures that domestic efforts positively contribute to continental and global agendas (African Union 2023).

The various agendas, as highlighted above, identify the availability of affordable and sustainable energy as key to the realisation of sustainable development (SADC 2018:12). Indeed, access to modern forms of energy is essential for providing sanitation, health care, and clean water. It can also be highly beneficial for development, as it provides reliable, efficient lighting, mechanical power, and telecommunications. Indeed, energy is essential to any kind of development and any thriving society (Walton 2018). And even though, since 2010, there has been an increase in the number of people with access to electricity—approximately 118 million each year—SADCs regional efforts need to accelerate if the region is to meet the UN's SDG 7, which is ensuring access to affordable, reliable, sustainable, and modern energy for all, by 2030 (World Bank 2018). The biggest hurdles to this, according to the World Bank (2018), are challenges related to the extension of grid-based electricity, such as poor transmission and distribution infrastructure, high costs of supply to remote areas, and a lack of affordability. This was one of the reasons for the alignment of the 2010–2020 SADC Regional Energy Access and Strategic Plan (REASAP) with SDG 7 and Sustainable Energy for All (SE4All) initiatives, which correlate access to energy with development (SADC 2020:32).

The SADC Treaty is the primary foundation of the integration agenda for the region. It is based on the premise of creating and enabling an environment of economic cooperation among the SADC member states in various sectors (SADC 2018:18). To keep pace with the rising electricity demand, and coupled with the need to continue supporting and promoting sustainable development and regional integration, certain elements need to be put in place, such as legal, regulatory, and institutional frameworks that help to facilitate the growth of the energy sector (SADC 2018). SADC has made some strides in this regard through power pooling, for example. The business of power pooling is clear and powerful. Energy producers are enabled to access larger markets through wheeling, thereby avoiding excessive grid losses by selling to customers close to where the energy is produced. This helps states with energy deficits or limited energy, and also enables access to reliable energy from neighbouring states (Medinilla, Byiers & Karaki 2019).

The practice of power pooling is not straightforward, however. Power pooling requires the gradual development of many interconnected bilateral arrangements and deals between members. A regional regulator should be given authority to facilitate this process and apply its rules, as a power pool is only as strong as its weakest link (Medinilla *et al.* 2019). Yet even though states join power pools, the producers of energy and utilities in those states are the real participants. This is evident with power pools in Africa: the real participants are often public enterprises usually operating as monopoly providers under specific market conditions. They have therefore become political champions, owing to their importance in the market, and form part of a wider system of rent capture and distribution (Barnett, Stockbridge & Kingsmill 2016). In the SADC region, however, significant progress has been made in promoting the development of least-cost power generation to the end-user and power trading, by linking its various generating plants through interconnectors and transmission systems (SADC 2018). Nine power utilities on the Southern African mainland are interconnected, with the exclusion of Angola, Malawi, and Tanzania. Botswana, the Democratic Republic of Congo, the Kingdom of eSwatini, Lesotho, Malawi, Mozambique, South Africa, Zimbabwe, and Zambia form part of the region's integration of power. This interconnectivity has facilitated the establishment of the SAPP as a power trading platform. It enables the SADC member states that experience shortfalls to purchase power from those with surplus power within the regional energy security framework (SADC 2018:14).

1.4 The role of South Africa and nuclear energy as an important player in regional integration in SADC

South Africa has consistently maintained a leadership position in SADC's regional integration and development. According to the International Business Publication (2019), South Africa is a hub for regional integration in Southern Africa. The state's dominance of economic activity in the region has accounted for 60% of SADC's total trade and approximately 70% of the region's gross domestic product (GDP) (Ettang & Leeke 2019). Much of the intra-SADC investment flows through South Africa. Therefore, South Africa's investments play a key role in neighbouring states by accounting for approximately 9–20% of the GDP in Namibia, Mauritius, the Kingdom of Eswatini, Lesotho, and Mozambique (International Business Publication 2019). As far as nuclear technology is concerned, one of the primary goals of South Africa's policy on disarmament, non-proliferation, and arms control includes reinforcing and promoting the state as a responsible producer, possessor, and trader of defence-related products and advanced technologies, such as nuclear technology for civilian purposes. As a member of the International Atomic Energy Agency (IAEA), the Nuclear Supplier's Regime, the Africa Group, and the Non-Aligned Movement, South Africa is in a position to promote the importance of nuclear non-proliferation, as export controls should not become a means of denying developing states access to advanced technologies (Government Communication and Information System 2020).

There may be regional perceptions and concerns that the gains from regional integration would be uneven because of South Africa's dominant status in the integration process. SADC member states, by contrast, view South Africa as a messiah that can potentially drive development and peace-making in the region. The state's soft-power approach has attracted many citizens from the region to its higher education institutions, and the state's exports of goods and services could serve as a model for the subregion (Ettang & Leeke 2019). Indeed, given Eskom's dominance in energy generation in the region, SADC ought to consider the importance of South Africa's hegemonic position when it comes to pooling resources through research-led development strategies.

The main objectives of SADC are to achieve economic development, enhance the standard of living and quality of life, peace, and security, and to support the socially disadvantaged through regional integration. This commitment has manifested in several regional integration projects in which South Africa is playing a leading role (Thekiso & Van Wyk 2019; SADC 2022). South Africa also plays a key role as a member of the SAPP by actively seeking to provide a sustainable, economical, and consistent supply of electricity to each of the SAPP members, making reasonable use of the state's natural resources and environmental effects (Thekiso & Van Wyk 2019:59). However, in recent years, due to South Africa's energy problems, its contribution to the SAPP has been limited, and when there is a shortage of supply, Eskom suspends electricity sales to Namibia and Botswana, while supplies to other SADC states that receive electricity from Eskom are cut by 10% (Le Roux 2022). A diversified and sustainable energy mix is desperately needed to bring an end to persistent load-shedding in South Africa, which negatively affects regional integration projects.

Nuclear energy has become one of the focal points when considering a diversified, sustainable energy mix. There are many advantages to nuclear energy, one of which is that nuclear fission does not emit carbon emissions, as opposed to chemical burning, which does and thus amplifies climate change effects. Nuclear energy provides baseload electricity to the electric grid with no carbon emissions output. Similarly, sSolar and wind energy also produce carbon-free electricity, however these energy sources are intermittent, require favourable conditions for efficient operation, and often need to be accompanied by a battery energy storage system (BESS). Nuclear energy is considered to have the highest capacity factor (a measure of what percentage of the time a power plant produces energy) of all energy sources. Nuclear energy produces carbon-free electricity that is reliable more than 92% of the time—twice as reliable as coal-fired plants at 43.3%, and also more reliable than natural gas plants at 54.4%, wind energy at 34.6%, and solar energy at 24.6% (Rhodes 2018; Office of Nuclear Energy 2020; Pierce & Le Roux 2022; Thermtest 2024). Additionally, nuclear energy releases less radiation into the environment than any other major source. Notably, while nuclear energy may be expensive to build, the cost of nuclear energy is ultimately a matter for the markets to decide (Rhodes 2018). Civilian nuclear programmes thus present significant potential for addressing Africa's energy challenges. However, the technology also raises several concerns around safety, security, waste management, public perception and acceptance, economic viability, environmental impacts, and regulatory and political challenges (Orikpete, Ewim & Egieya 2023).

Micro and small modular reactors (SMRs) are classified as advanced nuclear reactors that are smaller and have an average capacity of up to 300 MW per unit. Reactor designs are modular and simpler than previous designs, which makes them less capital-intensive, and they are also more fuel efficient, which makes them inherently safer. SMRs are purposely designed to address challenges faced by conventional nuclear power reactors, which have an average power capacity of 1,600 MW, making SMRs game changers and ideal for locations unsuitable for conventional nuclear power reactors (World Nuclear Association 2021). As of 2024, there are three operational SMRs in Russia, China, and India. Three further SMRs are in the construction phase, while approximately 65 SMRs remain in the design stage, with the majority possessing a capacity of between 100 and 300 MW (Liou 2021; World Nuclear Association 2023; Statista 2024).

Several African states, including Namibia, Zambia, and Egypt, have considered nuclear energy as a possible source in the state energy mix. In 2016, Zambia and Namibia each signed a memorandum of understanding with ROSATOM, Russia's state atomic agency corporation, to develop nuclear energy. Globally, the term nuclear renaissance has become a catchphrase. However, there seems to be a limited consensus on the benefits of nuclear energy (Mushota 2016; Madondo 2018; Khripunov 2007; Van Wyk 2013). In August 2024, during the US-Africa nuclear energy summit, Ghana signed an agreement with a US developer for a nuclear reactor based on NuScale Power SMR technology. The agreement will see the deployment of NuScale's VOYGR-12 SMR (Reuters 2024).

The attitudes held by African decision-makers, experts, and the public regarding nuclear energy range from the negative and cautious to the positive and enthusiastic. Supporters of nuclear energy see the energy source as a silver bullet that could enable the continent to demonstrate both its technical progress and competence. This vested interest in nuclear energy is motivated by the common concern that Africa is more vulnerable than other regions to climate change (Khripunov 2007). Indeed, Pedraza (2011) and Olutola (2018a) agree on the use of nuclear energy to produce electricity in Africa. African states should pursue the option of nuclear energy in the state's energy mix; it is their prerogative. This is largely attributed to the continent's dire energy crisis. Nuclear energy can become a consideration as it assists states in meeting their targets under the 2015 Paris Agreement to reduce carbon emissions by 35% compared to the business-as-usual levels by 2030 (United Nations 2015; Carbon Brief Staff 2015). It has been established that industrialised regions and states that have achieved relatively decarbonised economies have done so by including nuclear energy as part of the region or the state's low-carbon energy mix (Blue and Green Tomorrow 2016).

SADC (2018) notes the importance of nuclear energy as a key subsector in keeping up with electricity demand. This sub-sector is currently dominated by South Africa, home of the first and, to date, only nuclear power plant (NPP) in Africa. The Koeberg NPP was built in the 1970s on the west coast of South Africa to mitigate the cost of coal transportation from the coal-rich fields in the eastern part of South Africa. The two reactors at Koeberg were synchronised with the national grid in 1984 and 1985 (Eskom, n.d.), and the units together produce approximately 5% of the state's electricity capacity. Koeberg was scheduled to reach its end-of-design life by 2024; however, it is currently undergoing refurbishment to extend its operation by 20 years, which is critical for energy security in the period beyond 2024. It is considered to have low operational costs and is one of the best-performing NPPs in the world (DoE 2019; Cowan 2022). It has demonstrated the benefits of nuclear energy and has given South Africa a reason to continue extending the programme (Department of Mineral Resources and Energy 2019a; Matya 2022; Moonsamy 2022).

The success of Koeberg has demonstrated how the nuclear industry has a significant role to play in job creation and economic growth by providing short- and long-term employment and economic development. To put it into perspective, a 2017 economic impact assessment report of Koeberg prepared by KPMG found that its combined impact through investment and operations between 2013 and 2016 contributed R30.2 billion to the GDP of the Western Cape Province (approximately 1.4% of the provincial GDP) and R23.1 billion to the South African economy. In the same period, an average of 1,786 direct jobs were sustained while creating approximately 35,000 indirect and induced jobs per year, resulting in a total estimated revenue of R16.4 billion to the national government. Through direct and indirect tax collections, Koeberg and its supply chain stakeholders also contributed R8 billion to the Western Cape's provincial revenue between the 2011/12 and 2015/16 fiscal periods. Moreover, Koeberg contributed R9 billion to the national fiscus in the same period, while R15 billion was contributed to household income in the same fiscal period. Between 2016 and 2020, Koeberg was expected to create and sustain an average of 2,300 direct and 42,000 indirect jobs annually in the Western Cape. Furthermore, Koeberg's employees' income levels are above the industry average in South Africa due to the specialised nature of their work. In the rest of South Africa, during the same period, Koeberg contributed approximately 63,000 jobs. Thus, given that sustainable electricity is a key input for many products and processes in the state's economy, Koeberg is a direct contributor to economic growth, both in the Western Cape province and South Africa at large (KPMG 2017; World Nuclear News 2017; Department of Public Enterprises 2017).

Regarding development, ESI Africa (2016) has noted that building new NPPs has successfully reignited or expanded industrialisation in many states, namely China, South Korea, and the United Kingdom (UK) in the 1960s and 1970s. Interestingly, since 2000, China has increased its number of operating reactors by more than ten times, making the state the fastest-expanding nuclear power generator globally. As of April 2024, the state generates approximately 53.2 GW from 55 reactors (Gil 2017; U.S. Energy Information Administration 2024). A localisation strategy and the selection of the most suitable localisation scenarios have become essential to achieving the expansion of nuclear energy. It serves as a pre-qualification for local companies as per international standards (ESI Africa 2016). South Korea is a good example: it approached technological self-sufficiency in constructing NPPs, and the affected sectors increased their primary metal products, general machinery, and equipment and business services. The idea was to get local manufacturers to extend their normal product production and incorporate nuclear designs and standards (IAEA 2009). The positive spin-off effects from the localisation of plant construction have been evident in primary metal product sector activities. The economic value added during the operations of the NPP displays roughly the same kind of evolution as in the construction phase (IAEA 2009).

1.5 Proposals for moving forward

The adequate availability of uranium resources highly influences the growth potential of nuclear energy in developing regions. Globally, a few states with significant reserves, mining, and export capabilities dominate the uranium supply cycle. The top five uranium producers by mining include Kazakhstan (43%), Canada (14%), Namibia (11%), Australia (9%), and Uzbekistan (6%). South Africa's total uranium production from mines accounted for only 0.4% of the global total production in 2022 (World Nuclear Association 2024a). Currently, the uranium enrichment market is dominated by three key producers: Orano, Rosatom, and Urenco. These companies operate extensive commercial enrichment facilities in several countries, including

France, Germany, the Netherlands, the UK, the US, and Russia (World Nuclear Association 2024b). As technology evolves, the focus has shifted to designs less reliant on traditional uranium-based fuels to improve efficiency, reduce waste, enhance safety, and diversify the fuel supply (World Nuclear Association 2024c). The expansion of nuclear energy in SADC in the coming years largely depends on utilising the region's abundant uranium deposits, particularly in Namibia and South Africa. This endeavour could be supported by China, given its established partnership with Namibia, which has resulted in China's largest investment in Africa: the world-class Husab mine. There are also similarities between China's High-Temperature Gas-Cooled Reactor-Pebble-bed Module (HTR-PM) and South Africa's Pebble Bed Modular Reactor (PBMR) (World Nuclear News 2023b; Namibian Uranium Association 2024).

The revenue from uranium exports from South Africa is noteworthy. South Africa is home to large uranium reserves and maintains an extensive uranium mining industry that makes the state one of the key exporters in the world. By 2019, uranium exports alone have acquired revenue of over R1.5 billion, according to the Department of Mineral Resources and Energy (2019a). The abundance of uranium, therefore, drives the push towards nuclear energy. According to the IAEA (2006) and Dasnois (2012), Africa accounts for 18% of the world's known and recoverable uranium resources, but more uranium might be discovered in Africa through research and further exploration. It is up to the government, private industry, and civil society to work together in developing a robust policymaking framework for all options to be assessed and developed accordingly, taking into consideration the respective cost implications and the benefit to the state and region by supplying reliable sustainable baseload energy (Echávarri 2006; Gumede 2018; National Development Plan 2019). Furthermore, transitioning from coal to nuclear energy can be considered radical decarbonisation since NPPs only release carbon emissions from the ancillary use of fossil fuels during mining, construction, processing of fuel, maintenance, and decommissioning of the NPP (Rhodes 2018).

Some SADC member states plan to increase their uranium mining and consider the peaceful uses of nuclear technology, which is projected to drive regional growth. Several SADC member states are considering adding NPPs to their states' energy generation mix to help meet the rising electricity demand. A partial synchronisation of existing and emerging regulatory frameworks is required to achieve this, including better networking of the SADC nuclear regulators, development of human resources, and introduction of information technologies. Nuclear energy needs to be highly regulated to ensure the safe and secure handling of the nuclear materials, reactors, and waste disposal of all existing and new nuclear energy projects in the SADC region (SADC 2016; 2018; 2020; World Nuclear Association 2022).

South Africa's 2019 Integrated Resource Plan advocates for the immediate commencement of a nuclear build programme of up to 2,500 MW as a no-regret option in the long term (DoE 2019: 48). In 2019, in his budget vote speech, Gwede Mantashe, South Africa's Minister of Mineral Resources and Energy (DMRE), reiterated the need for the state to begin implementation plans for additional nuclear capacity beyond 2045, as it transitions towards a diversified cleaner energy mix in line with Chapter 5 of the National Development Plan (NDP) (DMRE 2019a). In the 2023 DMRE budget vote speech, Mantashe stated that in the 4th quarter of the 2023/24 financial year, a request for proposals to procure 2,500 MW of nuclear energy build would be issued (DMRE 2023). Mantashe consistently emphasizes that South Africa should have more nuclear energy capacity and be considered part of the green transition (Creamer 2023). However, in August 2024, Electricity and Energy Minister, Dr Kgosientsho Ramakgopa, withdrew a Ministerial Determination for the procurement of 2,500 MW of new nuclear capacity due to a lack of public consultation. The withdrawal came ahead of a scheduled court case initiated by anti-nuclear lobbyists, namely the Southern African Faith Communities' Environment Institute (SAFCEI) and Earthlife Africa Johannesburg, which contested the legality of the gazetted Section 34 determination signed by Ramakgopa (Creamer 2024; World Nuclear News 2024).

Through the SAPP, the SADC region stands to benefit greatly from South Africa's new nuclear build plans. Notably, the SAPP's mandate has always been clear in its attempt to link up the southern and northern energy sources and electricity grids to overcome member states' differences and allow support between states during peak periods and emergencies. The SAPP has observed an increase in the potential benefit that could be brought to the SADC region via nuclear energy. Expanding national electricity power markets beyond state borders could decrease the impact of variable supply and demand while stimulating the economy and investment capacity. Additionally, the SAPP has made significant progress in helping trades grow through the development of the Regional Electricity Market (REM) (Maupin 2016).

The embracing of new technologies, such as Digital Twinning (DT), by South Africa and, to some extent, the SADC region, could provide a perfect catalyst for replicating nuclear facilities. DT is a virtual replication of a nuclear energy facility or process by combining design information, process data, and simulation capacities that optimise operation throughout its entire life cycle (Tecnatom 2021). Companies can use DT when exploring novel technologies and ways of lowering costs or refining designs before breaking ground (Volodin & Tolokonskii 2019; Argonne National Laboratory 2020). DT would not limit SMRs to being built in states such as Namibia, the DRC, and Malawi, which already have existing operational uranium mines and have been uranium producers in recent years (Velichkov 2021).

DT could be particularly attractive, for example, if South Africa's previous design for an SMR, the PBMR, could be revived. The PBMR was envisioned to produce electricity based on a 400 MW design as compared with the pricy pressurised water reactor (PWR) plants like the Koeberg NPP. Initially, the PBMR aimed to deliver energy locally and for export to industry and households. It was expected that the PBMR programme would export 20 reactors per year and 10 reactors would be built for domestic use (Rennkamp & Bhuyan 2016:3; Fig 2010:1). The advantage of the PBMR was its size, as it allows the construction period to be staggered, thus allowing the initial reactor to be running and generating revenue before the others are completed. This assists in the funding of construction for other reactors. The capital cost required would be reduced by a significant margin as smaller core components would enable modular and standardised construction techniques (Staffel 2005). Unfortunately, the PBMR project was scrapped in 2008 because of the global financial crisis and a lack of potential investors and customers (DME 2008), and was replaced seven years later by plans to build more expensive pressurised water reactors (PWRs) NPPs (Rennkamp & Bhuyan 2017; Cameron 2020). As technology continues to advance, the South African Nuclear Energy Cooperation (NECSA) hopes that advanced designs could potentially lead to a first-of-a-kind high-temperature modular reactor (HTMR)-100 SMR built in five years using graphite-coated spherical uranium oxycarbide tristructural isotropic (TRISO) fuel, which the state has already produced. This design is well-suited to the African market, as it requires low cooling water and maintains the capability of powering remote mines and communities without the need for long-distance power distribution network lines (World Nuclear News 2023a). Dr Kelvin Kemm, Chairman and Chief Executive Officer of Stratek Global, believes this future is now. Stratek Global seeks to develop and implement multiple HTMR-100 in the state. The helium gas-cooled HTMR can be installed in groups of 6 to 10 units to generate power for conventional steam turbines, each with less than 300 MW capacity. This installation is sufficient to meet the energy demands of a major industrial mining complex or to supply electricity to a city comparable in size to Pretoria (World Nuclear News 2023b; Agence France-Presse 2024).

Another proposal is the technology transfer and localisation model. The SADC region's vast supply of natural resources, access to uranium, and established construction, manufacturing, and steel industries in some of the member states create an opportunity for South Africa to further develop a nuclear industry that holds great benefits for SADC states and the regional economy (Van Wyk 2012). Nuclear energy projects have the potential to greatly contribute to the economy of the region in which the project is built. Indeed, the IAEA's regional economic development analysis is based on the input-output analysis that evaluates the direct, indirect, and induced NPP programmes from the increased output and expenditures of labour income. Moreover, the expenditures for goods and services are included in the construction and operation of the plant. For instance, the Ulchin NPP located in the Ulchin region in South Korea is one of the well-documented NPPs regarding its regional economic contribution. The region has experienced a large economic growth spurt due to the construction of the Ulchin NPP. The project led to creating jobs in the construction and operation phases. The development of local infrastructure to support the project, such as the building of schools, training and scholarship programmes, and expansion of medical facilities, amongst other things, contributed immensely to the economic growth of the region (Van Wyk 2012).

Expansion of nuclear energy in SADC also requires consideration of the acquisition of fuel for the NPPs. Acquiring uranium is not the biggest obstacle; SADC has rich deposits. Furthermore, in 2007, the South African government declared uranium a strategic mineral for securing future domestic supply. This was conducted in preparation for the development of the local nuclear industry ahead of the state's uranium mining and beneficiation strategy and the 2008 nuclear energy policy (Van Wyk 2021:33). This policy provides a clear vision for the government to develop an extensive nuclear energy programme that involves the mining of uranium ore and the use of uranium for peaceful purposes. The long-term goal of the policy is to allow the state to be self-sufficient in all aspects of the nuclear fuel cycle (NFC). Additionally, to implement a sustainable nuclear programme and take charge of all potential economic benefits, the government should seek to return to implementation of, or obtain interests in, the complete NFC, which includes uranium mining and milling, uranium conversion, uranium enrichment, fuel fabrication, spent (irradiated) nuclear fuel and radioactive waste management, and reprocessing of spent (irradiated) fuel and recycling of fissile materials as strategic priorities for energy security (Department of Minerals and Energy 2008; Van Wyk 2021:34). It is indeed not far-fetched for the government to take charge of the entire

NFC, as the state did it once before with the building of the Y- and Z-enrichment plants in 1975 and 1984, respectively, at Valindaba near Pretoria. The Z-plant was a semi-commercial Helikon aerodynamic process enrichment plant that produced low-enriched uranium (LEU) for nuclear energy programmes. It was closed in 1995. The Y-plant was a pilot-scale, aerodynamic process enrichment plant that produced high-enriched uranium (HEU) for nuclear weapons. It was shut down in 1990, after the apartheid government decided to destroy its small, top-secret nuclear arsenal (Barletta & Ellington 1999; Cochran 1994:36; NECSA 2023). In 2013, an IAEA report on South Africa's integrated infrastructure review noted that the state maintains a strong background in the NFC, both in front- and back-end activities, with a vast accumulation of knowledge and technical expertise from the past (IAEA 2013:57).

Currently, however, South Africa faces a huge dilemma because on 4 December 2022, the United States-Republic of South Africa (US-RSA) Section 123 Agreement for Peaceful Cooperation expired. The agreement included a United States Nuclear Regulatory Commission (NRC) licence, XCOM1252, which authorised the export of fuel assembly components to Sweden for the fabrication of fuel assemblies and subsequent shipment of the completed assemblies to South Africa for use in Koeberg Unit 1 (Federal Register 2023). Subsequently, in January 2023, the NRC ordered the Westinghouse Electric Company LLC to suspend the licence. Negotiations around a new agreement are ongoing, with both parties citing the need to expedite the process whilst engaging in measures that ensure continuity of cooperation (Department of Mineral Resource and Energy 2023). At present, the absence of the 123 Agreement for cooperation between the USA and South Africa regarding the peaceful uses of nuclear energy has resulted in South Africa being removed from the advance consent list of states eligible to receive retransfers from Euratom. This includes low-enriched uranium, non-nuclear material, equipment, and source material that has been transferred, as well as low-enriched uranium produced using the transferred nuclear materials or equipment for nuclear fuel cycle activities, except for the production of high-enriched uranium (Federal Register 2024).

Meanwhile, NECSA and Russia's TVEL[1] signed a memorandum of understanding to collaborate in manufacturing nuclear fuel and its components. The strengthening of bilateral cooperation between the two states in this regard will be imperative for South Africa, should it seek to open the possibility of recreating its production capacity for the manufacture and supply of nuclear fuel, especially given the rise in the number of African states interested in nuclear energy. Historically, South Africa has sought self-sufficiency in its NFC. In 2011, initial feasibility studies were completed on re-establishing an NFC programme, with NECSA proposing to establish fuel fabrication capacity for PWR to ensure that the state has fuel supply security (World Nuclear Association 2023). Currently, South Africa has no immediate plans to manufacture its own nuclear fuel, but it wants the possibility of doing so to remain open, as enshrined in international nuclear agreements like the Nuclear Non-Proliferation Treaty (NPT) and the rules of the IAEA (Fabricius 2023). Therefore, any agreement that prohibits the state from this possibility is deemed unfavourable.

Some other challenges remain for the expansion of NPPs in SADC. For example, the physical infrastructure gap for nuclear energy relates to a lack of planned electricity generation projects and the technology's uncertain future (SADC 2018). There is a need, therefore, for nuclear-awareness-building to ensure that proponents and detractors of nuclear technology development agree on the technology's safety in the region. A presentation should accompany this on the safe disposal mechanisms for nuclear waste. The handling of nuclear waste is highly regulated, and no one is permitted to cause pollution (World Nuclear Association 2020). There must also be adequate and consistent assurance that nuclear disaster management plans are in place. While South Africa has measures in place for both waste and disaster management, none of these measures currently exists in the rest of the SADC region (SADC 2018). A demonstration is required to show that nuclear energy can be a safe electricity generation option. Given its long-standing

1 TVEL is a subsidiary of Russia's state atomic energy corporation (ROSATOM) responsible for uranium conversion, enrichment, and nuclear fuel fabrication (Kachkova 2023).

nuclear expertise, South Africa can best fulfil this role. This would help to win civil society's confidence and would help the regional government to endorse the deployment of nuclear energy in the region (SADC 2016).

Notably, exploration and mine development are still required in some prospective SADC states that have the potential to be suppliers of uranium, namely Botswana, Tanzania, Zambia, and Zimbabwe (Velichkov 2021). This would be in line with some IAEA nuclear-related agreements, such as the African Regional Cooperative Agreement for Research Development and Training Related to Nuclear Science and Technology (AFRA), signed in 1990; the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Material, signed in 1997; and the Revised Supplementary Agreement concerning the Provision of Technical Assistance by the IAEA, signed in 2006 (Van Wyk 2013). In the long run, there ought to be discussions by African states and regional blocs about establishing a SADC office on nuclear energy and regulation and commencing the building of NPPs (Dasnois 2012; Velichkov 2021).

1.6 Conclusion

The root of SADC's developmental challenges stems largely from inadequate access to electricity. Without immediate attention, the crisis puts the region's sustained economic and infrastructural development at risk. The energy challenge facing the region has implications for its industrialisation strategy. Structural transformation in the region is one of the key focus areas of SADC's strategy that seeks to industrialise, modernise, improve, and bring about closer regional integration. Compared to the rest of the continent with access to energy, SADC trails behind. Regional integration is a viable option when considering sustained development and free trade between states. Regionalism highlights the importance of regional collaborative efforts and fosters greater commitment by all member states. In essence, a state's economic development is stimulated by regional economic development. Greater efforts can be achieved through region-building and power pooling.

There has been a strong belief that, should African leaders create an environment that enables conducive growth and ultimately integrates the region, this would enable African states to reap the benefit of economies of scale to produce trade and thus maximise state welfare. Through regional integration, cross-border energy cooperation could be established to trade electricity to multiple states in need. There is much potential in the region's geopolitics when it comes to nuclear energy generation, which in turn could bolster economic regionalism. This makes it imperative for SADC member states to have economic policies that complement each other to ensure that collaboration yields fruitful results. A greater synergy is required between the region's developmental policies and member state policies, coupled with the implementation of key performance indicators, to monitor the region's success in policy implementation and to highlight ineffective policies that are not conducive to the developmental agenda. The latter is arguably the continent's challenge when it comes to ensuring integration and sustained development.

It has been well documented that the peaceful uses of nuclear technology positively contribute to the SDGs. Its applications are not limited to energy generation; they also contribute to other aspects of the SDGs. Future developmental prospects require energy generation to be low-carbon emitting. Nuclear energy has proven to be a viable alternative to coal in addressing not only the regional energy crisis but global energy insecurities as well. The inextricable link between access to energy and development is evident when considering the state's or region's access to energy and developmental progress. However, when it comes to ensuring sufficient power capacity some of the biggest hurdles that developmental regions face when increasing power are grid unavailability, the extension of grid-based electricity, and poor distribution and transmission lines to end-users.

There are a lot of misconceptions about nuclear energy in civil society, often due to a lack of information about the technology. This has become the playground for anti-nuclear lobbyists, who cite the dangers of radiation, costly build-up, and potential environmental harm. This makes information-sharing with civil society and communities important, as it creates awareness and ultimately ensures that proponents and detractors of the development of nuclear technology agree on the safety and economic benefit of the technology. Nuclear energy, being a low-carbon emitting baseload energy generation source, would be a no-brainer as a viable alternative, as states and regions seek to decarbonise. Between the SADC member states, there lie sufficient uranium resources to power their NPPs, which could positively influence the region's growth. The introduction of SMRs could be a game-changer for states looking for an alternative to traditional NPPs, as these states often cite limitations of the electric grid, of funding, and of skilled human resources as issues. SMRs require lower up-front funding, fewer skilled human resources, and have greater compatibility with existing electric grids.

As a dominant state in the region, South Africa has a significant role to play in strengthening regional ties through nuclear energy provision given its long-standing history with nuclear energy. The Koeberg NPP is regarded as one of Eskom's best-performing power plants in its generation fleet in terms of continued operation. Therefore, embracing DT would benefit the state and the entire region by replicating functional NPP facilities, especially in prospective states with functional uranium exploration and mine development. This would align with the SAPP mandate to link up the southern and northern energy sources and electric grids, to surpass member-state differences, and to enable support during peak periods and emergencies. This is subject to grid extension to accommodate additional energy capacity, but through DT, technology transfer could take place to support other states in the region interested in building nuclear energy to offset the energy demand and ensure energy security.

It can therefore be concluded that nuclear energy is a commodity that brings about regional socio-economic development whilst decarbonising the state and alleviating the energy crisis. Attitudes towards nuclear energy should not be subjective but should be based on research and science.

Nuclear technology is not a one-trick pony; it has several positive economic spin-offs that can contribute to the state's economic development and improve the standard of living. It is imperative that SADC member states strive towards harmonising regional energy policies that promote the building of necessary infrastructure to fulfil the SAPP mandate of supplying energy throughout the region.

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Chapter 2

Advancing Nuclear Energy: Why Peaceful Uses Need the Non-Proliferation and Disarmament Regimes

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2.1 Introduction

A significant number of African states are looking to nuclear power to address some of their biggest developmental challenges, including extending electricity access to their populations and addressing the difficulties brought about by climate change (Stott & Bosman 2021). This growing interest in nuclear energy is part of a developing trend, what the International Atomic Energy Agency (IAEA) calls "an evolution in clean energy generation" on the continent (IAEA 2022). Since 2009, more than 26% of the requests for assistance from the IAEA in determining the viability of nuclear power came from African states (IAEA 2022).

But nuclear science and technology remains a controversial subject. The detonation of atomic bombs has caused some of the biggest environmental destruction, health risks, and loss of human life in history (WHO 1995). Since the first of these weapons was tested in 1945 (the same year in which the only military application of nuclear weapons to date took place), more than 2,000 nuclear test explosions have followed (Duggal

& Haddad 2022). And no comfort is to be found in knowing that there are more than 12,000 of these weapons in nuclear arsenals today (Kristensen, Korda, Johns & Kohn 2023). This tally is split between nine states: China, France, India, Israel, North Korea, Pakistan, the Russian Federation, the United Kingdom (UK), and the United States of America (USA), with Russia and the USA possessing the largest arsenals in the world.

However, long before this knowledge was used to create weapons, nuclear energy was harnessed for peaceful purposes. The genesis of this science can be traced to 1895, when Wilhelm Röntgen discovered what he termed "x-rays", after passing electron beams through empty glass (cathode) tubes and creating the world's first x-ray image—that of the bones in his wife's left hand (Brown 2018; World Nuclear Association 2020). A mere 8 weeks after this revelation, the practice was incorporated in medical care and continued to evolve, resulting in many of the procedures we are familiar with today, such as brachytherapy, radiotherapy, and radionuclide diagnostics, to name a few (Brown 2018). With the discovery in the late 1930s of fission (the splitting of atoms, resulting in a sustained chain reaction that produces mass amounts of energy), a significant diversification of nuclear science and technology took place, and between 1939 and 1945 nuclear weapons began to take shape. According to the World Nuclear Association, only in 1945 did the focus really begin to shift again in the direction of peaceful purposes through work on "harnessing this energy in a controlled fashion for naval propulsion and for making electricity" (World Nuclear Association 2023). One of the most important focus areas of this renewed attention to the peaceful uses of nuclear science and technology involved nuclear power plants (World Nuclear Association 2023). Although there are several risks and concerns associated with the peaceful application of nuclear energy (accidents, radioactive waste disposal, and proliferation are some of the biggest), the potential of nuclear science and technology for enhancing living conditions by directly contributing to the improvement of healthcare, food security, and electricity access, *inter alia*, cannot be overstated.

This chapter aims to show that the application of nuclear science and technology for peaceful purposes, specifically for nuclear energy, is deeply dependent on the non-proliferation and disarmament regimes, a self-evident truth clearly contained in these legal frameworks. To illustrate these points, I draw briefly on the history of the legal case for peaceful uses, looking chiefly at the 1953 "Atoms for Peace" initiative, before exploring the ways in which this is made clear in the NPT. The chapter then considers the Treaty of Pelindaba, showing how it complements and enhances, perhaps even surpasses, the objectives of the NPT, before concluding with reflections on the current and future peaceful applications of nuclear energy in Africa and how these legal instruments will be vital for preserving its many benefits.

2.2 Promoting nuclear energy: what is required?

Because of the destruction that nuclear weapons can cause, many fear the peaceful application of this technology for civil electricity production. Disasters and nuclear accidents the like of Three Mile Island (1979), Chornobyl[1] (1986), and Fukushima Daiichi (2011) have also caused many to dismiss nuclear power altogether as dangerous, unreliable, and therefore not worth pursuing. Associating nuclear energy purely with the destructive force of which the atom is capable is a significant oversight. While it is true that the fission and fusion of the atoms of certain elements (most commonly uranium, plutonium, and hydrogen) have exhibited significant destructive force, nuclear energy can also be used to further human socio-economic development (Barbarino 2023).

The Three Mile Island, Chornobyl, and Fukushima Daiichi incidents all made a dent in the public opinion of nuclear energy. The threats of armed attack levelled against Zaporizhzhia Nuclear Power Plant (ZNPP) in the ongoing Russia-Ukraine war added to this. Fears of such disasters being repeated are understandable. But these incidents revealed where more focus is required to improve the safety of operating nuclear power plants going forward, whether in design, operator capabilities,

1 This is the accepted Ukrainian transliteration.

or disaster preparedness (Aytbaev *et al.* 2020). To address these concerns, science is constantly improving the technology, with safety always at the heart of new design developments. China, for example, is working on the world's first thorium molten salt reactor and plans to begin construction of this plant in 2025. It is widely recognised that such reactors would be safer to operate than traditional nuclear power plants, but it comes with its own challenges related to salt corrosion and waste disposal (Jackson 2024). In addition, the developing situation at the ZNPP shows that stronger physical protection of nuclear facilities is a necessity for preserving the peaceful use of nuclear energy (Bosman 2023). The question that many are grappling with is whether the benefits of this form of energy outweigh the costs of its implementation, real or hypothetical. The evidence indicates that the world has not yet discarded nuclear energy as an option.

The world's first nuclear power reactor came online in 1954, marking the beginning of the full-fledged development of a global nuclear power industry throughout the 1960s and an upscale of the implementation of nuclear power during the oil crisis of the early 1970s (Ge 2022). The World Nuclear Association reports that there are currently 436 nuclear power reactors in operation across the globe with an additional 59 under construction (World Nuclear Association 2023). Added to these numbers are 220 research reactors in use across 50 countries for "the production of medical and industrial isotopes, as well as for training" (World Nuclear Association 2023). As early as 1968, the IAEA stated that because of "over-population, lack of food and limited traditional resources, nuclear energy is emerging as a most powerful force for the benefit of man" (IAEA 1968). Today, rather than being resolved, these issues have only been compounded, and humanity is faced with addressing food insecurity, increased pandemic and disease risk, and a shift away from fossil fuels as the race to combat climate change is intensifying.

In its recent *Climate Change and Nuclear Power 2022: Securing Clean Energy for Climate Resilience*, the IAEA maintains that to address the growing impact of climate change, "energy sector investment must be scaled up and directed towards cleaner and more sustainable technologies that support climate change mitigation and adaptation" (IAEA 2022:84). It also maintains that there is a "need to reinvigorate and rebalance energy sector investment to address energy security vulnerabilities and broader sustainability challenges", all factors to which nuclear power can directly contribute (IAEA 2022:5). Thus, nuclear energy could be utilised to address some of the biggest socio-economic and environmental challenges facing humanity in the twenty-first century. But for these benefits to be harnessed, a robust legal framework is required not only to ensure that nuclear power plants are operated safely and securely but to create a security environment in which nuclear installations are protected in times of conflict and, more importantly, the authority of these legal instruments is respected (Ge 2022).

Such a framework has been developed over the last five decades (a process in which African states were, and continue to be, important players) to guide the peaceful application of nuclear science and technology and to mitigate associated risks. Africa has relied on the law to establish the continent as a nuclear-weapons-free zone through the Treaty of Pelindaba (1996). Apart from prohibiting the development, acquisition, possession, stationing, and testing of nuclear weapons on the continent, the treaty also provides the legal basis for the peaceful uses of nuclear energy in Africa and contains articles relating to the physical protection of and prevention of armed attacks on nuclear installations (Articles 10 and 11) (AU 1996). The Treaty of Pelindaba draws inspiration from the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) of 1968. The NPT was born from the need to prevent an increasing number of states from acquiring nuclear weapons (non-proliferation) and to achieve widespread nuclear disarmament. In addition, the peaceful uses of nuclear energy are one of its three core principles. The NPT (and the Treaty of Pelindaba) therefore make explicit the undeniable links between non-proliferation, disarmament, and peaceful uses. For this reason, as Black-Branch and Fleck (2016:1) rightly observe, non-proliferation, disarmament, and peaceful uses cannot be "examined in isolation". In other words, without including non-proliferation and disarmament in considerations, we miss a crucial aspect of what it means to benefit from the peaceful uses of nuclear energy.

2.3 Enshrined in international law: How the peaceful uses pillar ended up in the NPT and beyond

It is significant that the very first resolution adopted by the UN General Assembly addressed the concerns around the diversion of nuclear science and technology away from peaceful application (Chossudovsky 1990). On 24 January 1946, the 51 Member States gathered in the General Assembly adopted A/RES/1(I), "Establishment of a Commission to Deal with the Problems Raised by the Discovery of Atomic Energy". Apart from condemning nuclear weapons and calling for disarmament, A/RES/1(I) also calls on the committee established pursuant to the resolution to propose steps for "extending between all nations the exchange of basic scientific information for peaceful ends", the "control of atomic energy to the extent necessary to ensure its use only for peaceful purposes", and finally to implement "effective safeguards by way of inspection and other means to protect complying States against the hazards of violations and evasions" (UN General Assembly 1946).

Concerns about proliferation risks and growing nuclear arsenals continued into the 1950s and, soon enough, the matter of moving away from military applications of nuclear science and technology towards peaceful applications instead was brought to the table again (Chossudovsky 1990). At the 470th Plenary Meeting of the UN General Assembly on 8 December 1953, Dwight D. Eisenhower, then president of the USA, delivered what the media of the time famously called the "Atoms for Peace" speech (Drogan 2016:948–74). In this speech, Eisenhower made the case for the peaceful application of nuclear science and technology in healthcare, agriculture, and civil electricity production, *inter alia*. The speech also called for the creation of an atomic energy agency to oversee the international transfer of peaceful nuclear technologies and storage and dissemination of fissionable nuclear fuel. At the same time, Eisenhower also promised support from the

US (technology and knowledge transfers) for implementing the peaceful uses of nuclear energy so that "the miraculous inventiveness of man shall not be dedicated to his death but consecrated to his life" (Eisenhower 1953).

A symbolic type of fission, Eisenhower sought to separate the peaceful, progressive, developmental aspects of nuclear science from the violence and ruin for which the atom became known in 1945. A nuclear arms race swiftly followed. Eisenhower was convinced that "if the fearful trend of atomic military build-up can be reversed, this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind" (Eisenhower 1953). Drogan maintains that Atoms for Peace "grew out of a proposal to be more open with the U.S. public about the nation's nuclear project" (Drogan 2016:950). Until Eisenhower's speech, US policy on the matter of nuclear technology was "one of total secrecy and denial" (Krass *et al.* 1983:195). By publicly voicing the Atoms for Peace proposals, it switched to what Krass *et al.* (1983:195) term "selective secrecy and control by co-operation". But while more transparency as a factor was considered, the speech at its start also marked "the kick-off to a massive propaganda campaign by the U.S. Information Agency (USIA)" (Drogan 2016:948). Nuclear power, Gattie and Massey (2020:124) maintain, "had become a political issue 'in the context of the great contest between Western freedom and Soviet totalitarianism' and would require candour, trust, and confidence with the American public and with US allies in an emerging world order".

The Eisenhower administration was searching for a way to "offer a sense of optimism and portray the United States as an advocate for peace instead of war", an opportunity the speech provided (Drogan 2016:950). Referring to a 1955 National Security Document, "Peaceful Uses of Atomic Energy", that grew out of Eisenhower's 1953 proposals, Drogan describes it as "concerned almost entirely with the 'psychological benefits' to be gained from the globalisation of nuclear power under American leadership" (Drogan 2016:972). But it was also a clear indication that nuclear power had become an issue of national security to the US and, in this spirit, the US's leadership in the development of the peaceful uses of nuclear energy was viewed by the country's National Security Council as a way 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 people of the world" (National Security Council Report cited in Gattie & Massey 2020:124). When Eisenhower delivered the speech in 1953, no concrete plans for a project to promote the peaceful uses of nuclear energy were actually in place. In fact, apart from his inner circle, a significant number of officials in the US government were not aware of Eisenhower's proposals until he delivered the speech (Drogan 2016).

Furthermore, while he strongly emphasized civil electricity production in the speech, the US had no nuclear power reactors of the size and scale necessary for this task, with government reports from the time stating that "nuclear power was neither economical nor ready for export, and that it represented a serious proliferation risk" (Drogan 2016:949). Eisenhower's speech and the US's framing of nuclear energy coincide with both the establishment of a liberal post-war world order and the "rising Communist power", ultimately steering the National Security Council "to establish an international system to safeguard the US and the world from future great power conflicts by controlling atomic energy in all its various pathways that could offer peaceful applications and prevent military extensions" (Gattie & Massey 2020:125). Atoms for Peace had a lasting impact on the world and became the platform for the realisation of several bilateral cooperation agreements, and nuclear technology and fissionable fuel were shared; it would also ultimately result in the establishment of the IAEA in 1957 (Drogan 2016). By creating these formal platforms for sharing knowledge and technology related to nuclear science, Atoms for Peace contributed to an acceleration of their dispersal but at the same time delivered its crowning achievement: "the establishment of a normative framework that in its absence likely would not have emerged" (Scheinman 2003). Moreover, as Lawrence Scheinman, former Distinguished Professor in the Center for Non-proliferation Studies at Monterrey University argues, it is very likely that without the Atoms for Peace proposals, the IAEA would not have been created; and, in such an environment, it is anyone's guess as to whether nuclear technology sharing would have proceeded unabated or with clear-cut conditions (Scheinman 2003).

The two sides of nuclear science and technology that Eisenhower (and the UN General Assembly before him and advocates for peaceful uses to this day) sought to split, however, oscillate in "fundamental tension" (Krass *et al.* 1983:197). As David Bergmann, founder of the Israel Atomic Energy Commission remarked, "by developing atomic energy for peaceful uses you reach the nuclear option; there are not two atomic energies" (Bergmann quoted in Scheinman 2003:7). Thus, the same fears that plagued the international community in 1946, about nuclear technology and knowledge-sharing resulting in proliferation of nuclear weapons, still exist to some extent today. To dismiss such concerns offhand would be counterintuitive. As the so-called "father of the hydrogen bomb", Edward Teller, opined, "eventually nuclear proliferation is unavoidable unless we find better solutions to international problems than are now on the horizon" (Teller quoted in Scheinman 2003:7).

The consequences of unsafeguarded sharing of nuclear technology and scientific know-how have been well demonstrated. One example is Canada's transfer of a nuclear research reactor without safeguards to India in 1954, a reactor that was ultimately used to produce the plutonium for India's first nuclear weapons test in 1974 (International Panel of Fissile Material 2010). Another is the purchase of a nuclear reactor from France by Israel in 1956 (Scheinman 2003). The well-documented A. Q. Khan nuclear network incident also shows how it is possible to share the technical know-how needed to design nuclear weapons in the absence of strict trade regulations and control mechanisms. In his analysis, "Shadow and Substance: Securing the Future of Atoms for Peace", Scheinman argues that Teller's assessment of the inevitability of nuclear proliferation points to an unsettling but important probability: "that capability alone is an insufficient explanation of the risk of proliferation. Motivation also matters" (Scheinman 2003).

Many legitimate proliferation concerns have been raised, from reaching weaponisation from civilian application to proliferation by non-state actors and safeguarding of existing nuclear weapons and weapons technology from malicious actors. And while it could be possible, strictly speaking, to move from civil electricity production to weapons production, the very process itself is not easy, and a majority of states have no desire, or more precisely, lack the motivation, for the production, stockpiling, and maintenance of nuclear weapons. That is not to say that proliferation should not be a concern. In a 2007 debate between renowned political scientists Scott Sagan and Kenneth Waltz, Sagan (in Sagan, Waltz & Betts 2007:140) best summarised the issue in his criticism of Waltz's statement:

> Professor Waltz argues that we do not need to wonder whether new nuclear states will take good care of the nuclear weapons—they have every incentive to do so. 'They', an abstract entity called the state, may have the incentive to do so. But other actors inside these states may not have similar incentives.

The safe operating, safeguarding, and physical protection of nuclear installations is therefore of the utmost importance not only for preventing accidents but also for ensuring that the technology does not fall into the hands of actors whose interests do not align with this goal. Thus, as Sagan (in Sagan, Waltz & Betts 2007:145) posits, "[t]he key is to permit the development of civilian nuclear reactors but stop the spread of uranium enrichment and reprocessing technologies". The normative and legal framework that evolved from the Atoms for Peace initiative and that gave rise to the IAEA and the NPT can be regarded as some of the "better solutions" referred to by Teller. Their goal should be to remove the motivation states might have for diverting peaceful uses to weapons applications. To do this, various regional and international instruments have entrenched disarmament and non-proliferation as ideals and requirements, and made the peaceful uses of nuclear energy conditional on certain safeguards and circumstances and at the same time subject to a legal framework capable of penalising those who depart from the accepted standards. And this is precisely where the NPT comes in (Sagan 2009).

2.4 The Treaty on the Non-Proliferation of Nuclear Weapons: Peaceful uses subject to…

The NPT carries tremendous symbolic and practical weight. To date, the treaty has a total of 191 States Parties (Nuclear Threat Initiative 2024). States party to the NPT include China, France, the Russian Federation, the UK, and the US (the Permanent 5 or P5), all recognised nuclear weapon states (NWS) under the NPT. There are five non-state parties to the NPT: India, Israel[2], North Korea (who withdrew from the treaty in 2003), Pakistan, and South Sudan, the first four of which are considered nuclear-armed states. In the more than 50 years since its entry into force, the NPT achieved many milestones, especially as envisioned at the time of its negotiation, most notably near universal accession and the creation of several more regional nuclear-weapon-free zones that reinforce its legitimacy (Abe 2020).

But the drafting and eventual entry into force of this treaty was a long and winding path. Eisenhower's Atoms for Peace proposal set in motion a drive at the highest international levels to, firstly, place prohibitions on the development, dissemination, and possession of nuclear weapons and, secondly, to legitimise the peaceful application of nuclear science and technology under carefully laid out safeguards requirements to prevent diversion from this route. The 1950s arguably became the most important decade for promoting these ideals, especially at the level of the UN General Assembly. The General Assembly in the 1950s was dominated largely by US interests, and while these certainly played an important role in shaping the NPT and general disarmament and non-proliferation frameworks (as did

2 Israel has neither officially confirmed nor denied its possession of nuclear weapons. However, it is commonly believed that it does possess some and it is generally included in the list of nine NWS. According to the Center for Arms Control Non-Proliferation, estimates indicate that Israel is in possession of 90 plutonium-based nuclear warheads (Center for Arms Control and Non-Proliferation n.d).

the interests of the Soviet Union), several other (smaller) states or aligned state groupings became prominent actors in the field during this time (Macqueen 1984). They effectively used the General Assembly and its First Committee (Disarmament and International Security) as vehicles for tabling their interests on the most important issues of the day and pushing for action on these matters, which would ultimately result in the opening for signature of the NPT in 1968 and its entry into force two years later.

Key in this process was Ireland's minister for external affairs, Frank Aiken (Chossudovsky 1990). Aiken served as minister for external affairs from 1951–1954 and 1957–1969. A member of the UN since 1955, Ireland recognised the threat that the unrestricted spread of nuclear weapons (horizontally and vertically) could pose for international security going forward and used its UN membership between 1958 and 1961 to persistently push for legal mechanisms to rein in this rapidly evolving sphere of science (Chossudovsky 1990). During this time, Ireland submitted four resolutions (one in each year), addressing growing concerns about the spread of nuclear weapons, and successfully turning this item into a General Assembly (and First Committee) agenda action point (Chossudovsky 1990).

A precise history of this process spanning 1958–1961 is well beyond the scope of this chapter. To briefly summarise, however, Ireland's efforts led to the adoption of several General Assembly resolutions (including Resolution 1380 of 1959 and Resolution 1576 of 1960) on the matter, peaking with what Chossudovsky calls the "notable, if not historic" unanimous approval of its 1961 draft resolution by the First Committee (30 November 1961) and General Assembly (4 December 1961), and the introduction of UN General Assembly Resolution 1665(XVI) (Chossudovsky 1990). Resolution 1665(XVI), "Prevention of the wider dissemination of nuclear weapons", "calls upon all states, and in particular upon the states at present possessing nuclear weapons, to use their best endeavours to secure the conclusion of an international agreement containing provisions under which the nuclear states would undertake to refrain from relinquishing control of nuclear weapons and from transmitting the information necessary for their manufacture to states not possessing such weapons, and provisions under which states not possessing nuclear weapons would undertake not to manufacture or otherwise acquire control of such weapons" (UN General Assembly 1961:6; Chossudovsky 1990).

It is worth noting that Ethiopia, Liberia, Sudan, and Tunisia were some of the African countries also involved in these and other early efforts to create a single treaty document on non-proliferation and disarmament.[3] It would also be remiss to leave out consideration of the various proposals for nuclear arms control put forward by the US and the former Soviet Union in the creation of the NPT (Goldschmidt 1986). With nuclear weapons testing on the rise in the late 1950s and the ensuing Cuban Missile Crisis of 1962, the need for nuclear arms control was clear and the US, UK, and Soviet Union entered into the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water in August 1963 (Athanasopulos 1997). The importance of controlling the spread of nuclear weapons would be made even more apparent in 1964 when China conducted its first nuclear test. In 1959, the Soviet Union assisted China with the construction of a gaseous diffusion plant used to enrich the uranium to build its bombs. Krass *et al.* (1983:196) report that as a result of this "traumatic experience", no "further exports of enrichment technology by the Soviet Union" were recorded.

Subsequently, negotiations of the NPT kicked-off in 1965, and by 1 July 1968 a treaty document had been approved and opened for signature (Goldschmidt 1980). The NPT is built upon the distinction of peaceful uses from non-proliferation and disarmament. The Treaty consists of 11 articles that address non-proliferation and disarmament commitments as well as the continuation of the use of nuclear science and technology for peaceful purposes. The first four of these articles will be considered here. Acknowledging the existence of five nuclear weapons states, Article 1 of the NPT places restrictions on the

3 For a detailed history of Ireland's, and more specifically Aiken's role, see Chossudovsky (1990).

transfer of nuclear weapons or related explosive devices and their control to any of its non-nuclear weapons state parties and to not incentivise these states to want to produce or acquire nuclear weapons (UNODA 1968). Article 2 flips the table on the non-nuclear weapons states parties, requiring that they will not accept the transfer of nuclear weapons or related explosive devices, nor transfer of the control over such weapons systems, and not produce, or ask for assistance to produce, such weapons (UNODA 1968).

Article 3 of the NPT pertains to safeguards and is broken into four parts. According to Article 3(1), every state party to the NPT not in possession of nuclear weapons "undertakes to accept safeguards as set forth in an agreement to be negotiated and concluded" with the IAEA. These safeguards are to draw directly from the Statute and safeguards system of the IAEA (UNODA 1968). Safeguards under the NPT are put in place for "the verification of the fulfilment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices" (UNODA 1968). Article 3(2) provides that every party to the treaty (NWS included) shall not provide "(a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this Article" (UNODA 1968).

The safeguards provision in the NPT links directly to Article 4 (Peaceful Uses), and Article 3(3) states that the safeguards requirement "shall be implemented in a manner designed to comply with Article IV . . . and to avoid hampering the economic or technological development of the Parties or international co-operation in the field of peaceful nuclear activities" before finally concluding in Article 3(4) with an obligation on non-nuclear weapon states to "conclude agreements with the [IAEA] to meet the requirements of this Article either individually or together with other States in accordance with the Statute of the [IAEA]" (UNODA 1968).

This requirement is time-sensitive: within 180 days of the entry into force of the NPT, states were expected to begin these negotiations, and those that ratified it after this period will be subject to agreement that "enter into force not later than eighteen months after the date of initiation of negotiations" (UNODA 1968). Article 4(1) of the NPT provides for the "inalienable right of all the Parties to the Treaty to develop research, production, and use of nuclear energy for peaceful purposes without discrimination and in conformity with Articles I and II of this Treaty" (UNODA 1968). It is important to note, however, as Sagan emphasises, this inalienable right comes with the condition that states be in *good standing* with the NPT, the initial clause of Article 4 (Sagan, Waltz & Betts 2007:148). In other words, states should not be found to be acquiring nuclear technology under the pretence of civilian application only to be caught diverting it for weapons purposes.

Furthermore, according to Article 4(2), all state parties "undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy" (UNODA 1968). Proponents of nuclear energy frequently cite Article 4 of the NPT as the guarantor of its use, drawing on the phrase "inalienable right". And while this article does cement the right to peaceful uses of nuclear science and technology, it has also fallen victim to what Scheinman terms "an imperfect and uncritical reading" that veils the reality that the threat of proliferation still remains even where nuclear science and technology is applied for peaceful purposes (Scheinman 2003). Scheinman maintains that it is taken for granted that Article 4(1) goes on to say that peaceful uses will only be permitted "in conformity with Article I and II"—in-line with Sagan's "good standing" reminder—which specifically mandate non-proliferation and nuclear sharing within established safeguards mechanisms (Scheinman 2003).

Sagan notices the same frequent oversight and argues that "this 'inalienable right' is in reality a conditional right, dependent upon the state in question" adhering to Articles 1 and 2 (Sagan 2009:160). In other words, to separate peaceful uses from non-proliferation and disarmament—or put differently, to forget the dangers and destructive capabilities to which nuclear science and technology can be applied—is a mistake, since the application of this science for purposes of a peaceful nature does not remove the inherent risk that a state might succumb to the temptation, whatever the motivation may be, to divert and go down the explosive path. Referring to the case of suspected proliferation in Iran's nuclear programme, Sagan argues that "it is too often forgotten . . . that a state that is not behaving 'in conformity' with its Article II commitment . . . has at least temporarily sacrificed its rights to acquire civilian nuclear technology under Article IV" (Sagan 2009:160; cf. also Sagan, Waltz & Betts 2007).

Ultimately, it is compliance with Articles 1 and 2 that upholds the right supplied in Article 4. As the president of the tenth NPT Review Conference remarked at Wilton Park in 2021, "In this way, non-proliferation commitments enable peaceful uses, but it is the promise of the benefits under this third pillar that prop up the other two" (Zlauvinen 2021:2). In other words, states should be motivated to conform with Articles 1 and 2 to gain from the benefits of peaceful uses. At the same time, Kirsten and Zarka (2022:7) argue that there is also a generally noticeable "lack of awareness of peaceful uses, particularly of non-power applications", meaning that a significant majority of people are inclined to associate peaceful uses simply with nuclear power, ignorant of "the lifesaving applications in treating cancer, improving food security, and detecting and fighting disease". This necessitates placing more emphasis on the peaceful uses of nuclear energy, especially now when it is poised to alleviate so many of the developmental challenges the world faces. However, it should not be forgotten that it then rests ultimately on states to adhere to their safeguards and non-proliferation commitments. Applying nuclear science and technology peacefully therefore comes with the price of strict regulation.

In 1995, the NPT was extended indefinitely, a process in which South Africa, a new party to the treaty and widely acclaimed champion of disarmament after dismantling its nuclear weapons programme, was instrumental (Arms Control Association 2022). Discontent with the little progress made by NWS on disarmament since the treaty entered into force was high in 1995, and non-nuclear weapon states sought to increase the pressure on NWS to disarm. This included "the establishment of a set of principles and objectives on nuclear non-proliferation and disarmament to hold . . . particularly the nuclear-weapon states, accountable to their commitments" (Arms Control Association 2022). Furthermore, also on the table was the possible creation of a weapons of mass-destruction-free zone in the Middle East (Arms Control Association 2022). This ideal has not yet been realised.

African states, however, have further cemented their widespread support of the NPT by following this line of thought and creating a nuclear-weapon-free zone on the continent. This aligns with Article 7 of the NPT, which states that "Nothing in this Treaty affects the right of any group of States to conclude regional treaties in order to assure the total absence of nuclear weapons in their respective territories" (UNODA 1968). As the next section will show, although this aligned with the objectives of the NPT, Africa's commitment to nuclear disarmament and the peaceful uses far precedes the NPT. In addition to its domestic regulations, African states display high levels of support for the NPT, as outlined in Figure 1.

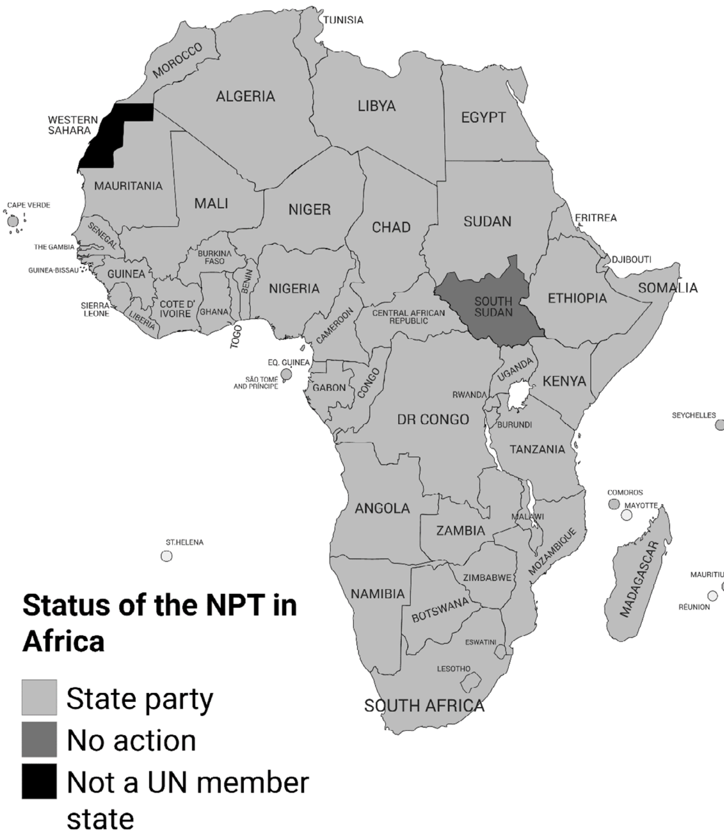

Figure 1: Map detailing the status of the NPT on the African continent. Source: Author

2.5 Africa's commitment to disarmament, non-proliferation, and the peaceful uses of nuclear energy: The African Nuclear-Weapon-Free Zone Treaty (Treaty of Pelindaba)

The African Nuclear-Weapon-Free Zone (NWFZ) Treaty, also called the Treaty of Pelindaba, is Africa's flagship nuclear non-proliferation and disarmament instrument. The Treaty opened for signature on 12 April 1996, and has been in force since 15 July 2009, following ratification of the Treaty by Burundi, the required 28th state depositary for entry into force (Nuclear Threat Initiative 2023). Its origins, however, go back to two documents introduced more than three decades prior to the opening for signature: the UN General Assembly resolution 1652 of 1961, and the Declaration on the Denuclearisation of Africa of 1964 by the Organization of African Unity (OAU), the predecessor of the African Union (AU).

Resolution 1652(XVI), "Consideration of Africa as a denuclearised zone", was born from the growing global concerns about the spread of nuclear weapons but, more specifically, considering the superpower politics of the Cold War, from "the need to prevent Africa from becoming involved in any competition associated with the ideological struggles between the Powers engaged in the arms race and, particularly, with nuclear weapons" (UN General Assembly 1961). The obligations of the resolution are threefold: nuclear tests of any kind in Africa are to come to an end; Africa's territory, including water and airspace, may not be used for nuclear weapons tests or to store and transport nuclear weapons; and, finally, Africa is to be considered a denuclearised zone and treated as such (UN General Assembly 1961).

In 1964, at the first ordinary meeting of heads of African states and government of the OAU, the continental body issued the declaration AHG/Res.11(I), "Denuclearisation of Africa", which was later also endorsed by the UN General Assembly (Nuclear Threat Initiative 2023). The declaration reaffirms both the statements made in General Assembly Resolution 1652 as well as the Resolution on General Disarmament adopted by African Heads of State and Government in 1963 (OAU 1964). In the declaration, African states "declare their readiness to undertake in an International Treaty to be concluded under the auspices of the United Nations not to manufacture or acquire control of nuclear weapons" (OAU 1964). Additionally, African states call upon "all peace-loving nations" to do the same, call on NWS to "respect and abide by this Declaration", and call for the approval of the declaration by the UN General Assembly (OAU 1964).

From these frameworks, cooperation between the OAU and the UN would progress to the creation of a Joint Group of Experts (GOE) for the drafting of an African NWFZ treaty. This GOE met for the first time in Addis Ababa in 1991 and in the ensuing years would meet again in Lomé (1992), Harare (1993), and twice in 1994 in Windhoek and Addis Ababa. It is during these latter two meetings that the GOE adopted the first draft of the envisioned African NWFZ Treaty (Nuclear Threat Initiative 2023). Meeting in Johannesburg and Pelindaba in South Africa in May and June of 1995 respectively, experts worked towards approval of the text, a goal it achieved on 23 June 1995. The UN General Assembly approved the treaty that November and by 11 April 1996, when it officially opened for signature, 47 African states added their signatures to the African NWFZ Treaty (Nuclear Threat Initiative 2023).

Athanasopulos (1997) regards the Treaty of Pelindaba as "an important legal development" worthy of being an example for the establishment of other nuclear-weapon-free zones around the world. In its preamble, African states recognise the Treaty of Pelindaba as "an important step towards strengthening the non-proliferation regime, promoting cooperation in the peaceful uses of nuclear energy, promoting general and complete disarmament and enhancing regional and international peace and security" (AU 1996:1). Furthermore, it also confirms the importance of the NPT and "the need for the implementation of all its provisions" (AU 1996:2). In particular, a deep-seated interest for "taking advantage" of Article 4 of the NPT is also expressed in the preamble (AU 1996:2). The Treaty of Pelindaba prohibits states parties from producing, acquiring, stockpiling, or controlling (briefly put) nuclear weapons or nuclear explosive devices (AU 1996:1). Article 8 of the Treaty provides the conditions for the peaceful uses of nuclear science and technology on the continent. As in the NPT, safeguards are awarded high importance in the Treaty of Pelindaba and states parties are "encouraged to make use of the programme of assistance available in IAEA and, in this connection, to strengthen cooperation under the African Regional Cooperation Agreement for Research, Training and Development Related to

Nuclear Science and Technology" (AFRA) in Article 8(3) (AU 1996:6).

The Treaty then takes a stricter tone, obligating states parties in Article 9(a) to "conduct all activities for the peaceful use of nuclear energy under strict non-proliferation measures to provide assurance of exclusively peaceful uses" (AU 1996:6). Whereas IAEA assistance is encouraged in Article 8, Article 9(b) mandates the conclusion of "a comprehensive safeguards agreement with IAEA for the purpose of verifying compliance with the undertakings in subparagraph (a) of this article" (AU 1996:6). The Treaty also establishes the African Commission on Nuclear Energy (AFCONE) as a further compliance mechanism (AU 1996). To complement its safeguards and verification provisions, the Treaty of Pelindaba also includes requirements for the "physical protection of nuclear materials, facilities and equipment to prevent theft and unauthorised handling" (Article 10) and calls on states parties to commit "not to take, or assist, or encourage any action aimed at an armed attack by conventional or other means against nuclear installations in the African Nuclear-Weapon-Free Zone" (Article 11) (AU 1996:7).

The Treaty of Pelindaba is an important legal basis for a continent that has over the years proven to be not only committed to nuclear disarmament and the peaceful uses of nuclear science and technology but deeply interested in applying it to enhance its socio-economic development. Beyond the NPT and Treaty of Pelindaba, African states have also been active members of the international grouping of states and civil society organisations that promoted the so-called "humanitarian consequences" initiative from which the Treaty on the Prohibition of Nuclear Weapons (TPNW)—the treaty banning nuclear weapons—evolved (Swart 2016:753–773). This initiative turned the nuclear disarmament debate on its head by suggesting that nuclear weapons should be banned because, in the event of a nuclear bomb detonation, the humanitarian consequences would be grave and responding to such a disaster almost impossible, since critical infrastructure is likely to be destroyed, emergency relief personnel also injured, and the risk of radiation exposure very high. Beginning with the first international conference on the Humanitarian Impact of Nuclear Weapons in 2013, several African states have stepped into active leadership roles, delivering remarks and suggestions, allowing for input on a subject that has for decades been the domain of the nuclear expert and not civil society and states sure to be affected by the use of nuclear weapons (Swart 2016:753–773).

Remaining active players in this discussion will also benefit the wishes of African states to upscale the role of nuclear energy on the continent. Apart from the continent's one existing nuclear plant in South Africa, ten research reactors are also present on the continent and used in a variety of applications, including the production of medical isotopes, research, training, food nutrition analysis, soil fertility analysis in the agricultural sector as well as processes such as neutron activation analysis in geology (Stott & Bosman 2021). As African countries seek to expand their economies and become more industrialised, nuclear energy could add value in meeting rising electricity demand (Gil 2018; Foy & Bosman 2021). Construction is currently underway on Egypt's El Dabaa nuclear power plant, the result of a bilateral agreement between the Nuclear Power Plants Authority of Egypt and the Russian state nuclear corporation, Rosatom (World Nuclear News 2023). This means that in the near future, the continent will have a second, operational nuclear power plant. Other states have also indicated their desire to turn to nuclear power and the IAEA has reportedly been contacted by Algeria, Ghana (who has made significant progress in assessing its viability), Kenya, Morocco, Niger, Nigeria, Sudan, Tunisia, Uganda, and Zimbabwe for assistance in determining readiness and other requirements (Foy & Bosman 2021; Bosman 2021).

Nuclear science and technology provide a unique opportunity for addressing the Sustainable Development Goals and the AU's Agenda 2063 beyond just diversification of electricity supply and widening access to electricity; they can also assist in improving healthcare, agriculture, food security, and education, which are all included in these development agendas in one form or another (Stott & Bosman 2022). Nearly 50% of the population of sub-Saharan Africa does not have access to electricity and it is believed that the addition of nuclear energy could alleviate this shortage (Stott & Bosman 2021). African states will also become more reliant on nuclear science and technology in the future to address key health and food security challenges. There is a continent-wide shortage of radiotherapy machines, vital in treating cancer, and the number of cancer cases diagnosed on the continent is also on the rise (Stott & Bosman 2021). Furthermore, nuclear technology will prove a vital component of science in a world where future zoonotic disease outbreaks are predicted to increase. Future programmes to mitigate this challenge can build on the existing Zoonotic Disease Integrated Action (ZODIAC) and Veterinary Diagnostic Laboratory Network (VETLAB) initiatives established in conjunction with the IAEA to monitor and mitigate zoonotic disease outbreaks and treating animal disease outbreaks to protect livestock and human populations simultaneously (Stott & Bosman 2021). All of these uses of nuclear science and technology will require strong domestic regulatory frameworks and adherence to regional/continental and international legal guidelines. Africa's strong support for the NPT combined with widespread ratification of the Treaty of Pelindaba will help ensure that nuclear science and technology is continuously applied within the safeguards and verification measures implemented to prevent diversion and, ultimately, ensure the longevity of the use of nuclear energy for peaceful aims. To date, the Treaty of Pelindaba has 44 states parties and 52 signatory states, as illustrated in Figure 2. One state, South Sudan, has neither signed nor ratified the Treaty.

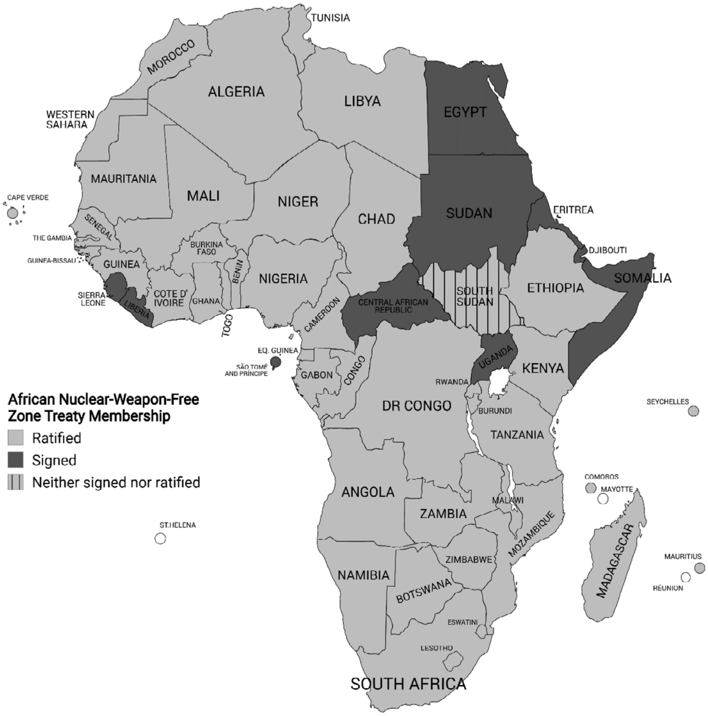

Figure 2: Map detailing the status of the NPT on the African continent. Source: Author

2.6 Conclusion

It is ironic that the science behind one of the most destructive human-made forces on earth could also be precisely what is required to extend to humanity some of its most crucial rights and provisions like access to clean and reliable energy sources, healthcare, and a secure food supply. Of course, nuclear energy is not a cure-all and, in some contexts, might not even be the best solution. But aside from its ability to produce electricity, nuclear science and technology also hold many other advantages, without some of which twenty-first century life would be drastically altered. This is a form of science that is continuously evolving and developing with an eye on improvement, higher precision, and, importantly, increased safety and security.

New technology such as Small Modular Reactors (SMRs) have garnered a lot of attention due to the significantly cheaper costs and flexibility attached to them. SMRs typically have a production capacity of around 300MW and their small physical size allows for these reactors to be placed on sites not suited to traditional power plants (Liou 2023). Their application can also be tailored to geographical location, and an SMR could, for example, be used to power just one city. Microreactors, a sub-category of SMRS, are even smaller (10 MW) and according to Liou (2023) are good candidates for "backup power supply in emergency situations" or for the replacement of diesel-powered generators in remote areas. SMRs could be especially useful in Africa where electricity access is low, especially in rural areas.

Peaceful uses of nuclear science and technology have been guaranteed in a vast collection of legal instruments, the most important of which is the NPT. It is the most important because it holds some of the biggest NWS in the world to a requirement to disarm and holds its other states parties to the obligation of non-proliferation— to respect the right to peaceful uses by not violating this principle. Africa is not alone in its quest to draw more on these peaceful uses, and it has without doubt displayed exemplary levels of commitment to the NPT's three pillars. Although it boasts near universal accession to the NPT, the continent added an additional layer in the form of the Treaty of Pelindaba. By enshrining those same conditions—application of peaceful uses conditional on safeguards and verification—the Treaty of Pelindaba reinforces the commitment of African states to the NPT and its own commitments to nuclear disarmament that precede it. It also has an important role to play in the global disarmament and non-proliferation regimes and these continental mechanisms add to its reputation as leader in the field. For this reason, more should be done to increase the number of states parties to the Treaty of Pelindaba. Moreover, more focus should be placed on educating people about the peaceful uses of nuclear science and technology and, equally, about the legal mechanisms that exist to protect and, ultimately, guarantee it. This framework developed alongside it and therefore should not be neglected. The Humanitarian Consequences Initiative proves that that narrative matters. Perhaps it's time to remember that nuclear science and technology started out peacefully and to return it to that purpose alone.

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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.

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Chapter 4

Unfulfilled Desire, Impossible Futures: The Contradictions of African Regional Nuclear Ordering

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4.1 Introduction

This chapter is about African agency when it comes to ordering the nuclear issue-area at the regional level. Walker (2011:12) defines nuclear ordering as the evolution of "patterns of thought and activity" towards goals, including the avoidance of nuclear war and economic development. Implied is a quest for "a tolerable accommodation" of the discrepancies between the rights and responsibilities of different states entailed by an imperfect and unequal order (Walker 2011:12). Our focus here is on regional organisations with a nuclear mandate in Africa, specifically the African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA); the African Commission for Nuclear Energy (AFCONE); and the Forum of Nuclear Regulatory Bodies in Africa (FNRBA). This chapter draws heavily upon our study of African regional nuclear institutions and complexity in nuclear ordering (Pretorius & Vaughan 2024) and reproduces some material from that article. However, here we develop two additional elements of African nuclear ordering efforts, which limited space restricted us from discussing in that article. These are, firstly, the relationship between nuclear failure, or denial, and nuclear desire, and, secondly, the implications of this relationship for how possible African nuclear futures are defined.

There is a drive to "become [more] nuclear" at the regional level through African nuclear organisations. This drive is framed as follows: the continent suffers from energy poverty with more than half of the states on the continent unable to provide electricity to even 50 percent of their populations. To attain the United Nations (UN) sustainable development goals and the African Union's Agenda 2063, whilst minimising greenhouse gas emissions, African states are looking to nuclear energy (Sah *et al.* 2018:2). Non-electricity uses of nuclear technology are pursued as "low hanging fruit" but the real prize is nuclear power generation (Adenji 2002:4). Nineteen African states are currently pursuing nuclear electricity generation capacity, albeit at a varied pace (Otwoma 2021; NBP 2023). African states, bar South Africa and Egypt, the framing continues, are not ready or safe for nuclear power generation yet; the regulatory frameworks and scientific know-how are still lagging. For most analysts, continental "arrangements and their institutional mechanisms can enable African states to enhance security and cost-effectively develop nuclear power infrastructure" (Chacha 2012:38). Thus, African nuclear organisations come to play a significant role in this nuclear drive by facilitating vertical (between international organisations and African partners) and horizontal (intra-regional) scientific, technological, and regulatory nuclear knowledge and skills transfer.[1]

1 This framing of the regional role is also perpetuated by multinational industry actors facilitating nuclear power expansion, e.g. Nuclear Business Platform (NBP), a Singaporean-based company, advertised a recent conference on regional collaboration and nuclear energy in Africa as follows: "With regional organizations taking center stage as nuclear advocates, the continent can secure

On face value, regional agency is seen as a common-sense good to take ownership of ordering nuclear matters in Africa, and to map a path to development in Africa amid climate change through nuclear energy. There is also no doubt that these organisations pursue these activities to give Africa a louder voice in the global nuclear order. However, there is reason to look more critically at the performative agency of regional nuclear organisations. The critical framing we bring to the table employs the notions of nuclearity as set out in the work of Gabrielle Hecht (2006; 2012) and nuclear desire as set out by Shampa Biswas (2014)the Nuclear Non-Proliferation Treaty (NPT. We also evoke two opposing images of the nuclear future that are brought into view by Africa's regional nuclear agency: the idealised vision of "nutopia" as described by Columba Peoples (2016) versus the dystopian vision of "nuclear eternity" described by Benoît Pelopidas (2021).

We argue that African nuclear ordering at the regional level is driven by nuclear desire, which is in turn fuelled by the constantly deferred promise of an independently "nuclear" continent. Through regional organisations, a collective "African" agency is performed (in the sense outlined by Butler 2010) whereby African states prove themselves competent handlers of civilian nuclear technology, ready to pursue a prosperous and energy-independent future. At the same time, the same institutions (and several African states) performatively pursue a future of global nuclear disarmament. Both impulses are rooted in radical and (post)colonial histories. However, as nuclear desire leads Africa on a constant quest for nuclearity and increased authority on global nuclear matters, the necessary (re) committal to global nuclear ordering arrangements closes off this future. Instead, Africa is committed to a techno-managerial global nuclear future in which nuclear disarmament is infinitely deferred, while the African continent continues to serve as the "nuclear backyard" of the five nuclear weapon states.

The chapter proceeds as follows. We provide a brief explanation of the concepts of nuclearity, nuclear desire, and

clean, reliable energy while positioning itself as a leader in the global energy transition!" (NBP 2024).

nuclear futures. Then we situate African nuclear ordering agency in historical context. We then move on to a discussion of the three African nuclear organisations under review and analyse their performative agency through a critical-conceptual lens, before concluding with a discussion of the contradictory visions of Africa's (non-)nuclear future that they express: the ideal "nutopian" future, and the reality of business-as-usual under "nuclear eternity".

4.2 Nuclearity, nuclear desire, and nuclear futures

Gabrielle Hecht (2012:14) employs the term nuclearity to tease out "[w]hat things make a state 'nuclear,' what makes things 'nuclear,' and how do we know? Are the criteria scientific? Technical? Political? Systemic?" Hecht shows that "being nuclear" is socially constructed and not based solely on the material quality of something; something is not nuclear, for example, just because it has radio-active properties. Hecht's work on uranium and its waning and ebbing nuclearity since the 1940s gives us a sense of how nuclearity gets assigned and the role of (techno)politics in this process. As such, there are contested hierarchies and values around nuclearity, often connected to other expressions of power hierarchies in global, regional, and national contexts. Advocates of nuclear deterrence assign nuclear weapons the highest form of nuclearity as well as the five so-called nuclear weapon states (NWS)[2]. This label was assigned, in the Treaty on the Non-proliferation of Nuclear Weapons (NPT), to states that had tested these weapons by 1967 and tried hard to forge these weapons' value as the ultimate guarantors of international security and peace *in their own hands* (UK Government 2023). The NPT codifies this construction further by making the spread of nuclear weapons beyond these five states illegal and illegitimate. The Treaty on the Prohibition of Nuclear Weapons (TPNW), informally the "Ban

2 Only the United States (US), Russia, the United Kingdom (UK), France, and China are formally recognised as NWS under the NPT. The other four states possessing nuclear weapons—India, Pakistan, North Korea, and Israel—do not benefit from formal NWS status and, as such, may be understood as being somewhat 'less nuclear' than those which do.

Treaty", contests the value of nuclear weapons but confirms their nuclearity at the top of the hierarchy by emphasising their existentially destructive power.

Other forms of nuclearity are accessible to "non-nuclear weapons states'' (NNWS)—as the NPT label suggests—that had not tested these weapons by 1967 and even those that had tested them after this date, for example through nuclear technology for peaceful purposes. However, what is military and what is peaceful nuclear technology remains the subject of negotiation (diplomatically and discursively) and is again not a function of material properties alone, if at all. The value of Hecht's intervention is that it dislodges the idea that nuclear and non-nuclear are determinable through an essential ontology; that is, being nuclear is not self-evident, not simply a material property of states and things, but "distributed" amongst things and arises as a matter of practice. Technopolitical complexes inform nuclearity—what actors and things come to be deemed nuclear and how they are prioritised and treated.

Biswas (2014:41) argues that the nuclear non-proliferation regime "depoliticize[s] nuclearization, which in turn occludes a deeply hierarchical global nuclear order that helps produce *nuclear desire* [emphasis added] as well as deflecting from the interests that benefit from the pursuit of those desires." Nuclear desire is a useful concept with which to investigate the dynamics of African agency in relation to the global nuclear order. "Nuclear desire" conceives of the nuclear weapon as a fetish commodity invested with the power, like totems or crosses in some cultures, to fix what seem like impossible problems or at least provide hope and courage to those faced with these problems (Biswas 2014:41). Nuclear deterrence theory, which claims nuclear weapons' usefulness through their uselessness reflects this fetishization—their value lies in the belief that they scare off attacks from enemy others without being "used". The fetishization of nuclear weapons is possible through the way in which they are talked about: "nukespeak" uses highly technical, abstract, or euphemistic and playful language to obscure what their use actually implies, to make them more morally acceptable, and to domesticate their dangers (Cohn 1987). In addition, Biswas also explains how nuclear weapons, like luxury goods, become commodity fetishes through their exclusivity, cost, and the complex social messages that they send out about those who can acquire them. They signal complex social messages, communicating not just security but status, power, and modernity. Specialised knowledge of deterrence strategies, infrastructure, and control is a prerequisite for their "appropriate" consumption, which reserves them for societies deemed sufficiently rational and technologically proficient (Biswas 2014:179–189). The control regime around nuclear technology at once serves to prevent the spread of nuclear weapons beyond the original five and to fuel nuclear desire amongst the states prohibited from acquiring them.

Engagement in nuclear ordering, we argue, is a particular practice that represents a kind of nuclearity. Exercising ordering agency through regional nuclear institutions, then, is a relatively accessible mode of nuclearity for African states, rooted in a number of historic ordering imperatives and fanned by the fetishisation of things nuclear. The final part of our conceptual framework is the idea of nuclear futures. Africa's regional nuclear agency has a temporal component: Africa is currently not very 'nuclear', in Hecht's sense, but developmentalist narratives invoke a vision of the future in which nuclear power can provide the continent with energy independence and associated economic benefits. Although this is rooted strongly in the political imperatives of decolonization, non-aligned solidarity, and national liberation (see below), it channels the cosmopolitan optimism of "Atoms for Peace". In this vision of the future, nuclear energy abundance coexists with a nuclear-weapons-free African continent (and, indeed, world). Columba Peoples has coined the term "nutopia" to denote the faith in the benefits of civil nuclear energy to "redeem" the evils of nuclear weapons. Peoples points out that "nutopianism" underlies the global nuclear order at large: "International proposals to control, reduce, and end the horrific potential of nuclear weapons tend to be predominantly and crucially predicated on the assumed redeeming features of nuclear power as an embedded form of 'common sense'" (Peoples 2016:219). Although African regional initiatives for building nuclear energy capacity and keeping the continent free of nuclear weapons are sometimes expressed in rhetorically radical terms, they hew closely to the ideal of a "nutopian" future.

By contrast, Benoît Pelopidas (2021:484–485) has introduced the idea of "nuclear eternity" to denote a globally hegemonic consensus that "no future without [nuclear weapons] is conceivable". Nuclear eternity may not necessarily last forever, since humanity could be destroyed in a nuclear war tomorrow, but a nuclear-free future is broadly understood among policymakers, experts, and citizens to be impossible. While Pelopidas is not primarily concerned with nuclear energy in this treatment, he recognizes its inseparability from nuclear weapons. Our analysis expands upon this link. We demonstrate that, under the NPT regime, African regional efforts to pursue nuclear energy inadvertently entrench nuclear eternity even further, despite pioneering African contributions, past and present, to regional and global nuclear disarmament initiatives. Regional nuclear institutions promise nutopia but end up delivering nuclear eternity, even when good faith commitments to global nuclear abolition exist. This is a consequence of the interaction between postcolonial African nuclear desire and the global non-proliferation regime.

We now detail how this paradoxical situation has developed, beginning with an outline of historic African exercises of nuclear ordering agency.

4.3 African nuclear ordering agency from decolonisation to 1995

Political ordering, it is assumed, occurs because agents recognise an ordering imperative and reflexively act on it. For the purposes of this investigation, three exigencies stand out as those in which Africans recognised an ordering imperative and, subsequently, engaged in ordering activities:

1. Decolonisation, coinciding with a) UN efforts to control nuclear energy after the use of nuclear weapons in Japan and b) nuclear testing by the nuclear-weapons states, particularly in the Sahara Desert;

2. The promise of nuclear technology for continent-wide economic and social development;
3. Apartheid South Africa's pursuit of a muscular national nuclearity and ultimate attainment of a nuclear weapons capability.

The first two of these encouraged straightforwardly the development of the two pillars of the African nuclear order, as identified by Kornprobst (2020): prohibition and peaceful use. The third is more "ambivalent" (Abraham, 2006). While South Africa's actions in pursuing a nationalist and militarised nuclearity in some ways worked against the imperatives of prohibition and peaceful use, the ultimate result of Pretoria's nuclear programme was to energize and further embed them in the regional nuclear ordering landscape.

4.3.1 Decolonization and nuclear testing

The earliest exigency to prompt performances of African agency in regional nuclear ordering emerged from the confluence of formal decolonisation processes, UN-led efforts to control the spread of nuclear weapons, and French nuclear testing in Algeria from 1960 to 1966. French testing began during the Algerian Revolution of 1956 to 1962 and went ahead during an ongoing war of independence. Seventeen tests were ultimately conducted, with atmospheric tests ending but underground tests continuing after the end of the war. Selection of the test sites and decisions around safety and the habitability effects of testing were conducted according to a nakedly colonial logic. Nuclear explosions were conducted far away from the colonial metropole, on colonised lands in close proximity to colonised populations, without consultation or apparent concern for their wishes or wellbeing (Jacobs 2013; Maclellan 2017; Maurer & Hogue 2020). The test programme was accordingly deemed "nuclear imperialism" by Kwame Nkrumah's Ghana and encouraged pan-African as well as pan-Arab sentiment (Ahlman 2010:79; Intondi 2015:45–61). It highlighted the links between European—particularly French—colonialism and the global nuclear complex (Hecht 2012:107–140). The tests spurred some of the earliest discussions conducted in a postcolonial register regarding the possibility of a nuclear-free African continent and, more broadly, a disarmed world. Nkrumah convened seminal regional organisations during the French tests such as the First Conference of Independent African States (FCIAS). In the context of cascading decolonisation, the Organization of African Unity (OAU) was formed in 1963 and issued its "Declaration on the Denuclearization of Africa" in 1964 (Organisation of African Unity 1964), cementing the idea of an African NWFZ in regional thinking. As Mpofu-Walsh (2022:158) notes, another significant development was the increased African representation (from nine to 35 delegations) at the UN General Assembly, which was crucial in pushing disarmament (and non-proliferation) up on the broader agenda. Elsewhere, Abraham (2018) documents the work of the Afro-Asian Legal Consultative Committee in the 1960s towards laying the legal groundwork for the delegitimisation of nuclear weapons.

At the same time, the two Cold War superpowers were jointly recognising a need to collaborate to restrict the further spread of nuclear weapons in order to maintain the strategic balance in Europe but also to reduce the number of actual and potential regional nuclear confrontations. Regional nuclear developments appeared to pose increasing threats to stability and to complicate assessments and perceptions of threat on the part of the superpowers, and Washington and Moscow thus agreed on "the need to find a universal solution to the proliferation problem" (Popp 2017:21). In the context of bitter confrontation, then, was a shared interest in limiting the spread of nuclear weapons, which would form the basis of the Cold-War (and post-Cold-War) global nuclear order (Potter 1985); and out of this order arose negotiations towards a treaty on non-proliferation. It was therefore significant that UNGA resolution 1652 (XVI), on the "consideration of Africa as a denuclearized zone", not only condemned French nuclear testing and proposed a complete ban on nuclear-weapons-related activity in Africa on the whole but also noted concern about the "present rate of nuclear armament and possible spread of nuclear weapons" (UN General Assembly 1961). This resolution was prelude to the eventual creation of an African NWFZ under the Treaty of Pelindaba and also to the integration of African states and their non-aligned, non-nuclear armed counterparts into the global non-proliferation architecture on unfavourable terms—a contribution to the fetishisation of nuclear technology in Africa and an expression of what Mpofu-Walsh calls "obedient rebellion" (Mpofu-Walsh 2022). These measures would soon serve to restrict African states from access to nuclear technology for peaceful developmental use.

4.3.2 The promise and denial of peaceful use

Nuclear colonialism in Africa was not limited to nuclear testing, and a cruder form of extractive nuclear relationship predated the French testing programme. Despite abundant raw resources and hence a crucial enabling role in the nuclear programmes of the Western powers, African states served only as resource colonies. Extraction of South African uranium, later boosted by output from occupied Namibia, was vitally important for the British and US nuclear programmes before Pretoria embarked on its own national effort (De Villiers, Jardine & Reiss 1993; Hecht 2012). Elsewhere, Gabon and Niger produced uranium for France, and French companies prospected for uranium ore in Cameroon, Congo, Mali, the Central African Republic, Nigeria, Senegal, and Zambia (Adeniji 2002:25). Despite this, South Africa was the only African state to operate a nuclear power station during the period under review. Aside from South Africa, Egypt and Ghana were most interested in extracting the benefits of nuclear power. Egypt inaugurated a nuclear research programme in 1954 and opening a Soviet-supplied research reactor in 1961. Despite efforts by successive presidents, Egypt was repeatedly thwarted in its ambitious plans to establish an advanced indigenous nuclear research capability during the immediate postcolonial period (Taha 2021:13–16). Ghana's nuclear power programme abruptly ended in 1966 when the Nkrumah government fell to a military coup (Foy & Bosman 2021).

The relative absence of civil nuclear technology in Africa, then, is not always for want of trying. During their post-independence years, African states organised regionally around the principle of peaceful use and lobbied hard within the fledgling IAEA to try and extend its developmental and technical assistance remit (Roehrlich 2016). Kornprobst (2020:901) details how "African states quickly converged around a much broader view of what a nuclear order ought to look like, including an institutionalized system of technology transfer from 'haves' to 'have-nots'". Apartheid South Africa opposed such a developmental remit for the IAEA (see below). The push for access to nuclear technologies for peaceful use was spearheaded during the early and middle Cold War years by NAM, with participation from a number of African states, including the drafting and insertion into the NPT of Article IV in 1966—a late stage in NPT negotiations (Potter & Mukhatzhanova 2012:81). Egypt (then the United Arab Republic), Nigeria, and Ethiopia, as members of the Eighteen-Nation Committee on Disarmament, teamed up with other non-aligned states to press for the nascent triadic structure of nuclear order that included peaceful use and nuclear disarmament. Shaker (1980) describes how these states, led by the UAR's delegate in the ENDC, put forward the guidelines for the NPT's negotiation as set out in UNGA Resolution 2028 XX. Although Kornprobst (2020) recounts many initiatives that African states pushed for in the NPT negotiations that were shot down, the triadic structure was secured, albeit on an unequal footing.

In 1969, the OAU hosted a symposium on "Peaceful Uses for Nuclear Energy in Africa" in Kinshasa, in collaboration with the IAEA and the DRC's own Commission on Nuclear Sciences (the DRC had operated a research reactor since 1959). In Kinshasa, the IAEA's delegation recognised the need to incorporate the peaceful use of nuclear energy into African states' plans for development but highlighted that the structural barriers to implementation (personnel, investment, training, *inter alia*) were the responsibilities of individual African states and their planners to overcome, rather than the responsibilities of a developmentalist IAEA (Lloyd 1969). A further decade of stunted progress led the issue of peaceful use to be raised again in NAM's 1979 Havana Declaration, which recorded dissatisfaction with "the obstacles which the developed countries place in the way of transfers of technologies", as well as concern with the use of non-proliferation as "a pretext to prevent states from exercising the right to acquire and develop peaceful nuclear technology" (UNGA 1979:74). These concerns would be borne out. African states would continue to make the case for stronger technical assistance programmes and greater access to peaceful nuclear technology—but largely through the provisions of the NPT. In highlighting (for some) the dangers of "diversion" of peaceful technology towards weapons programmes, the South African weapons programme was a double-edged sword for African nuclear ordering.

4.3.3 Apartheid South Africa's nuclear programme: ambivalent ordering

The third ordering exigency was South Africa's pursuit of an "indigenous" nuclear industry, complete domestic nuclear fuel cycle, and eventually nuclear weapons. Contradictory ordering forces were at work here. On the one hand, Pretoria performed a militarised and techno-nationalist agency, attempting to carve out a niche for itself in the global nuclear order while isolating itself from the rest of the continent, restricting other African states' access to technical assistance for peaceful use, and ultimately obtaining the continent's first and only domestic nuclear capability. On the other hand, South Africa's active involvement in the foundation of the IAEA helped to embed the norm of peaceful use in a manner that opened the door for future African participation in ordering and provoked a strong pro-disarmament response from both the OAU and the African National Congress (ANC) in exile. This paved the way for South Africa's present-day "norm entrepreneurship" role in non-proliferation (Van Wyk 2012b; Van Wyk & Van Wyk 2015).

Well before Pretoria embarked on its nuclear weapons programme, it saw the fledgling IAEA as a forum in which to position South Africa as a leading force and representative of the African continent, even as it was progressively marginalised elsewhere over apartheid. Hecht demonstrates how South African diplomats lobbied within the Agency to make "production of source materials" an indicator of "nuclear advancement", and therefore to position South Africa as the "most nuclear" state in Africa and secure the African regional seat (Hecht 2006:30). They sought to protect this influence by pushing the IAEA to adopt a purely "technical" mandate and arguing against the expansion of developmental technical assistance programmes. This militated against wider African demands for expanded access to nuclear technologies for peaceful use. These efforts ultimately generated mixed results: South Africa was replaced by Egypt on the board in 1977 over apartheid, postcolonial politics having breached Pretoria's bureaucratic defences within the organisation. However, the IAEA's codification of its "technical" mandate remained as a durable legacy for global and regional nuclear ordering.

Even more significant as an ordering exigency was South Africa's nuclear weapons programme, which began in earnest in the first half of the 1970s (Masiza 1993). Although official confirmation that Pretoria had successfully constructed six viable nuclear warheads did not come until the fall of apartheid (De Klerk 1993), explicit declarations of nuclear ambiguity by South African officials and the so-called "Vela incident" of 1979 led analysts to conclude with reasonable certainty that South Africa was seeking the bomb (Betts 1979). By the early 1980s, this was an open secret and a prominent transnational campaign spearheaded by other African nations and the ANC in exile through organisations like the Anti-Apartheid Movement and the UN Centre Against Apartheid. This worked to align the rapidly solidifying non-proliferation regime with the anti-apartheid struggle (Van Wyk & Van Wyk 2020). Although the ANC maintained a nominally critical stance towards the discriminatory nature of the non-proliferation regime and attacked instances of Western nuclear collaboration with apartheid South Africa, this campaign aligned the South African resistance movement with the anti-(techno) political ideals of non-proliferation (Vaughan 2021). Although it is difficult to judge the success of the campaign amid the broader context of sanctions on South Africa, the progressive collapse of apartheid, and the end of the Cold War (Fig 1999), the domestic and regional struggle against the apartheid bomb strongly informed future African approaches to nuclear ordering.

When South Africa's formal announcement of disarmament in 1993 and the ANC's subsequent victory in the first post-apartheid elections arrived, South Africa bore a special status: newly disarmed, newly democratic. As such, its intervention was pivotal in the indefinite extension of the NPT in 1995, where its credibility on both disarmament and the liberation struggle proved crucial in helping to win over recalcitrant NAM states to agree to extension. Onderco and Van Wyk (2019) offer the most comprehensive history of this process (see also Welsh 1995 for individual NAM delegate perspectives). The most important South African contribution to extension was the so-called "package deal" on disarmament and peaceful use, which reaffirmed the obligations of the NWS as set out in the NPT's original text but, crucially, created no further binding commitments and no new mechanism for the NNWS to hold them to account. With specific regard to peaceful use, the statement of the "package deal" pointed to the NWS's obligation under Articles I–III of the NPT to respect the "inalienable right" to nuclear technology for development purposes but added a further layer of complexity in the form of additional restrictions. Delegates affirmed that all new supply arrangements should require full-scope safeguards "as a necessary precondition" (Kimball & Rydell 2020:36). The outcome may have been a coup for South Africa's status as a progressive and responsible "norm entrepreneur" in multilateral circles (Van Wyk 2012b), but it represented the culmination of the three Cold War-era ordering exigencies into a highly discriminatory (and now indefinite) instrument, which defanged the postcolonial demands of African states.

The failure of the non-proliferation apparatus to provide the desired access to civil nuclear technology has drawn African agents into the nuclear order at the regional level, encouraging them to generate and participate in an ever more baroque web of institutions and instruments. While agency is exercised, it functions in the interests of the hegemonic nuclear order (Ritchie & Egeland 2018; Ruzicka 2018; Ritchie 2019) to further deny and restrict and, as we explain below, cement the status of nuclear technology (including but not limited to weapons) as a highly desired fetish commodity.

4.4 The regional dimension of Africa's nuclear drive

As we discuss below, the three key African nuclear organisations—the African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA), the African Commission on Nuclear Energy (AFCONE), and the Forum of Nuclear Regulatory Bodies in Africa (FNRBA)—are intimately linked to the IAEA as the body that operationalises the NPT's peaceful use/non-proliferation mandate to the extent that they form regional iterations of the global nuclear control regime.

4.4.1 AFRA

AFRA was signed into force in 1990 as a framework for encouraging and intensifying collaboration on nuclear technology for sustainable development within Africa. It consists of a technical working group made up of national coordinators appointed by each member state. An annual meeting of representatives (member-states) determines the programme of activities, including cooperative projects among states. The IAEA is not party to AFRA, though it supports it under its technical assistance mandate. Having existed for two decades longer than AFCONE, AFRA claims a number of successes, most tangibly in the broad field of health and nuclear medicine. "Under AFRA, 40 radiotherapy centres in 18 African countries have been upgraded and more than 250 radiotherapists, medical physicists, nurses and radiographers have been trained on improved radiotherapy protocols, medical physics and management of radiotherapy departments" (AFRA 2017:11). Advances have also been made in disposal technology for sealed radioactive sources and training in nuclear science. The AFRA Regional Strategic Co-operative Framework, the organisation's main planning document, identifies seven agreed-upon thematic areas of focus: human health, food and agriculture, water resources, sustainable energy development, industrial applications, radiation safety/nuclear security, and human resource development (Van Wyk, Turianskyi & Bosman 2021:6). Being longer-established, AFRA is "more influential" than AFCONE, and had 39 partnered African states as of 2012, which at the time was greater than the number of parties to the Treaty of Pelindaba (Van Wyk 2012a:290).

As of September 2024, AFRA had 38 states parties (IAEA 2024). This is a marked improvement from 2021, when just 10 states parties had renewed their membership (Van Wyk *et al.* 2021:6). Membership appears to fluctuate because of the rolling five-year extension period and the non-renewal of membership on the part of several states, and this issue has been addressed by a "revised agreement of indefinite duration" (Van Wyk *et al.* 2021:7). The considerable overlap and potential for competition between the mandates of both AFRA and AFCONE as well as AFRA and the FNRBA (Van Wyk 2012a:290) may have contributed to this dynamic. In 2020, AFRA and AFCONE went as far as signing a memorandum of understanding in the pursuit of "greater synergy in the programmes and optimisation of resources" (AFCONE 2020). Van Wyk *et al.* (2021:14) identify this need in their recommendation that AFRA "increase co-operation with regional and international bodies", along with AFRA's apparently spotty membership record.

4.4.2 AFCONE

The African states' efforts to denuclearise the continent as set out in the 1961 UNGA resolutions and in the 1964 Cairo declaration came to fruition with political change in South Africa during the early 1990s, when African states approached the UN to prepare for negotiations of an ANWFZ. The resulting Treaty of Pelindaba addressed several failures, identified by African states in the global nuclear control complex, in an accretionary manner. Foremost, special emphasis was placed on promoting peaceful use of nuclear science and technology through regional cooperation, especially in nuclear energy. The implementing body of the Treaty, AFCONE, had as a primary task regional cooperation on peaceful use. Secondly, AFCONE was designated as an inspection body in addition to the IAEA, particularly because "while the expertise and experience of IAEA inspectors was well known, Africa should not totally rely on the Agency for performing such a vital function in the treaty [...] these IAEA experts had failed to confirm Africa's earlier loud, bitter and accurate allegations of a South African nuclear weapon capability that posed a grave threat to the continent's security" (Adeniji 2002:84). The lack of (political) will here led to the IAEA's failure. AFCONE, they argued, "should be given the flexibility to call upon expertise from other sources than the Agency" (Adeniji 2002:84). AFCONE would thus be a regional forum for African agency on nuclear matters, aiming to "establish a *continental* legal and institutional framework for nuclear security and safety, and promote African and international partnerships" (Van Wyk *et al.* 2021:9; emphasis added).

The Treaty of Pelindaba entered into force only in 2009, and as a result AFCONE itself was not instituted until 2010. In 2012, Van Wyk (2012a:282) remarked that "the process for a fully operational AFCONE is debatable and not positive" owing to an overall lack of financial and political commitment as well as disagreements between important state backers. After this "initial impasse", however, AFCONE is claimed to have made "progress" in its broad mandate, which *inter alia* covers the exchange of information, the general implementation of the Treaty of Pelindaba, ensuring compliance with IAEA safeguards, and encouraging nuclear co-operation both between African states and between African states and "extra-zonal" states on peaceful use (Van Wyk *et al.* 2021:9). Specifically, this progress has mostly concerned the establishment of co-operation agreements with the implementing organisations of other NFWZs, but also with the IAEA, the CTBTO, and Rosatom, the Russian state nuclear utility. The 2019 Co-operation Memorandum of Understanding between AFCONE and Rosatom "establishe[d] a basis for Russia to help African countries with various projects related to nuclear energy" (NEI 2020), an important step in peaceful use given several African states' existing intentions (and, in some cases, contracts) to acquire Russian-supplied nuclear infrastructure. Indeed, an "action plan for co-operation" was further signed in late 2023 (Rosatom 2023). In addition, AFCONE has integrated itself with the African Union's broader peace and security architecture and, in March 2022, briefed the AU Peace and Security Council on "how the Pelindaba Treaty could contribute [to] advancing [the] global nuclear disarmament and non-proliferation agenda, thereby promot[ing] international peace and security" (Amani Africa 2022)—thus positioning itself as the authoritative continental voice on nuclear issues.

AFCONE nevertheless faces several challenges. In a set of recommendations, Van Wyk *et al.* (2021:13) note that not only have several African states failed to ratify the Treaty of Pelindaba but existing states parties have not yet "fully commit[ted] to financial and technical support for AFCONE". Indeed, AFCONE is still in need of "additional human resources [for] the Secretariat, such as ICT personnel to complete and maintain its website" (Van Wyk *et al.* 2021:13). The full programme of regular activities envisioned for AFCONE is yet to be fulfilled. Another potentially thorny issue is the threat to the full implementation of the Treaty of Pelindaba posed by the island of Diego Garcia. Formally a British Overseas Territory leased to the US Navy and claimed by Mauritius, Diego Garcia is a crucial element of US military capabilities in the region. The island hosts and services nuclear-powered submarines and B-52 bombers, though it is unclear whether nuclear warheads themselves are stockpiled there (Bashfield 2020). The status of Diego Garcia's boundaries, with regard to whether it is covered under the Treaty of Pelindaba, is contested, and in 2016 Mauritanian activists requested AFCONE inspections of the island (Lalit 2016). No response from AFCONE is documented.

4.4.3 The FNRBA

The FNRBA, established in 2009, consists of the national nuclear regulators of 34 member states and aims to "strengthen and harmonize radiation and nuclear safety and security regulatory infrastructures in its member countries, and serve as an effective platform for the exchange of regulatory experiences and practices among the nuclear regulatory bodies" (IAEA 2022b). It signed a co-operation agreement with the IAEA in 2013, and the two bodies work closely together. The FNRBA's 2016 Strategic Action Plan identifies several problems to be addressed in the region, including but not limited to inadequate resourcing, inadequate commitment to and implementation of regulation, competing priorities among member states, different regulatory terrains and infrastructures among member states, lack of co-ordination between regulators, and a lack of co-ordination with AFRA, AFCONE, and other regional organisations (IAEA 2016:5). As such, the purpose of the FNRBA is mainly to bring African nuclear regulatory bodies up to IAEA safety standards and encourage the implementation of IAEA methodologies in regulation (see IAEA 2016 for a highly detailed breakdown of the FNRBA's strategic priorities).

Van Wyk *et al.* (2021:11) state that there is "something … to be said for the precise institutional nature of the FNRBA", which claims a straightforward mandate and creates "an opportunity for member states to 'learn from their peers' and experts alike, resulting in a well of knowledge and experience from which members can readily draw". However, a representative of the Sudanese Nuclear and Radiological Regulatory Authority nonetheless identified in 2014 a "lack of financial resources" which "significantly" affected the FNRBA's ability to carry out its mandate (Osman 2014). Once again, van Wyk *et al.* (2021:14) recommend that the FNRBA intensify its efforts at co-operation with "other regional bodies dedicated to the safe and secure use of nuclear science and technology".

These organisations are each engaged in developing links between each other, fostering intra-regional connections, and forging connections between their own region and others. There are varying degrees of crossover between their mandates, and each organisation hosts sub-groupings, committees, and additional agreements. In addition, the AU's African Energy Commission (AFREC) is "likely to jump into the fray and consider nuclear options" (Van Wyk 2012a:290), while analysts (cf. Velichkov 2021) recommend further integration with sub-regional bodies like the Southern African Development Community (SADC).

Furthermore, the implementation of UNSC Resolution 1540, which aims to diffuse nuclear security norms and regulations around illicit nuclear trafficking, has taken on a regional dimension through conferences and workshops hosted by the African Union Commission and the United Nations

Regional Centre for Peace and Disarmament in Africa (Broodryk & Stott 2014; UN 2019). See also Foy's (2019) discussion of regional mechanisms to further nuclear security.

We now analyse Africa's regional nuclear ordering agency within the critical conceptual framework we set out in section 3.

4.5 Nuclear denial, desire, and reification of hierarchy

The NPT can be understood as a foundational instrument that distributes and mediates nuclearity (e.g., Peoples 2016). By drawing a formal distinction between nuclear and NNWS and the relationship between them, the NPT aims to fix in place these differential nuclearities. Hamidi (2020:551) argues:

> By enacting and performing nuclearity through NPT negotiations, states attempted to order the world around what appeared to be a natural distinction between nuclear and non-nuclear states. But these negotiations … themselves solidified and embedded these categories into nuclear discourse. Rather than being a pre-existing ordering, the distinction between nuclear and non-nuclear states was also a product of NPT negotiations.

As noted above, nuclear weapons were assigned the highest order of nuclearity, but the separability of military and civilian nuclear technology codified in the treaty allows for non-nuclear weapon states to have a circumscribed degree of nuclearity through the "inalienable right" to nuclear energy for peaceful purposes (Hecht 2007:102–103). However, the distinction between military and civilian is not clear-cut—nuclear technology is always "ambivalent" (Abraham 2010), the distinction requiring constant discursive reification and policing—and the risk of proliferation is always present. This leads Baker *et al.* (1976:137) to raise questions about:

> the ability of the nuclear states to raise the threshold for entry to the nuclear club. That is, which states—nuclear, soon-to-be nuclear, and non-nuclear—ought to be

> involved in such arrangements?... Is a concerted effort by the nuclear powers desirable or necessary or, to the contrary, might this be perceived as an attempt to form a 'nuclear OPEC'?

The NPT is set up to entangle the three "pillars" of non-proliferation, disarmament, and peaceful use discursively in what Pretorius and Sauer (2022:109) liken to a perpetual game of rock-paper-scissors. Under the logic of the NPT and the wider non-proliferation regime around it, nuclear disarmament cannot occur while there is a risk of proliferation. According to this same logic, however, proliferation is an inherent risk of peaceful use, and peaceful use is an inalienable right. Therefore, the peaceful-use pillar and consequent proliferation risk make nuclear disarmament an impossibility, which in turn unravels the grand bargain of the NPT that links non-proliferation and disarmament. NNWS may think of their peaceful programmes as nuclear hedging, and this allows NWS to play up proliferation risks to justify continued possession of their own nuclear weapons.

Why would African states play the NPT game? The answer is likely bound up in nuclear desire created by the NPT. It is not just the NPT's reserving of the highest order of nuclearity for nuclear weapons and their possessors but its restricting of the (inalienable) right to peaceful nuclear energy—by upping the threshold—that is key to understanding why nuclearity or "being nuclear" is sought after by states, especially African states, in the first place. African states can access the kind of nuclearity that the NPT makes possible for states without nuclear weapons through the promise of an inalienable right to peaceful technology.

Just as the consumption of luxury goods is related to the status and personality of a person, the possession of nuclear weapons is linked to the state by signifying statehood. As Biswas (2014) notes, nuclear weapons become spectacular national monuments. Restriction flames nuclear desire, because "like money, it is the 'scarcity' of nuclear weapons that makes them an appropriate carrier of social value" (Harrington de Santana

2009:333). But this scarcity is not restricted to nuclear weapons alone. As noted earlier, the built-in risk of proliferation is understood as the self-evident flipside of the inalienable right to peaceful uses, and therefore peaceful technology is not a free for all. The logic of restriction that makes nuclear weapons commodity-fetish objects is also at work in the case of the peaceful use of nuclear energy for development. Just as nuclear weapons come to stand in for security, societies can also become dependent (psycho-politically and techno-politically) on peaceful nuclear technology to provide "impossible development", worshipped as having magical powers to deliver Africa from "the cheapest nights"[3].

When we peel back the sometimes lavish nuclear development speak used in relation to and by African nuclear organisations through a critical lens, we also excavate the deeper meanings and power relations of the kind of agency that African organisations perform. Hamidi suggests that NNWSs, like those in Africa, use non-proliferation forums to exercise their identities and pursue their broader interests. Restrictive regimes not only come to constitute nuclear and non-nuclear states but provide a way for these states to construct and perform their nuclear identities (Hamidi 2020:545). Just as Hecht explores "being nuclear", Hamidi draws attention to "being non-nuclear". She tracks debates around the nuclear and non-nuclear distinction in the Eighteen Nation Disarmament Committee (ENCD), the forum established to negotiate the NPT, from 1962 to 1969. Hamidi shows that these debates acquired an identitarian "us vs. them" quality that framed the material difference of having and not having nuclear weapons. NNWSs, and, for our purposes, African states, signed up to a discriminatory treaty that codified the hierarchy between nuclear and non-nuclear states because "Non-nuclear status presented a way to perform a burgeoning

3 The allusion, which is to the short story titled 'The Cheapest Nights' by the Egyptian author, Yusuf Idriss, was made by David Otwoma (2021) in a presentation to motivate why Africans need nuclear energy. The story describes a poverty trap at the level of the family in the absence of development manifesting in lack of public services, such as access to electricity.

post-colonial identity for states" (Hamidi 2020:552). Especially for non-aligned states, there was much at stake in presenting such an identity that could be inserted as a force in the bipolar configuration of international politics. Nuclear disarmament was one aspect that NAM states agreed upon, and non-nuclear status therefore provided a framework by which to bind states together. An imagined Pan-African community identity has found and continues to find expression through Africa's nuclear ordering activities.

In the ENDC, non-nuclear states advocated for the "inalienable right" to nuclear energy and linked this right with the self-determination of people: "Developmental concerns drove these states to both revile nuclear weapons while remaining open to the economic potential brought by nuclear technology, which entangled strategic concerns with normative ones" (Hamidi 2020:559). Although non-nuclear states, especially in NAM, participated in the construction of what it means to be non-nuclear and used the NPT's categories strategically to perform certain identities and to get the inalienable right and disarmament clauses in the NPT set up, the exercise of this type of agency comes at a cost. The cost is reifying the NWS's top spot in the nuclear hierarchy by performing the NPT script and thereby conferring status and prestige on the nuclear haves. Even in nuclear-weapon-free zones like Africa, there can only be obedient rebellion, as Mpofu-Walsh asserts. Bergenäs (2008:6–7) argues that regional and sub-regional African organisations may help to overcome countries' resistance to "assistance from outside states and international organisations out of concern for protecting state sovereignty and to shield themselves against outside actors seeking to gain political influence over their internal affairs" (Bergenäs 2008:7). As shown in the previous section, African nuclear organisations are intimately linked to the IAEA as the body that operationalises the NPT's peaceful use/non-proliferation mandate to the extent that they form regional iterations of the global nuclear control regime. As a result, African agency often comes to mimic the technical rather than the political nature of the IAEA's performance of global nuclear order and its hierarchies. This is not to say that African actors have not used international forums in the past to exercise more activist agency, but, by and large, African nuclear organisations serve the goal of obedience rather than rebellion, in Mpofu-Walsh's terminology.

One of AFCONE's key activities is encouraging African states to accede to international non-proliferation and disarmament treaties and conventions. In this way AFCONE is instrumental in disseminating global nuclear controls to individual African states where international agreements must find expression in national legislation and eventually practice. South Africa's nuclear regulatory framework, for example, is already extensive and complex, but still not considered adequate (Qasaymeh 2016; Reddiar 2021).Very few African states have the kind of nuclear facilities and capabilities that would justify membership of and allocation of resources to these international institutions and diffusing controls and requirements to their national regulatory space. Nuclear controls expose NNWS to political pressure and intrusion, not only with respect to legitimate concerns about nuclear proliferation, safety, and security, but as a guide to achieving other political objectives. Sanctions on Iran and the war on Iraq in 2003 are the more grotesque enactments of power through the nuclear control regime complex. Goldemberg (2009) explains that in 1970s the US blocked Germany from installing enrichment plants in Iran and Brazil because *political* conditions were not met. In both cases, the states involved then started developing their own enrichment facilities—something that is still on the table in SA. Once in place, national regulatory institutions may well serve to manufacture nuclear desire and rationales for nuclear energy, expanding state power vis-à-vis other local actors, like civil society groups or communities living in the shadow of nuclear power plants and nuclear waste disposal sites. Our investigation thus turns to the contradictory futures that find expression in African nuclear organisations' agency.

4.6 Contradictory nuclear futures

The programmes of Africa's regional nuclear institutions are future-facing: they orientate the continent towards idealised visions of the nuclear future, proceeding temporally from widely accepted "not-yets". These are also inexorably bound up with broader global nuclear futures, since African regional nuclear institutions are nested within larger international organisations such as the IAEA and implicated within global nuclear trade networks and agreements. Broadly, these visions can be summarised as 1) an abundant, clean, and energy-independent future for Africa (for which, as we have seen, the continent is considered not yet ready), and 2) a future of global nuclear disarmament (to which the nuclear weapons states have not yet committed). While this volume addresses the issue-area of nuclear energy in Africa, "civil" and "military" uses of nuclear technology are inseparable—what Abraham (2006; 2010) calls the fundamental "ambivalence" of nuclear technology. This inseparability results in African regional nuclear institutions serving contradictory aims. As we have shown, both articulations of the future have their roots in historic and often radical political projects. While, in Butler's (2010) terms, the agency performed by African regional nuclear institutions is in keeping with this legacy, the nuclear future which they actually serve to bring about is not. Following Columba Peoples and Benoit Pelopidas respectively, we can contrast these two visions of the future as "nutopia" and "nuclear eternity".

Taken together, the aims of the AFCONE, AFRA, and the FNRBA are oriented towards a "nutopian" future. Peoples (2016:224) sees nutopianism as "predicated upon the assumption that nuclear power has redeeming features that outweigh its destructive application". Civil applications of nuclear technology offer tremendous opportunities for development and energy abundance which redeem the attendant threat of nuclear destruction. The boundary between "civil" and "military" nuclear technology is not a physical one, but discursive and therefore requiring constant policing and re-inscription. Activities like the development of best practices and standardisation of regulatory frameworks pursued not only maximise opportunities for the development of nuclear energy but also limit opportunities for military diversion and "proliferation". AFCONE's mission as the implementing body of the Treaty of Pelindaba also commits Africa formally to nuclear abstinence, and AFCONE additionally notes that Pelindaba's "normative congruence" with the TPNW aligns Africa with the ideal of global nuclear disarmament (Van Wyk & Turianskyi 2021:2). In fact, as Futter and Samuel (2023) show, African states have helped to stamp this nutopian vision onto the TPNW. At least in performative terms, then, the missions of Africa's regional nuclear institutions appear to work towards a nutopian African future.

However, the concrete effects of African regional nuclear activities, as outlined in this chapter, are more likely to commit Africa in practice to a future of "nuclear eternity". Pelopidas identifies three "modes of perpetualization": styles of reasoning implicit within global policies which, intentionally or otherwise, serve to entrench nuclear weapons as an eternal presence in global politics (Pelopidas 2021:487). Respectively, these take the form of images of "disconnected", "absent", and "inconsistent" post-nuclear futures. The nutopian future articulated through African regional nuclear agency falls into the latter category. An inconsistent post-nuclear future does, at least, present nuclear disarmament as a feasible goal, demonstrated here by the commitment of Africa's regional nuclear apparatus to Pelindaba and the TPNW. However, this future is inconsistent, because it "cannot be reached by the steps that are advocated" to reach it (Pelopidas 2021:488). This is because of African regional institutions' alignment—which continues to deepen—with those of the broader global nuclear order, principally the IAEA and the NPT.

As we have discussed, African expressions of nuclear desire are channelled through regional institutions. These conspicuously perform African nuclear ordering agency, technological and bureaucratic capability, and therefore trustworthiness in handling nuclear technology. In doing so, they imbue Africa with an enhanced status of nuclearity. As more African states become more nuclear, however, the capability—not to say the intention—to proliferate increases, which raises the perennial question of "who's next?" (Abraham 2010) among global nuclear policymakers.

It should be noted here that this fear is usually misguided: Pelopidas points out that pessimistic predictions of "cascading" nuclear proliferation once states acquire the requisite technical abilities have not come true (Pelopidas 2011). These fears are not rooted in historical experience but are an important part of the techno-political ideology of the global nuclear order, which justifies restrictions on peaceful use to "stop the spread" of nuclear weapons (Egeland 2021).[4] Therefore, as African states acquire more advanced nuclear capabilities, the imperative to demonstrate compliance with global standards of safeguarding and security is sharpened, and regional nuclear institutions intensify their adoption of international standards and frameworks and their collaboration with the mainstream non-proliferation agenda. While it places formal obligations on NWS to disarm, these are not time-limited. NWSs thus reserve the privilege to judge when "the international security environment and the actions of potential adversaries" permit concerted action on disarmament (UK Government 2023). The denial of this prerogative to NNWSs entrenches global hierarchies of power (Biswas 2014; Ruzicka 2018)the Nuclear Non-Proliferation Treaty (NPT.

Additionally, for Pelopidas (2021:496), the "technical practices of safeguard agreements and verification by the associated International Atomic Energy Agency have naturalized the eternal nuclear present and contributed to the entrenchment of nuclear eternity". In this context, as Mpofu-Walsh (2022) demonstrates, exercises of politicised dissent through Pelindaba or the TPNW can at best be understood as "obedient rebellion". So long as African regional nuclear institutions attempt to satisfy African states' nuclear desire through ever denser and more complex enmeshment with the non-proliferation regime,

4 For this reason, it is also unlikely that further progress in "proliferation resistant" (Emblemsvåg 2022), next-generation technologies like liquid thorium reactors will help African countries escape suspicion of proliferation. This suspicion is a product of the ideology of global nuclear order and will not be allayed by technical fixes. Relatedly, it should also be noted that this technology is not uncontroversial (Ramana 2022), and some scientists have warned that claims of intrinsic proliferation resistance may be overstated (Ashley *et al.* 2012; Uribe 2018).

the future is not nutopian. Instead, it is a techno-managerialist form of nuclear eternity, under which Africa is continually thwarted in its attempts to unlock the full developmental potential of nuclear energy. Moreover, while Africa itself may be free of nuclear weapons (with the notable exception of Diego Garcia), disarmament by the NWS is no closer at hand.

We reserve judgment on the political question of whether or not African states should pursue civil nuclear technology for development purposes. We simply point out that an idealised, "nutopian" future of nuclear-powered energy abundance and independence for Africa on the one hand, and African-led progress towards global nuclear disarmament on the other, is functionally impossible to achieve within the confines of the NPT. Recognising that this contradiction works to implicate Africa in the perpetuation of nuclear eternity, rendering the nuclear-free future absent, does not necessarily require giving up on either ideal. In fact, it invites us to imagine alternative nuclear futures for Africa, beyond the cycle described in this chapter, of eternally frustrated nuclear desire leading to performances of compliance with global non-proliferation policy, *ad infinitum*. Divergences from this path may appear ambitious, but addressing this contradictory dynamic is necessary for a feasible African nuclear direction.

Several alternative African nuclear futures are possible. On one extreme of the spectrum is a non-nuclear future, in which Africa foreswears not only nuclear weapons but also nuclear power. Civil resistance to nuclear energy is most developed in South Africa, home to the continent's only nuclear power station, Koeberg (Rennkamp & Bhuyan 2017; Fig 2018) and was sharpened by historic suspicions about the links between the country's civil nuclear industry and the apartheid regime's covert nuclear weapons programme. However, the strength of the regional drive to become more nuclear suggests that a nuclear-free African energy future is unlikely. On the other extreme, an alternative African nuclear future, unyoked from the NPT, might resemble that proposed by the late Ali Mazrui (1980)—a resurgent, nuclear-armed Africa. Although we argue alongside Mpofu-Walsh (2022) that African commitments to nuclear disarmament are likely to be ineffective under current non-proliferation arrangements, there is little reason to doubt that they are sincere. Africa's commitments to regional and global nuclear disarmament appear normatively strong, and Mazrui's vision subsequently implausible.

A middle path may be possible. Pretorius and Sauer (2022) have suggested that non-nuclear weapons states may legitimately abandon the NPT in favour of the TPNW: a radical departure indeed, but one which could not only advance disarmament but also permit the pursuit of more autonomous energy futures. Indeed, the TPNW's legitimacy rests partially on its accommodation of the desire of Global South states to pursue nuclear energy without restriction (Futter & Samuel 2023). By contrast, as Singh (2023:15) argues, "[w]ithout accommodating the interests of the rising powers and preparing for foreseeable shocks (challenges) to existing frameworks", the "fragile bargain" of the NPT is precarious indeed. African regional nuclear institutions may find a more fruitful means of pursuing nutopia through the TPNW, though this would require not only a parallel treaty but a parallel set of nuclear trade, regulation, and verification frameworks outside of the NPT. Efforts towards this have already begun (Durso 2023). Whether or not they will be successful remains to be seen, but an Afro-nutopian future under the NPT is, we argue, even more implausible.

4.7 Conclusion

This chapter framed the ordering agency of the three regional organisations with a nuclear mandate in Africa through a critical lens. The focus was especially on their role in negotiating and practising Africa's "non-nuclear" nuclearity through the pursuit of peaceful use and through the exercise of postcolonial identity in nuclear forums and how their agency relates to nuclear desire, fetishising nuclear technology as an answer to development and a way to a rightful place in the global order (nutopia). Our analysis argues that the likely outcome of this kind of agency is a contradictory nuclear future that reifies nuclear hierarchies and the continued existence of a world with nuclear weapons. Alternative African nuclear futures can be and indeed have been imagined. By introducing them here, our aim was not to exhaustively explore their desirability or even plausibility, but rather to prompt thinking beyond the categories of the NPT that fans nuclear desire with a view to cementing the horizon in this issue-area for Africa's ordering agency.

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Chapter 5

The Necropolitics of Africa's Nuclear Sacrifice Zones

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5.1 Introduction

The contemporary African nuclear landscape is dynamic and remains relevant in constantly shifting global geopolitics. However, this landscape is deeply embedded in the emergence of the nuclear age during the Second World War, and on the continent. Global interest in Africa's uranium resources continues but so, seemingly, does global interest in continued practices of nuclear necropolitics on the continent. This is evident in the prevalence of nuclear sacrifice zones on the continent wherein communities, generations, and geographical areas, sometimes across national borders, continue to be exposed to the violence associated with nuclear technology and the military-industrial complex of nuclear weapons states as well as states aspiring to acquire these weapons of mass destruction.

This chapter considers nuclear necropower and necropolitical practices in Africa with specific reference to uranium mining on the continent and the illicit disposal of radioactive waste. The chapter begins by outlining the theoretical and conceptual framework of necropolitics before proceeding to explore Africa's historical and contemporary nuclear landscape. Then the chapter turns to uranium mining as a nuclear necropolitical practice in Africa and the effects thereof. The penultimate section explores illicit radioactive waste disposal as a necropolitical practice and its impact on the continent. The final section of the chapter offers an assessment and concluding remarks.

5.2 Nuclear necropolitics and sacrifice zones

This section outlines the chapter's analytical framework by presenting a brief genealogy of the concepts of nuclear necropolitics and nuclear sacrifice zones. It begins with Foucault's concepts of biopower and biopolitics. The latter refers, *inter alia*, to the state's power over the biological sphere to control, regulate, and secure life under its sovereignty, and a state's biopower to control the biological health of its populations' bodies and the environment in which they live (Foucault 1967; 1979). To preserve the human and environmental lives that the state deems liveable, the state applies certain technologies, i.e., death technologies like weapons of mass destruction to threaten or proceed to kill and extinct with the goal of securing the survival of what a state deems worthy of living. The control over biological processes involves the appropriation of and control over space (land, territory, regions, etc.), which thereby creates spatial hierarchies, the distinction between spaces (utopias and heterotopias), and the political relations within these spaces where biopower is exercised (Foucault 1967:1–2).

Following on from his work on colonialism, slavery, and apartheid, Achille Mbembe (2003; 2019) expands on Foucault's (1979) notions of biopolitics and biopower by introducing the concept of necropolitics. Unlike Foucault's emphasis on life, Mbembe (2003; 2019) emphasises the state's control over death, both physical and symbolic. The state's preoccupation with death is also spatial, as it creates "death-worlds, new and unique forms of social existence in which vast populations are subjected to conditions of life conferring upon them the status of living dead" (Mbembe 2003:9–40). These life and death conditions, and the power structures associated with them, are relevant to the politics of nuclear technology and nuclear energy. The designation of places, objects, and hazards as "nuclear" confers a status of nuclearity (Hecht 2012:3–4). Uranium, nuclear energy, nuclear weapons, and nuclear waste are thus all illustrations of a state's nuclearity. Alexis-Martin's (2019:152–176) idea of nuclear necropolitics extends these ideas by focusing on the nuclear imperialism-necropolitics nexus. Nuclear imperialism comprises "the economic and spatial needs created by nuclear weapons and energy, as resources such as uranium are exploited, or spaces become militarized for nuclear weapon development and testing" (Alexis-Martin 2019:153).

This chapter considers nuclearity and nuclear necropolitics in Africa. It is posited that African societies are living the "bare life" (Agamben 2005) due to the "slow violence" (Nixon 2013) caused by exposure due to state control, or lack thereof, to radiation in a particular nuclear space. This spatial dimension causes environmental injustice, as these societies and geographical areas also live and die in "sacrifice zones" (Lerner 2012), i.e., spaces disproportionately exposed to toxicity that have an impact on health and livelihoods and cause environmental harm on behalf of the state and others. This socio-ecological injustice is evident in the sacrifice of vulnerable communities for nuclear purposes, which thereby prolongs poverty and marginalization (Kaur 2021:1–12; Juskus 2023:4, 9). By extension, some African communities, regions, and states are sacrifice zones for global nuclear energy production and the nuclear military-industrial complex, as African uranium is exported to maintain these power structures in other states.

Two examples include the communities near the Shinkolobwe Mine in the Democratic Republic of the Congo (DRC), which produced uranium for the United States' nuclear weapons programme (Williams 2016), and the communities near the sites of the French nuclear tests in the Sahara Desert (Hennaoui & Nurzhan 2023:91–109). Uranium extraction and nuclear waste are thus linked to nuclear necropolitics and sacrifice zones. However, sacrificing on behalf of others has an underlying etymological religious connection to the word 'sacred'. For Juskus (2023:16–17, 20), this sacrificial ecopolitical theology binds some lives and lands to ecologies of death in sacrifice zones so that other lives and lands may be freed to sustain themselves and flourish in greener pastures: in other words, some must die to save others. We now proceed to explore Africa's nuclear landscape in order to contextualize the continent's nuclearity and the prevalence of nuclear necropolitics and their associated sacrifice zone.

5.3 Africa's nuclear landscape

The contemporary African nuclear landscape is dynamic and remains relevant in constantly shifting global geopolitics. The need for global climate action and decarbonisation of energy production, together with increasing global energy demands, means that uranium remains important for global energy futures. Therefore, global interest in Africa's uranium continues. Globally, three of the top ten countries with uranium resources are African, namely Namibia, Niger, and South Africa (NEA & IAEA 2023:39). Besides these countries, uranium also occurs across the continent in Algeria, Botswana, Cameroon, Egypt, the Central African Republic, the DRC, Ethiopia, Gabon, Ghana, Lesotho, Madagascar, Malawi, Mali, Mauritania, Morocco, Nigeria, Rwanda, Somali, Sudan, Tanzania, Zambia, and Zimbabwe. Despite the prevalence of uranium resources in Africa, uranium mining varies depending on the economic viability and sustainability of mining (NEA & IAEA 2023:40–76).

In 2022, the United States (US), China, France, Spain, Poland, Canada, Germany, Denmark, Finland, Ireland, Luxembourg, and The Netherlands were the largest importers of uranium ores and concentrates (World Bank 2022). Moreover, in Niger there are Canadian, Chinese, French, Japanese, Spanish, and South Korean mining companies that own shares in uranium mining operations (NEA & IAEA 2023:395). Africa's nuclear renaissance has drawn several state-owned nuclear utilities to the continent. Utilities that have signed memoranda of understanding and cooperation agreements in the field of nuclear energy with African states include China, South Korea, and Russia. In August 2024, Ghana's nuclear utility Nuclear Power Ghana (NPG) signed an agreement with the Regnum Technology Group, a US firm, to develop a small modular reactor (SMR) (Department of State 2024). Nuclear energy cooperation has also featured in several country-to-continent summits (e.g. US-Africa Nuclear Energy Summit in August 2024) and continent-to-continent summits (e.g. EU-AU) summits (Department of State 2024; Olutola 2018:20–36).

Despite the continent's rich uranium resources, Africa does not have a well-developed nuclear technology and energy sector. Notable exceptions are South Africa and Egypt. The former operates the only nuclear power plant in Africa while Egypt is constructing its first nuclear power station at El Dabaa in partnership with Rosatom. Several other African states, notably Algeria, Ghana, Kenya, Morocco, Namibia, Niger, Nigeria, Rwanda, Tanzania, Tunisia, and Uganda, have also expressed interest in developing nuclear power for electricity generation and desalination (NEA & IAEA 2023:110).

Africa's status and role in the global nuclear sector has been described elsewhere (Hecht 2012). At least three aspects are pertinent to Africa and nuclear security (e.g., non-proliferation). The continent's historical experience of French nuclear weapons testing in the Sahara Desert was one of the factors that contributed to the Organisation of African Unity's (OAU) adoption of the Cairo Declaration on a nuclear-weapon-free Africa in July 1964 (OAU 1964). This historical commitment was operationalised with the entry into force of the African Nuclear-Weapon-Free Zone Treaty (Treaty of Pelindaba) on 15 July 2009. In terms of the Treaty of Pelindaba, African states endeavour to renounce nuclear weapons and devices (Article 3), prohibit the stationing of explosive nuclear devices on the continent (Article 4) and the testing of nuclear weapons (Article 5), dismantle all nuclear weapons programme (Article 6), prevent the dumping of radioactive waste on the continent (Article 7), use nuclear energy for peaceful purposes (Articles 8 and 9), and protect nuclear material and facilities (Article 10) and an armed attacked thereon (Article 11) (OAU1996).

The African Nuclear-Weapon-Free Zone Treaty (the Treaty of Pelindaba) is universally accepted on the continent. It ensures the continent's future as a nuclear-weapon-free zone. Despite this normative and the legal commitment, several challenges pertaining to the continent's nuclear future should be considered. Besides uranium exports to nuclear weapons states, African states' involvement in the development of other nuclear programmes have been questioned. Namibia's relations with Iran and North Korean have been flagged as nuclear proliferation concerns. Iran, for example, owns 25% of Namibia's Rössing Mine (El Obeid 2021:24–25). Moreover, uranium is a declared "strategic resource" in Namibia and South Africa (El Obeid 2021:15).

5.4 Uranium mining as a nuclear necropolitical practice in Africa

The time-bending quality of nuclear energy adds to its necropolitical features. A nuclear chain reaction can continue for a significant period, and thereby generate electricity, produce generative medical isotopes or the devastating effect of a weapon of mass destruction. Nuclear weapons are decidedly necropolitical: as weapons of mass destruction, whether used or not, affect life and death on a grand scale. The nuclear reaction of a destructive force such as a nuclear bomb is used to produce life-giving medical isotopes. Besides the duality of nuclear energy as a destructive and healing force as mentioned, nuclearity also relates to race. This is clear in uranium extraction in Africa for the global market (Hecht 2012), nuclear weapons tests, nuclear waste disposal on Aboriginal land, and the use of nuclear weapons against Japan. Moreover, references to a Black Bomb or an Arab Bomb abound in a world where The Bomb is typically regarded as "white". In addition, uncontained radioactivity continues over space and time, thereby producing interregional and intergenerational effects. Therefore, the contemporary dynamics and relevance of the African nuclear landscape cannot be divorced from the continent's historical role in shaping and being shaped by global geopolitical dynamics.

Africa's nuclear landscape emerged with the dawn of the atomic age during the Second World War when Britain and the US raced against Nazi Germany's production of an atomic bomb. At the time, South Africa's uranium resources were also considered as a source for the Manhattan Project's atomic bombs, but the country's uranium resources and mining were too underdeveloped. Instead, the US used uranium from the Shinkolobwe Mine in the Katanga province in the Belgium Congo (present-day DRC) to produce two atomic bombs that were used against Japan in August 1945 (Williams 2016). After the war, both Britain and the US were involved in the development of South Africa's uranium mining and refinement, which commenced in earnest in 1952; uranium exploration in other African states also began after the Second World War. The 1960s saw France conducting 17 nuclear weapons tests in its North African colony, Algeria. By March 1970, the global nuclear order was established with the designation of nuclear weapon states (NWS) and non-nuclear weapon states (NNWS). South Africa commenced with its nuclear weapons programme in 1972, which resulted in the country producing six nuclear bombs. In 1993, South Africa became the first country to have voluntarily terminated its nuclear weapons programme and dismantled its nuclear weapons.

Underlying these developments and events are uranium's status as the most important resource for producing nuclear energy. However, plutonium and thorium production, as well as new nuclear technologies and advanced reactor technologies, are also concerning in terms of safety, radioactive waste, and resources. China is expected to start construction of the first thorium molten-salt nuclear power plant reactor in 2025 (NEI 2024). However, compared to newer nuclear technologies, uranium mines remain nuclear necropolitical sacrifice zones. Mining disturbs the earth, exposing radioactive uranium ore, which is dispersed by the wind as radioactive dust. Uranium mining is also water-intensive because of the leaching process that separates uranium from the ore. Moreover, uranium mining can also affect groundwater sources, as mining operations draw water from aquifers. The case of Niger is illustrative of this.

Niger is the world's fifth largest uranium producer (NEI 2023), providing about 25% of the EU's nuclear utilities' uranium supplies and making Niger the largest uranium supplier to the EU (ESA 2022:19). However, the country remains a nuclear sacrifice zone, and the benefits of uranium mining accrue to external states and interests. Moreover, uranium mining and its legacy in Niger has created Foucauldian heterotopias such as radioactive contaminated regions and villages, and nuclear colonial infrastructure such as uranium roads and uranium railways. Moreover, the Nixonian "slow violence" of radiation has added to populations' poor health and degraded natural environments. French company AREVA, in its 40 years of operation in Niger, has used 270 billion litres of water, "contaminating the water and draining the aquifer, which will take millions of years to be replaced" (Greenpeace 2010a:6). A study on Gabon and Niger by the European Parliament (2010:iii–iv) found that in both countries there have been problems and negligence related to uranium mining and mine safety, a lack of transparency from mining companies about radioactive pollution, and the contamination of water sources and soil around mining villages. Despite the findings by Greenpeace (2010a), AREVA (2014) maintains that it remains transparent, environmentally accountable, and supportive of local populations. In April 2010, AREVA and local Nigerian authorities signed several protocols to "implement multipartite radiological control of materials and equipment" in the desert towns of Arlit and Akokan (NEA & IAEA 2023:396). Orano (formerly AREVA) maintains a similar position regarding its uranium mining operations in Niger (Orano 2024). However, aquifer depletion in Niger's uranium mining region continues (Dobi *et al.* 2021:1–15). The French-based *Commission de Recherche et d'Information Indépendantes sur la Radioactivité* (Independent Research and Information Commission on Radioactivity) reported that radioactive waste is threatening the water supply of Nigeriens, as about "20 million tons of radioactive tailings from uranium mining [that] have been dumped on the ground are still uncovered. Radioactive substances are dispersed by the wind and increase health risks for the population" (NEI 2023). Africa remains a major uranium market for EU states. Besides Niger, EU utilities purchase natural uranium from Malawi, Namibia, and South Africa (ESA 2022:84). Divergent views and data on the impact and socio-economic benefits of uranium mining in Africa persist.

The role of development cooperation in the environmental governance of the uranium mining sector in Niger, exposed to the expanding global uranium frontier, has been ambiguous. Donors have actively promoted the extractive industries, whilst grave environmental governance issues associated with uranium mining, pertaining to both alleged impacts and rampant institutional failures, have been a blind spot in the aid portfolio. Foreign aid to Niger has ignored grievances about grave environmental impacts and rampant institutional failures, while a crisis discourse on desertification and food insecurity diverts attention from geopolitical interests in mineral wealth (Larsen & Mamosso 2014:62).

There are continued efforts to counter such narratives on the negative impact of uranium mining on populations and the environment. In 2023, for example, the Nuclear Energy Association and the Organisation for Economic Co-operation and Development produced a guide for stakeholders to expand uranium mining's social and economic benefits, citing uranium mining operations in Namibia and Niger as examples of "leading practices" (NEA & OECD 2023:9, 69–74). OECD member countries are Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Latvia, Lithuania, Luxembourg, Mexico, The Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, the UK, and the US. The European Commission participates in the work of the OECD. The OECD Nuclear Energy Agency (NEA), established in 1958, includes 34 states, namely Argentina, Australia, Austria, Belgium, Bulgaria, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia (suspended), the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, the UK, and the US. The European Commission and the International Atomic Energy Agency participate in the work of the NEA (NEA & OECD 2023).

The NEA and OECD have also remained headstrong in advancing and supporting uranium mining by shifting the blame for the negative effects caused by mining companies to governments and local authorities:

> Delivery of these [social and economic] benefits, and contributions to the broader sustainable development of the communities and regions in which they operate, has been a priority for uranium companies seeking to establish operations and build and maintain social and political support for their presence. But the role of local and/or regional, provincial and national governments in supporting and contributing to the socio-economic development of mining communities cannot be overlooked. Indeed, the primary responsibility of all tiers of government is to ensure citizen wellbeing, safety and security, essential to which are basic services and infrastructure. Too often, however, mining companies have been asked to take on (or by necessity have assumed) the exclusive role of services and infrastructure provider. In these cases, governments have regrettably neglected or abrogated their responsibility to provide basic goods and services to their citizens, outsourcing this responsibility to the private sector and/or civil society instead (NEA & OECD 2023:57).

Besides the nuclear necropolitics associated with uranium mining in Africa, there is another nuclear heterotopia associated with uranium mining that relates to nuclear colonial infrastructures such as roads, railways, and ports. Uranium products are often transported over large distances and across national borders to ports. These transport routes are effectively radioactive roads as communities remain exposed to risks. In Niger, for example, uranium concentrates from Arlit and Akokan are transported by truck 1,600 km to Parakou in Benin before being transported by train for 400 km to Cotonou port whence it is shipped to Comurhex in France (WNA 2024). The "uranium road" between Tahoua and Arlit, a 685 km road built in the wake of Niger's uranium boom in the 1970s and 1980s, remains in a state of disrepair due to flash floods, poor maintenance, and insecurity in the Sahel. In Namibia as well, Chinese uranium investments were complemented by infrastructure developments such as the "uranium railway" from Walvis Bay to Kranzberg. China also constructed a container terminal in Walvis Bay in line with its Belt and Road Initiative (El Obeid 2021:22).

Like Niger, Malawi is a landlocked uranium-producing country. The Kayelekera Uranium Mine is in northern Malawi, and uranium oxide concentrate is trucked from there to the port of Walvis Bay, Namibia via Zambia, making it the world's longest transport route for uranium (NEA & IAEA 2023:339). These radioactive roads are also sacrifice zones. In February 2014, a shipping contractor's truck transporting uranium oxide concentrate from Kayelekera to Walvis Bay overturned, causing spillage of the radioactive material (WNN 2014). Besides this, elevated levels of uranium in soils around the Kayelekera Uranium Mine have been reported (Majawa, Tshivhase & Dlamini 2022:1353). African states such as the DRC, Malawi, Namibia, Niger, and South Africa that are heavily involved in uranium mining and milling, and states with extensive transport and port facilities such as Djibouti and Tanzania, do not have established or optimally functioning institutions and regulations for the safe handling and transportation of radioactive material. In addition, states such as Benin, which does not have any uranium mining operations, is affected by the transport of radioactive material from outside its borders (IAEA 2021). In May 2024, 23 African states completed a first draft of regulations, or revised their national regulations, on the safe transport of radioactive material in compliance with IAEA requirements (IAEA 2024c).

A neglected aspect of nuclear necropolitics relates to the uranium mining investment agreements signed between governments and foreign investors such as mining companies. In the case of Malawi, for example, the country's benefits from an agreement on the Kayelekera Uranium Mine were described as "tangential and dismal" due to hastily negotiated and non-transparent agreements (CHRR 2021). Moreover, the government officials performing the negotiations were often not on par with the investors' astute negotiators, resulting in investors often benefitting disproportionately more than the government. Investors have also benefitted from Malawi's "archaic" tax and revenue legislation, resulting in less income for the state of Malawi, which could have been used for social development (CHRR 2021). A similar conclusion was reached by the United Nations Special Rapporteur on the Right to Food after a visit to Malawi: the country offers extensive tax incentives to domestic and foreign companies. Mining companies are exempt from customs duty, excise duty, and VAT on mining machinery, plants, and equipment. They can also sign special deals on the rate of royalty owed to the government. Companies operating in Export Processing Zones pay no corporate tax, no withholding tax on dividends, no VAT, and no duty on capital equipment, machinery, and raw materials. Revenue losses from special incentives given to Australian mining company Paladin Energy, for instance, which manages the Kayelekera uranium mine, are estimated to amount to at least US$ 205 million (MWK 67 billion) and could reach up to US$ 281 million (MWK 92 billion) over the 13-year lifespan of the mine. This amounts to at least US$ 15.8 million (MWK 6.5 billion) or up to US$21.65 million (MWK 8.9 billion) a year. The Special Rapporteur is convinced that, unless combined with a comprehensive enhancement and optimisation of tax revenue in Malawi, current macroeconomic reforms may not have substantive positive impacts on the realisation of the right to food (UN 2013). Archaic tax legislation in Namibia and Niger has also disproportionately benefitted uranium mining companies (The Namibian 2018; El Obeid 2021).

5.5 Radioactive waste as a nuclear necropolitical practice in Africa

The Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa entered into force on 22 April 1998. The Convention includes a ban on radioactive waste (Art 2(2)) (AU 1991). Despite the Bamako Convention, some African states have been caught up in organised criminal networks' illicit toxic waste industry. North Africa is considered a common destination for Europe's waste for recycling, but these African states do not always have the technical expertise to process it, resulting in pollution, toxic environments, and health risks (Abderrahmane 2022). Moreover, radioactive waste has been dumped in Africa. The Indian Ocean Earthquake and Tsunami of 26 December 2004 exposed radioactive uranium waste that had been illegally dumped along Somalia's coastline in "containers and disposable leaking barrels which ranged from small to big tanks", causing health and environmental problems to fishing communities and groundwater contamination (UNEP 2005:134). But Somalia's nuclear necropolitics pre-dates the 2004 earthquake and tsunami. Hazardous waste, including radioactive waste, has been dumped in Somalia since the 1980s. Since 1991, Somalia has descended into civil war and lawlessness, which have exacerbated the natural and human-made environmental degradation. Since then, some industrialised countries such as Switzerland and Italy (Leonard & Ramsay 2013) have also been accused of dumping nuclear and other hazardous waste in Somalia, which due to its political instability (the country lacked a central government to guard and protect its coast and territory) has created attractive conditions for these activities. These conditions also meant that Somalis were not informed of these developments. Moreover, the country provided ample sites for dumping waste (UNEP 2005:11, 135). More evidence of the illegal dumping of radioactive waste in Somalia emerged in 2010 when it emerged that Italian businessmen and Somalian warlords entered into an agreement to dump radioactive and other toxic waste at Eel Ma'an, a port north of Mogadishu, between 1990 and 1997 (Greenpeace 2010b; Financial Times 2010).

These developments have not been limited to east Africa and to dumping by Europeans. In 2013, Algeria intercepted three containers of radioactive waste from China (Abderrahmane 2022). In 2015, a former director of the Sudan Atomic Energy Commission in Sudan, Mohamed Siddig, who was also responsible for the Sudan Radioactive Waste Management programme that commenced in 1995, declared that China brought 60 containers of radioactive waste to Sudan. Of these, 40 were buried in the desert near the Merowe (Hamdab) Dam, which was constructed by Chinese, French, and German companies and funded by Chinese and Arab financiers between 2004 and 2009, while the remaining 20 containers were disposed of, unburied, in the desert (Dabanga 2015). Since 2020, Kenyans from the Chalbi Desert have also been involved in a legal battle against their government. The applicants allege that, since the 1980s, the Kenyan government under Daniel Moi has dumped nuclear waste in their region that has caused deaths, long-term health effects, and environmental damage (Nation 2020; Kenya Insights 2024).

Radioactive waste remains a major global concern because of its health and environmental impacts but especially so given the explicit nuclear aspirations of African states and the continent's calls for nuclear redress and nuclear equity. In 2024, the African Commission on Nuclear Energy (AFCONE) signed an MOU with DeepGEO, a US-based company involved in the development of multinational deep geological high-level radioactive waste sites. The African Nuclear Energy Funding Initiative (ANEFI) agreement supports the development of multinational repositories for high level nuclear waste in Africa to promote regional governance and secure financing for vital infrastructure development (AFCONE & DeepGEO 2024).

According to AFCONE, the Initiative offers African states an opportunity "to leapfrog the established nuclear status quo, to collaborate as equal partners, and to take the development of nuclear power in Africa into their own hands" (AFCONE & DeepGEO 2024). DeepGEO is reportedly cooperating with several African governments that have expressed a willingness to host such facilities. DeepGEO will be introduced to African financial institutions and "will gain enhanced access to African decision-makers"; AFCONE, on the other hand, will benefit from a portion of the future proceeds and will immediately start work on establishing a template for regional nuclear governance that will facilitate nuclear energy deployment and the use of shared fuel-cycle facilities across the continent. ANEFI will also support the development of African financial institutions and enhance their capacity to invest in nuclear energy projects.

These institutions will seek to partner with international institutions to bring investment to the African nuclear sector. The goal is to eventually achieve nuclear autonomy for Africa, supporting regional nuclear fuel-cycle facilities, research and medical facilities, and a domestic supply chain (AFCONE & DeepGEO 2024).

5.6 Assessment and conclusion

Free-trade agreements aim to foster economic development, cooperation, and regional integration through the free movement of people, goods and ideas. This contributes to more trust between states and societies, and politically more stable regions. However, these ambitious and liberal conditions, often alike illiberal conditions, have a dark side, as illicit trade, insecurity, and environmental pollution can proliferate under these liberal conditions, making illegal activities more difficult to curb (DiLorenzo 2016). Besides arms, human, and drug trafficking and the proliferation of chemical, biological, radiological, and nuclear (CBRN) weapons, nuclear material, its means of delivery, and dual-use goods remain a major international security concern (UNICRI 2024). In addition to this, advanced technologies (processes and equipment such as nuclear reactors), alternative fuels, SMRs, and micro-reactors pose emerging security problems and may raise proliferation concerns that the continent collectively, and states individually, should be mindful of. Moreover, these developments could have a significant necropolitical consequence. What is required, therefore, is increased scientific accountability, political oversight, security cooperation, and practical commitment to nuclear non-proliferation in Africa.

The African Union (AU) adopted the African Continental Free Trade Agreement on 21 March 2018. The Agreement entered into force on 30 May 2019, thus creating the African Continental Free Trade Area. It aims to stimulate and develop extensive intra-African trade as a flagship of the AU's developmental blueprint, Agenda 2063. The free trade area consists of all 55 African states and eight regional economic communities

(RECs). Article 3 of the Agreement contains its general objectives, namely:

- the establishment of a single market for goods, services, and the free movement of people to deepen African economic integration;
- the creation of a liberalised market for goods and services through successive rounds of negotiations;
- the movement of capital and people to facilitate investment;
- the establishment of a Continental Customs Union;
- the promotion and achievement of sustainable and inclusive socio-economic development, gender equality, and structural transformation of member states;
- the enhancement of the competitiveness of members within the continent and the global markets; and
- the promotion of industrial development through diversification and regional value-chain development, agricultural development, and food security (AU 2018:4).

Following these general objectives, Article 4 of the Agreement outlines specific objectives:

- eliminate tariffs and non-tariff barriers to trade in goods;
- liberalise trade in services;
- cooperate on investment, intellectual property rights, and competition policy;
- cooperate on all trade-related areas;
- cooperate on customs matters and the implementation of trade facilitation measures;
- establish a mechanism for the settlement of disputes concerning their rights and obligations; and
- establish and maintain an institutional framework for the implementation and administration of the Agreement (AU 2018:5).

Article 4 of the Agreement is complemented by Article 2 of the Protocol on Trade in Goods, which aims to improve intra-African trade by eliminating tariffs and non-tariff barriers, improving customs procedures, trade facilitation, and transit, cooperating to remove technical barriers to trade and sanitary and phytosanitary measures, and developing and promoting regional and continental value chains and socio-economic development, diversification, and industrialisation across Africa (AU 2018:19).

Despite these ambitions, perennial concerns about illicit economies in Africa, such as arms trafficking, drug trafficking, and trade in counterfeit goods, are amplified by the possibility of nuclear proliferation under the liberal conditions of the African Free Trade Agreement (Van Wyk & Bosman 2023). Nuclear proliferation can be defined as the illicit spread of nuclear technology, equipment, fissionable material, and expertise related to nuclear weapons that could be used to manufacture nuclear weapons. For the International Atomic Energy Agency (IAEA), nuclear proliferation also includes "unauthorized acquisition … through theft, supply, possession, use, transfer or disposal (intentional or unintentional) of nuclear and other radioactive material, with or without crossing international borders" (IAEA 2024a). Moreover, nuclear proliferation also includes unauthorised activities and incidents involving nuclear and other radioactive material inside or outside of regulatory control within or across national borders (IAEA 2024a).

The extent of global nuclear proliferation is unknown. However, the IAEA Incident and Trafficking Database (ITDB), established in 1995, provides some insights into the scope of global nuclear proliferation. The ITDB includes states' reporting of incidents of "illicit trafficking of nuclear and other radioactive material" and "all incidents in which nuclear and other radioactive material is or was out of regulatory control" (IAEA 2024b:1). In 2023, 168 incidents (22 more than 2022) were reported to the ITDB by 31 states. By mid-2024, 145 states, including 39 African states, were participating in the ITDB (IAEA 2024b:8). Between 1993 and 2024, the IAEA ITDB has recorded 4,243 incidents (IAEA 2024b:3). However, the IAEA ITDB is a voluntary mechanism for states and does not publicise the countries where these incidents occur or those involved, thus the true extent of incidents and trafficking remains unclear.

Another African security concern emerges from financial products and services linked to trade in proliferation-sensitive items. The rise in proliferation financing is associated with technological advances, sophisticated evasion techniques, and a variety of state and non-state actors, including complex criminal networks, front companies, and professional intermediaries conducting operations on their behalf (UNICRI 2023:8). According to the United Nations (UN), the security threats associated with proliferation financing include:

- trade finance services for the procurement of strategic goods, material, and technology for weapons of mass destruction (WMD) proliferation programmes;
- finding through illicit and licit revenue-raising activities; and
- any form of financial service or related technical assistance facilitating financial support for WMD proliferation (UNICRI 2023:8).

There is no universally accepted definition of terrorism. However, the international community has adopted several legal instruments to counter terrorism. Seven of the nineteen international legal instruments against terrorism address CBRN terrorism, namely:

- The Convention on the Physical Protection of Nuclear Material (1980)
- The International Convention for the Suppression of Terrorist Bombings (1997)
- The International Convention for the Suppression of Acts of Nuclear Terrorism (2005)
- The Amendment to the Convention on the Physical Protection of Nuclear Material (2005)
- The Protocol to the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (2005)
- The Protocol to the Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms located on the Continental Shelf (2005)
- The Convention on the Suppression of Unlawful Acts relating to International Civil Aviation (2010) (UNODC 2023).

Examples of nuclear sacrifice zones in Africa have been presented here in the context of nuclear necropolitics and attendant features of physical and symbolic nuclear landscapes, i.e., the "bare life" (Agamben 1998) and "slow violence" (Nixon 2013). In this context, the deathscapes created by decades-long uranium mining in Africa have been presented as a nuclear necropolitical practice. These deathscapes have emerged since the dawn of the nuclear age, colonial powers' nuclear aspirations, and during the Cold War. Whereas nuclear weapons states have decreased their nuclear weapons arsenals, their need for uranium has not abated. For African states, uranium mining has been presented as the panacea of post-colonial development but these extractivist practices created a new type of colonialism: nuclear colonialism. In this power structure, violence continues but as "slow violence" (Nixon 2013). Uranium mining operations have created employment opportunities, but once mining operations become too costly, operations are terminated, and communities became entangled in the realities of the "bare life" (Agamben 1998). Moreover, "slow violence" continues to manifest in poor health and environmental degradation in uranium mining areas. Similar necropolitical practices and outcomes are evident in radioactive waste disposal in Africa. Nuclear waste sacrifice zones and its effects occur in, for example, Kenya and Somalia.

Given the continent's nuclear energy ambitions as well as the greater global demand for uranium to offset carbon-intensive energy generation, the continent faces several challenges. Radioactive environments, created by uranium mining and milling and the transport and disposal of licit and illicit nuclear waste, cannot be quickly decontaminated because of the half-life of radiation. This means that the effects of nuclear necropolitics are interregional and intergenerational and can at best only be managed rather than stopped or undone. For this, a stable political environment, accountable governance, law enforcement, and transparency are required. In this respect, the case of Somalia remains instructive. After the country spiralled into political chaos in the 1990s and continued without a central functioning government, illicit nuclear waste entrepreneurs were able to dump radioactive material in the country. Several cases have also shown the importance of equitable agreements between African states and the African and international nuclear sector. In several cases, elites have benefitted more than the national fiscus, which meant less development could take place.

Another significant development is the uranium mining industry's efforts to counter narratives about the negative impact of uranium mining. African civil society is simply not able to compete with these interests. The expected benefits of uranium mining and nuclear development in Africa have not been realised. Instead, the social cost will remain and increase across time and space. These costs are likely to be exacerbated by political instability caused by coups. Ironically, the Sahel is one of the most important uranium mining areas in Africa, but it is also one of the most ungoverned territories on the continent. Since 2020, military coups have occurred in Gabon, Niger, Burkina Faso, Sudan, Guinea, Chad, and Mali.

In the above examples of Africa's nuclear sacrifice zones, common themes have emerged: the unequal distribution of, and lack of transparency about, the mining rent; poor health and safety; negative environmental impacts, such as depleted or contaminated aquifers and surface water resources; poor labour practices and unresolved disputes; and archaic legislation and ineffective legal controls and law enforcement.

Finally, the continent's efforts to assert its own agency, independence, and self-reliance are embedded in the ideals of Pan-Africanism and continental integration and unity. However, given the poor state of governance and ungoverned spaces resulting from conflicts and wars, the continent's developmental agenda, based on the peace-development-trade triad, is unlikely to achieve nuclear equity on and for the continent. The African Continental Free Trade Area is more likely to see illicit nuclear-related activities.

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Chapter 6

Koeberg Controversies

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6.1 Introduction

South Africa has always heavily relied on coal-fired power stations for its electricity provision, but as early as the 1950s, there were discussions about diversification through other means of energy generation. This included the use of nuclear power, which was viewed as a viable alternative owing to its lower carbon emissions and operating costs relative to coal-based power generation. Subsequently, in 1966, a farm near Cape Town was purchased, where South Africa's (and Africa's) first nuclear power station was built by the French company Framatome between 1978 and 1984. It is still the only nuclear power station in Africa. It supplies 1,860 MW to the national grid and initially supplied 100% of all the Western Cape's energy demands, but increased demand has brought this down to 50% by 2017. The power station was built to accommodate several additional nuclear power reactors, were the need to arise (KPMG 2017; Winkler 2022).

Koeberg was granted a 40-year operational licence, which aligns with international practice. Koeberg Unit 1's licence expired in July 2024 and was subsequently extended to 2044. Unit 2's licence expiry date is 9 November 2025, with an extension hinging on the completion of various prerequisites (Ramdass 2024). Some civil society groups have called for the facility's closure; however, KPMG and others have argued that, given South Africa's protracted electricity crisis, such a closure would be difficult to absorb (KPMG 2017; Winkler 2022). A recent study by the Council for Scientific and Industrial Research (CSIR) suggests otherwise, noting that the national grid can run without Koeberg (Kemp 2023). Nonetheless, Eskom, the national electricity provider who also operates Koeberg under the Nuclear Installation License, NIL-01 Variation 19 (as amended from time to time in terms of section 23 of the National Nuclear Regulator [NNR] Act (NNR 2023), regards the long-term operation (LTO)[1] of the nuclear power station up to 2045 as a vital part of the electricity provider's energy planning strategy (IAEA 2019) and Generation Operation Recovery Plan[2]. As noted by then Eskom chief executive officer, André de Ruyter, in December 2021, "Koeberg station is Eskom's cheapest electricity generation option, costing about 42 cents per kilowatt-hour generated. This is around half the cost of coal-fired generation … This is probably one of the most lucrative projects and economic projects in Eskom. As far as Eskom is concerned, life extension for Koeberg is a no-brainer" (Metelerkamp 2021).

Eskom decided in 2010 to pursue Koeberg's LTO and engaged with the NNR about extending the operating licence for an additional 20 years beyond 2024 (NNR 2023). The South African government subsequently endorsed the Koeberg LTO, in its 2019 Integrated Resource Plan for electricity, for a total lifespan of 60 years for each Koeberg unit. The extension was deemed achievable in the short term and financially defensible compared to the prohibitively expensive and time-intensive construction of new power plants (Winkler 2022). Eskom

1 "LTO of nuclear power plants is defined as operation beyond an established time frame determined by the license term, the original plant design, relevant standards, or national regulations. As stated in the IAEA safety standards, to maintain a plant's fitness for service, consideration should be given to life-limiting processes and features of systems, structures, and components (SSC), as well as to reasonably practicable safety upgrades for enhancing the safety of the plant to a level approaching that of modern plants" (IAEA 2019).

2 The Generation Operation Recovery Plan was launched in April 2023 following extensive stakeholder engagements. It aims to address challenges affecting South Africa's energy availability factor within a two-year timeframe (Arnoldi 2024).

subsequently embarked on the LTO project but has faced numerous obstacles and delays that have shrouded the project in controversy. These are expanded upon in the forthcoming chapter through a historical and chronological narrative and analysis based on desktop research of primary sources such as archival documents, online newspapers, official documents from government departments, Eskom, and the NNR, as well as secondary books and journal articles.

6.2 Building Koeberg: a tale of negotiation and high drama

The early history of the Koeberg nuclear power station was typified by hurdles and high drama, from tugs-of-war about who would supply the reactors to a face-off with the United States (US) regarding the fuel needed to start up the reactors to a bombing by the exiled African National Congress (ANC) in 1982, which delayed Koeberg's start-up by many months. It took almost seven years to find a site on which to build South Africa's first nuclear power station. Ultimately, Koeberg's selection boiled down to its position: "It fitted national grid requirements, it was in a sparsely populated area, it is on the coast—so seawater can be used to cool the condensers; and the ground conditions were suitable for the construction of a nuclear station with its enormous loads" (Eskom 2022a). To ensure that there would be no shortage of essential data, the site's geology, hydrology, seismology, and meteorology were investigated by working groups (Eskom 2022a).

South Africa approached the Nixon Administration in the US in 1971 with a request for enriched uranium for two nuclear power-generating reactors for Koeberg. The US firm General Electric was approached to put in a tender for a 600 MW nuclear power reactor, as well as Canadian, British, West German, and French firms (Nixon Presidential Materials 1972). Despite some initial reservations, due mainly to the South African government's apartheid policy and the possible military application of the technology and materials involved, the Nixon Administration and the South African Atomic Energy Board signed a contract in 1973 for the US to supply enriched fuel for Koeberg (Nye 1977). In 1975, the agreement was amended to note that US fuel deliveries to Koeberg would continue for 25 years after the plant went critical as planned in 1982. In addition, in August 1974, Eskom and the US Energy Research and Development Administration (ERDA) signed contracts to enrich South African-supplied uranium at US facilities to 3% or less for delivery to Eskom. The contracts were later transferred to the US Department of Energy (Walters 1987:91; Ronald Reagan Library n.d.; DIRCO Records Division 1981).

Substantial Congressional opposition to the prospective General Electric sale caused Pretoria to instead award the sale to the French consortium Framatome (O'Toole 1976:1). In 1978, the US passed the Nuclear Non-Proliferation Act, which embodied much of the US policy for dealing with the linkage between nuclear power and nuclear proliferation, that is, the risk that the "materials, technologies, equipment, and facilities associated with civilian nuclear power programs could be of use in the production of nuclear weapons" (Nuclear Non-Proliferation Act 1978: 44). The legislation was expected to affect directly, or indirectly, most nuclear power programs in the non-communist world, given that the US was the leading supplier of equipment and services in the nuclear field (Nuclear Non-Proliferation Act 1978:44). South Africa was no exception: the US resolved not to supply the LEU for the two Koeberg power reactors, unless South Africa acceded to the Nuclear Non-Proliferation Treaty (UK National Archives 1977).

When the Reagan Administration came to power in the US in 1981, Pretoria tried to get the LEU fuel supply for Koeberg back on track. But, despite some positive signs from Washington, it was ultimately Framatome that would export 100 tons of LEU to South Africa to start up the plant (Murphy 1981; Parker 1983:153–54; O'Toole 1982:A5). However, the completion of Koeberg was set back significantly when it was bombed in December 1982 as part of the exiled ANC's strategy to destroy crucial infrastructure in its fight against apartheid. Koeberg was but one of a variety of strategic facilities that were targeted. It would appear, though, that Koeberg was explicitly targeted due to the ANC's belief that it was a cover for a nuclear weapons programme and that plutonium for the latter would be produced there (Van Wyk & Van Wyk 2024). The bombing caused significant damage, and construction was delayed for about 18 months. Ultimately, Unit 1 went online in July 1984 and Unit 2 in November 1985.

6.3 Life extension controversies

The looming licence expirations in 2024 and 2025 meant that Koeberg was on the verge of being closed unless it could be successfully refurbished and relicensed (Ebrahim & Paton 2024; Ramdass 2024; Slabbert 2023). The LTO process was a race against time and shrouded in multiple controversies. Faced with several of its coal-fired power stations being at the end of their lives, endless problems with new coal-fired power stations, organisational chaos, corruption, and a debt of more than R420 billion, Eskom determined that it could not lose Koeberg's 1,840 MW power in order to limit load-shedding, which was costing the country an estimated R411 billion a year in economic losses by 2022 (Taylor 2024). But for Eskom to apply for the necessary approvals to extend Koeberg's operating license with the NNR for another 20 years, specific technical work was required, for example, replacement of worn-out parts and modifications based on lessons learnt. Overall, while an LTO programme is complex and technically demanding, it is not unheard of and was also done in France with 56 reactors, many of which have the same design as Koeberg (Eskom 2022a; Taylor 2024).

Eskom started planning for Koeberg's LTO in 2010 (Slabbert 2023). At this stage, the life-extension project was budgeted at R20 billion, with the most significant single item in the scope of work being the replacement of three steam generators in each Koeberg unit. This was estimated to cost R5 billion. The initially planned completion date was 2018, but a court case, significant manufacturing problems, and delays in the replacement of the steam generators delayed the project to December 2022, when Unit 1 was finally shut down for maintenance, refuelling, and installation of the new generators (Yelland 2021b; Slabbert 2023; Illidge 2022a).

The first step in commissioning the LTO was contracting an overseas firm to replace the steam generators. Invitations for tenders went out in 2012. Subsequently, a R5 billion contract was awarded to the French nuclear power firm Areva (Framatome, since January 2018) in August 2014, despite the US-based firm Westinghouse being less expensive. Westinghouse had designed Koeberg and was Areva's only competitor for the contract, but the Eskom board tender committee decided on Areva due to "strategic considerations" (Slabbert 2023). Westinghouse challenged the decision, leading to a protracted legal battle (Parliamentary Monitoring Group 2022). The Constitutional Court finally upheld the awarding of the contract to Areva, based on the legal and technical consideration that the latter was the only company that indicated it would be able to meet the project timelines and deliver the generators by 2018 (Slabbert 2023; Parliamentary Monitoring Group 2022). 2018 came and went, however, with no steam generators installed. Instead, Areva/Framatome's casting of the six steam generators in France ended in disaster. Eskom and Framatome then agreed to fly the 320 tons-a-piece generators to a partner in China, for fixing. Once in China, however, it was found that the generators were unusable, and production had to start from scratch (Slabbert 2023) at Framatome's cost. This resulted in a delay of three years (Yelland 2021a).

It was projected that each Koeberg unit would need to be shut down for five months for general maintenance, steam generator replacement, and upgrades required to secure the 20-year operating licence extension (Metelerkamp 2021; Winkler 2022). The shutdown for Unit 2 was planned for January 2022, and if all were to go well, Unit 1 would be shut down in October 2022. This meant that in total, Eskom would be without at least 920 MW of supply from Koeberg for about 10 months between January 2022 and February 2023, leading to an average energy availability factor (EAF) probably dropping below the prevalent 62% and an increased probability of load-shedding (Yelland 2021a). Meanwhile, Unit 1 had been on an extended outage of six months since January 2021, prompting Eskom to investigate matters at the power station (Arnoldi 2021). While reassuring the public that there were no nuclear safety concerns at Koeberg, Eskom noted that it was important to take the required time to complete outstanding routine maintenance work and refuelling before the unit could be returned to the grid (Eskom 2021).

By the end of 2021, there were already several signs that the LTO project was faltering. In addition to the delays caused by Framatome, Eskom had failed to submit a crucial safety case report for the LTO project to the NNR for approval. The report was due in November 2021 and left a very small window for Eskom to address any issues raised before the first scheduled shutdown in January 2022 (Yelland 2021b). Furthermore, when the Framatome workers arrived at Koeberg in January 2022 to replace Unit 2's generators, they discovered a containment building that was supposed to store the old radioactive steam generators after removal from Unit 2 had not been completed. This was a serious lapse on the parts of both Eskom and the NNR. Framatome's specialists had to leave as the work had not been done, and the project was postponed so that Unit 2 could be online during the winter peak demand period (Slabbert 2023; Illidge 2022a). This never happened, though. After discovering that the containment building was not completed, the maintenance schedule was adjusted in March 2022. The plant was initially planned to return to service at the end of June 2022, but the date was pushed to mid-July because of defects picked up during commissioning. Then, unexpected issues were detected in the unit's polar crane, which pushed the date back to the end of July. Unit synchronisation only began on 5 August, however, and on 19 August, the unit had to be taken offline again so that a mechanical problem with the control rod could be addressed. On 3 September, the unit tripped at full capacity during a control rod test, and 920 MW of generating capacity was again wiped off the grid (Labuschagne 2022). The unit was ultimately returned to service on 25 September, but in April 2023, it tripped again and went offline for a day (My Broadband 2023). The irony is that each time one of the reactors had to be started up, it required electricity to avoid a meltdown. Hence, instead of providing electricity, which was its sole purpose, Koeberg put demand on the grid every time a reactor tripped or was taken offline (Feldman 2023).

The serious lapse of Eskom and the NNR, in not having the containment building ready by the first scheduled shutdown in January 2022, resulted in serious delays. Together with a high number of breakdowns at the coal-fired power stations, South Africa's energy supply was severely hampered (Illidge 2022a; Illidge 2022b). Initially, Ridewaan Bakardien, Eskom's Chief Nuclear Operator, blamed limitations and travel restrictions caused by the COVID-19 pandemic for difficulties in getting the LTO under way timeously (Illidge 2022b). However, Eskom later explained that the deferred outage for the steam generator replacement had to be re-planned entirely in view of its impact on the country's overall outage scope. Additional scope also had to be added to inspect and maintain the existing steam generators until replacement could take place. Emergent technical issues, coupled with maintenance and LTO project work, delayed the return of Unit 2 to service. Eskom admitted that the delay was a key component of the Stage 6 load-shedding[3] experienced in 2022 because it coincided with peak demand during the winter season (Parliamentary Monitoring Group 2022).

Eskom's Chief Nuclear Officer, Keith Featherstone, also later explained that Unit 2's deferred outage for generator replacement was due to several serious deficiencies in the front-end loading of the LTO project, which would have caused significant delays to the outage—something that Eskom and the country could ill afford. Featherstone noted that both Framatome and Eskom had contributed to these deficiencies, with several associated disputes being dealt with through dispute adjudication. Eskom's role in the delay included the incomplete facilities where the old steam generators would be stored. Other contributing factors included poor project

3 The load-shedding implemented by Eskom is a controlled process that responds to unplanned events to protect the electricity power system from a total blackout. According to Eskom (n.d.), it is used only under emergency conditions, for limited periods. Eight stages were developed based on the level of the risk, ranging from 1,000 MW of national load to be shed at Stage 1, to 8,000 MW shedding at Stage 8, in blocks of 2–4.5 hours at a time, depending on the area. The stages are meant to ensure that load-shedding is applied in a fair and equitable manner (Eskom n.d.).

management, inadequate contract management, and a lack of financial discipline (Parliamentary Monitoring Group 2022). Up to that point, three senior employees had already been placed on precautionary suspension with full pay (Parliamentary Monitoring Group 2022). In addition (if all this wasn't already ominous enough), one of the new steam generators was dropped inside the Chinese factory contracted by Framatome. Eskom insisted that the damage was minor, as confirmed by an expert review by a panel of internal Eskom staff and independent industry experts. Eskom foresaw that the generator would be delivered by December 2022 (Magubane 2022).

Human error at Koeberg also caused significant concerns. In March 2022, while Unit 2 was still offline, a worker cut a safety valve at Unit 1 instead of the same valve at Unit 2, resulting in Eskom nearly losing 920 MW of power to the grid—in addition to the 920 MW already lost due to Unit 2's maintenance outage. Eskom admitted that it was a significant error that could have resulted in the loss of Unit 1 (Omarjee 2022a; Taylor 2023) but then claimed that Koeberg's high safety measures managed to identify the error in time and, as such, avoided any damage. What was concerning, though, was that it was the second time that this incident had happened during Unit 2's outing, prompting Eskom to refer to "very poor human performance and … an unacceptable practice" in an internal Eskom newsletter (Omarjee 2022a).

Meanwhile, Eskom was also conducting benchmarking activities with other global utilities and requested assistance from international safety review bodies, including the International Atomic Energy Agency (IAEA), the Institute for Nuclear Plant Operators, and the World Association of Nuclear Operators (Omarjee 2022b). The IAEA conducted SALTO (Safety Aspects of Long-Term Operation) reviews at Koeberg as part of Eskom's preparations for the LTO project. This was a necessary exercise, as nuclear activities in South Africa are controlled and regulated by the NNR, which is expected to be guided by IAEA recommendations (Winkler 2022; Illidge 2022b). SALTO reviews focus on ageing management of several aspects related to mechanical, electrical, civil systems, structures and components, knowledge management, and human resources (Omarjee 2022b).

The first SALTO mission to Koeberg occurred in 2015, the second in 2019, and the third in 2022. The missions focused on aspects of the safe LTO of both Koeberg units, based on IAEA safety standards and Eskom's preparedness and programmes for safe operation. During the 2019 and 2022 missions, the SALTO team, consisting of ten international experts and two IAEA staff members, found Koeberg staff to be professional, open, and receptive to suggestions for improvement and observed that the plant had made progress in ageing management activities and preparation for LTO since the first SALTO mission in 2015, despite many challenges and delays (IAEA 2019; Illidge 2022b; Omarjee 2022b). The SALTO mission of 2019 also identified some good practices, which they noted would be shared with the nuclear industry globally. These included: "A water chemistry programme implemented in line with IAEA safety standards, supporting ageing management for safe LTO; a surveillance programme to monitor vessel embrittlement under operation for all relevant plant conditions, including LTO; and the use of a simulator of mechanical, electrical, chemistry and radiation protection processes to improve staff performance and plant safety in these areas" (IAEA 2019). Recommendations for further enhancing the preparations for LTO safety included: empowering plant management and staff with all necessary mandates and processes, which must include adequate resources to achieve safe LTO promptly; adequately planning and implementing impressed cathodic protection of the reactor containments, including tests with a mock-up to further improve corrosion prevention; and developing and implementing a knowledge management programme (IAEA 2019).

At the end of March 2022, the SALTO team left Koeberg with serious concerns, despite noting some significant improvements and elimination of several deviations in ageing management activities and preparations for safe LTO (Illidge 2022b). The team's report listed fourteen safety issues for further improvement. The report was not intended for public consumption (Taylor 2023); however, the Democratic Alliance

(DA)[4] had long-standing concerns over Koeberg's safety and lodged a successful PAIA[5] application to Energy Minister Gwede Mantashe for access to the complete report. Once the full report was released, it became shockingly clear that the LTO project was in a crisis (Mileham 2022). The SALTO Team found the following deficiencies:

1. Koeberg would not be able to implement all activities promptly to demonstrate preparedness for safe LTO without effective management of the LTO programme (IAEA 2022; Koeberg Alert Alliance 2022).
2. Complete safety documentation for LTO could not be ensured without an adequately updated safety analysis report (IAEA 2022; Koeberg Alert Alliance 2022).
3. Ageing management and the safety function of some structures, systems, and components (SSCs) critical to safety could be compromised due to incomplete or inconsistent scope setting (IAEA 2022; Koeberg Alert Alliance 2022).
4. The safety function of SCCs in the scope of plant programmes could not be ensured without comprehensive revision and implementation (IAEA 2022; Koeberg Alert Alliance 2022).
5. The ageing management review of mechanical SSCs could not be effectively done without consistent management and documentation of information (IAEA 2022; Koeberg Alert Alliance 2022).
6. Koeberg could not ensure preservation of the safety function of SSCs for LTO without complete ageing management programmes (IAEA 2022; Koeberg Alert Alliance 2022).
7. The safety function of safety-related cables could not be demonstrated without implementing a comprehensive cable ageing management programme. Koeberg's cabling did not meet IAEA safety standards. Wetted cables, problems

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4 The Democratic Alliance is a broadly centrist party and the second biggest political party in South Africa. Since 2024, it has been part of the Government of National Unity.

5 Promotion of Access to Information Act, 2000 (Act 2 of 2000). The purpose of the Act is to give effect to the constitutional right of access to any information held by the State and private bodies that is required for the exercise and protection of any rights (PAIA 2000).

identifying individual cables, overloaded cable trays, cables bunched together as they passed through firewalls, and poor illumination in some cable corridors meant that the control room could be left blind in the case of a cable failure. Particularly concerning was that Eskom had been fully aware, since 2009, that it would need to replace cables and switchboards (IAEA 2022; Koeberg Alert Alliance 2022; Taylor 2023).

8. Koeberg's ability to perform safety functions could not be demonstrated for LTO, as a complete revalidation of environmental qualification of the relevant SSCs had not been done (IAEA 2022; Koeberg Alert Alliance).
9. The safety function of electrical components related to electromagnetic compatibility had not been thoroughly assessed, despite it being known since 2015 that there was a need for an assessment. The compatibility was crucial, as it would prevent the kind of electromagnetic interference that had caused safety problems in other plants, such as emergency reactor shutdowns, erroneous readings in the control room, and false dosemeter readings (IAEA 2022; Koeberg Alert Alliance 2022; Taylor 2023).
10. The safety functions of qualified cables for LTO could not be demonstrated without a complete revalidation of environmental qualification (IAEA 2022; Koeberg Alert Alliance 2022).
11. Koeberg risked unavailability of SSCs critical to safety, as a proactive approach to technological obsolescence management had not been fully implemented (IAEA 2022; Koeberg Alert Alliance 2022).
12. Koeberg had not comprehensively validated the Time Limited Ageing Analysis (TLAA) for concrete structures and, therefore, could not demonstrate maintenance of its safety functions (IAEA 2022; Koeberg Alert Alliance 2022).
13. The intended safety function of reactor containment structures during LTO could not be demonstrated as the containment monitoring system was not fully functional. This was one of the biggest concerns because it meant that Eskom could not accurately determine the pressure inside the containment structure. Furthermore, cracking concrete,

large-scale delamination, and corrosion of reinforcing bars in Koeberg's containment structures were very concerning. While Eskom had made temporary repairs since 2000, it admitted in 2017 that delayed maintenance and environmental conditions had caused further damage (IAEA 2022; Koeberg Alert Alliance 2022; Taylor 2023).

14. Preservation of safety functions could not be ensured without the complete implementation of ageing management programmes for civil SSCs. A concerning issue was that Eskom's subscription to Westinghouse's POMS software system had expired. This system tracks obsolescence in 12 million plant components and provides an up-to-date database of 30,000 suppliers. Letting the subscription expire was a serious issue; without the software, Eskom would not know when individual parts would reach their end of life or whom to buy replacements from. According to the SALTO report, "the plant does not have access to any tool to proactively identify obsolescence" (IAEA 2022). Furthermore, when the SALTO team visited Koeberg, the software tracking for the LTO process was unavailable due to technical problems (IAEA 2022; Koeberg Alert Alliance 2022; Taylor 2023).

In connection with point (13) above, the SALTO team emphasised that Koeberg should ensure the full functionality of the containment structure monitoring system. It was also deeply concerning to the team that Eskom had not yet conducted fast fracture analyses at the time of the inspection. The leak-tightness and structural integrity of the containment building had to be checked to ensure that the structure would not be breached in the case of reactor malfunction and a subsequent rise in pressure. Eskom conducted the last integrated leak test for both reactor units in 2015, and the next test for Unit 1 was only slated to occur after the July 2024 deadline for the renewal of the operating licence. Furthermore, Eskom needed to replace components of the containment monitoring system, but the safety case report merely stated that a purchase request had been initiated and that repairs would only be done after July 2024 (Taylor 2023). It also noted that the "current condition of the buildings remains fit for purpose and suitable for long-term operation" (Taylor 2023).

The SALTO team further noted that Unit 2's spent fuel pool, which contained highly radioactive contents, had leaked sometime during Koeberg's life, but the cause of the leak had not been discovered. This came on the back of Koeberg's fuel pools, which were already seriously overloaded with spent fuel due to Eskom's lack of a long-term plan for what to do with spent fuel. In light of this and numerous other concerns, the IAEA concluded that "management of the LTO programme [was] not effective to timely complete all actions to prepare for LTO" (Overy 2024).

Koeberg management expressed a determination to address the areas identified for improvement (IAEA 2022) and invited the IAEA to do a SALTO peer-review follow-up mission in 2024 to ensure that Koeberg achieve the highest level of safety on par with best practices globally (Illidge 2022b). The follow-up mission took place in September 2024, resulting in a positive response, with the IAEA noting that the plant "has made significant improvements in ageing management and resolved most of the issues identified in 2022" and, as such, was on track to complete the remaining items in a reasonable timeframe (IAEA 2024). Meanwhile, in December 2022, Koeberg Unit 1 was shut down for what was only supposed to be 180 days to replace the steam generators, with a completion date set for June 2023. This date was repeatedly pushed back, the ultimate date being 1 November 2023. This created a critical concern, as Unit 2 was scheduled to be decommissioned on 7 November 2023 for the same procedure. Another concern was the billions of rands the Koeberg project was costing, with Eskom persisting with Framatome, arguing that the contractor could not be replaced at this late stage of the project despite a game of claims and counterclaims. Both entities had been hit with huge penalties because of the delays (Slabbert 2023). As Pieter Becker of Koeberg Alert pointed out, "there are now over 100 active contractual disputes between Eskom and Framatome" (Fraser 2023a). In March 2023, an adjudication ruling awarded Framatome a whopping R950 million due to Eskom's postponement of the planned maintenance work on Unit 2 in 2022. This followed on the heels of the Constitutional Court upholding a R650 million cost order from the Supreme Court of Appeal in favour of Framatome. This pushed the refurbishment cost at Koeberg far beyond Eskom's initial costing of R20 billion, to an estimated R40–70 billion (Fraser 2023a).

During 2023, South Africa experienced its worst load-shedding ever, at a time when Koeberg was scheduled to undergo steam generator replacements. By August 2023, the work was already significantly delayed. Unit 1's completion moved from June to November 2023, which was close to the 7 November date on which Unit 2 had to be decommissioned for the same work. If Unit 1 was further delayed, it would mean that the national grid would lose Koeberg's full generating capacity of 1,840 MW (equivalent to two extra stages of load-shedding) (Slabbert 2023). In addition, once the steam generator project was completed, Eskom intended to conduct pressure tests on the reactor containment buildings, requiring another 200-day outage for each unit (Polity News24Wire 2023). However, Unit 1's timeline had to be extended when unanticipated logistical obstacles and issues related to the integration of a local workforce caused delays that doubled the time it took to complete the work (Bloomberg 2023; My Broadband 2023). To further exacerbate matters, Unit 2 tripped in April 2023, which meant that both units were out for 48 hours, causing an additional 920 MW power loss to the grid (Feldman 2023).

Unit 1 came back online and synchronised with the national grid only in November 2023—after almost a year's delay (Ebrahim & Paton 2024). According to Eskom, returning Unit 1 to service was "intentionally thorough" because it was essential to ensure all the safety systems were functioning correctly (Patel 2023). Ultimately, Unit 2's scheduled shutdown was pushed to 25 November 2023. It was delayed because the NNR first had to approve Unit 1's return to operation (Smit 2023) and to avoid both units being out at the same time. Given the rolling load-shedding in South Africa at the time, the delays in refurbishment meant a continued absence of 920 MW on the grid, which was equivalent to almost a stage of load-shedding

(Wilson 2023; Omarjee 2024a). Unit 2 was on its scheduled outage by the beginning of 2024 and was expected to be online again only by September 2024 (Omarjee 2024a). By 12 February 2024, however, Unit 2's synchronisation was already 107 hours (or four days) behind schedule (Ebrahim & Paton 2024), which did not bode well for on-time synchronisation following LTO.[6]

Meanwhile, the accumulation of delays at Koeberg had prompted the Minister of Electricity, Kgosientsho Ramokgopa, to state in July 2023 that while nuclear technology was one of the safest in the world, "the longer the refurbishment was delayed, the greater the concern created in the market that something was brewing that might be a safety concern" (Wilson 2023). He did not want this view to gain traction, so he escalated the matter to the Eskom board. Ramakgopa also claimed that even after receiving an extensive presentation from the Koeberg project team, he still did not have a clear picture of the situation (Wilson 2023). Also, the delays and the likelihood of having both units offline simultaneously risked the possibility of disastrous consequences for the economy, as it would mean vastly increased load-shedding (Fraser 2023b). Furthermore, Koeberg played a key role in ensuring power supply in Cape Town (Patel 2023), and any prolonged outage would put pressure on the city, which would then have to rely solely on electricity supply from the northern parts of the country. Indeed, the country was already at 3% less generating power, which was expected to persist for the next two years (My Broadband 2023).

These were not the only signs of turbulence at Koeberg. Other concerning issues over the preceding months involved the delayed application to the NNR to extend Koeberg's operating licence; the controversial dismissal of Koeberg Alert Alliance's Peter Becker from the NNR; and a spate of resignations of senior staff at Koeberg. While there were no signs that the departure of senior staff members, such as Eskom's Chief Nuclear Officer, Riedewaan Barkadien, and Koeberg's Acting General Manager, Nomawetu Mtwebana, were caused by the LTO delays or other sinister reasons, it did raise concerns about lost expertise and

6 Ultimately, Unit 2 was successfully synchronised with the national grid on 30 December 2024 (Eskom 2024).

created speculation that the LTO exercise was in difficulty (Winkler 2022; Illidge 2022c). Statistics tell their own story: between 2021 and 2022, about 250–300 skilled employees left Koeberg (Taylor 2023). As early as November 2021, Eskom's Chief Operations Officer, Jan Oberholzer, commented that the loss of crucial skilled personnel at Koeberg posed a significant risk to the LTO (Yelland 2021b). He remained confident that additional planning would enable Eskom to complete the project properly and without any significant issues. However, the National Union of Mineworkers was not convinced and raised concerns about "a huge exodus of their [*sic*] nuclear plant licensed operators … to the point where they [*sic*] had been left with one extra operator to carry on producing electricity [at Koeberg]" (Parliamentary Monitoring Group 2022).

And then, another large elephant entered the room: future fuel for Koeberg. The US firm Westinghouse Electric lost its licence from the US Nuclear Regulatory Commission to export fuel-assembly components to Koeberg after the Agreement for Cooperation in Peaceful Uses of Nuclear Energy between the US and South Africa expired on 4 December 2022. Eskom tried to downplay the issue by noting that no fuel shortage was expected at Koeberg in the immediate future, as Westinghouse had already delivered the fuel that would be loaded on Unit 1 during the maintenance it was undergoing at that point, while Framatome, which had also been maintained as a nuclear fuel supplier for Koeberg, would provide fuel for Unit 2 (Tirone & Burkhardt 2023). (Unit 1 has always relied on fuel from Westinghouse and Unit 2 from Framatome.) Eskom's Keith Featherstone later added that further fuel from Westinghouse for Unit 1 would only be needed by about mid-2024. At the time of the statement, the South African government had just over a year to re-establish the agreement. The Department of Mineral Resources and Energy ((DMRE) 2019) indicated that, despite no immediate crisis, an urgent resolution was needed to allow Westinghouse to provide future fuel for Unit 1. The DMRE noted that it had initiated negotiations in 2018 and was working with other government departments to expedite the talks (Omarjee 2023). US President Joe Biden was poised in August 2022 to extend the agreement; however, the licence was allowed to expire for unknown reasons (Tirone & Burkhardt 2023). According to Featherstone, finding a new nuclear fuel supplier was not considered an option, as it takes quite a few years to get the fuel qualified for use in Koeberg. Hence, Eskom felt "it would be better just to revive the agreement with the US for Westinghouse to continue to supply fuels" (Omarjee 2023).

6.4 Licence renewal controversies

Eskom applied to the NNR on 10 May 2021 for a variation of the Nuclear Installation License (NIL-01) to operate Koeberg for an additional 20 years (National Nuclear Regulator 2023). By June 2024, the NNR had not yet approved the variation, and time was running out fast. If the refurbishment was not done and the units relicensed by mid-2024 and 2025, respectively, the plant would have to close completely.

Eskom issued its annual Medium-Term System Adequacy Report, as required under the Grid Code, at the end of October 2022 (Eskom 2022b). The objective of this report is "to assess over a five-year period, the electricity supply shortfall risks that may arise based on foreseeable trends in demand and generation capacity in South Africa" (Moneyweb 2022). In the 2022 report, Eskom considered the impact of a possible two-year delay in Koeberg's LTO, with no additional capacity, resulting in a loss of 1,860 MW or up to 15 TWh per year. However, in 2023, the CSIR modelled the South African system and found that it could run without Koeberg, especially with increased renewable energy contributing to the national grid. Eskom also indicated that the Western Cape had stability without Koeberg, which was exemplified by a situation in April 2023, when both Koeberg units were off for 48 hours (Kemp 2023; Koeberg Alert Alliance 2023b). Nonetheless, since the steam generator replacements had already been completed in Unit 1 and were underway in Unit 2, Eskom forged ahead with the LTO project.

According to the NNR (2023), following Eskom's June 2020 indication of its intent to pursue LTO at Koeberg, the NNR established the regulatory framework for LTO after benchmarking international approaches and standards (including in France, Sweden, Switzerland, the US, Canada, Finland, Hungary, Romania, and Spain). The framework considers administrative and technical provisions, as enshrined in the Constitution, associated legislation, and the NNR Act. As such, the LTO framework includes a variation to NIL-01 to include an operation timeframe. This was done in 2019. The framework also includes the issuing of LTO regulations and associated regulatory guidance, which happened between 2020–2021. These LTO regulations stipulate processes and requirements, including the submission of an application and a safety case. In terms of the NNR Act, submitting an application triggers the formal licensing process and associated provisions, which occurred when Eskom applied for a variation of NIL-01 on 10 May 2021, as stated earlier (NNR 2023). In December 2023, the NNR indicated that the regulatory approach to LTO would take 48 months.

Meanwhile, the application for extending the operational life of Koeberg required a public hearings process as well as the compilation of a public information document (PID), as required by regulations for any projects that are likely to have a direct or indirect impact on the lives of neighbouring communities (Matavire 2023). The licensing application and the PID had to be published in the Government Gazette and newspapers, and notices had to be served to interested and affected parties. By July 2022, none of this had happened. Eskom was also very late in submitting a safety case in support of its LTO application. At the time, the NNR nuclear power plant programme manager, Peter Bester, declared: “We are beginning a process of robust scrutiny of the safety case on which we will report our progress and findings including public comments received in a safety evaluation report to the NNR board of directors” (Parker 2022). The first set of public hearings was scheduled to be held by the NNR between February and June 2024 in the Western and Northern Cape (Omarjee 2024a; Overy 2024). This was quite late in the process, given the impending expiry date of the operating licence.

Eskom’s 290-page “Safety Case for Long-Term Operation of Koeberg Nuclear Power Station” was completed in July 2022. As public scrutiny of the report was a regulatory requirement, the NNR forced Eskom to put the report into the public domain (Taylor 2023). Eskom subsequently released a report dated 13 February 2023 to the public, but it was heavily redacted in places, especially in Appendix D, which deals with the prevention and mitigation of a nuclear accident. Sixteen of the 24 pages of this appendix were fully blacked out, and four were partly or almost entirely redacted.[7] Also, a separate confidential submission was made to the NNR, which dealt with Koeberg's physical and cyber security (Taylor 2023). As freelance journalist, Tristen Taylor, aptly points out, "the details of Koeberg's strategy to prevent, contain and deal with a meltdown, partial meltdown, reactor vessel rupture and/or explosion, [were] being withheld without good cause" (Taylor 2023).

In August 2023, the NNR asked Eskom to undertake additional engineering studies on Koeberg before it could deliberate on the extension of the LTO licence. Two weeks prior, the NNR had cancelled a scheduled press briefing on the licence without explanation, and Eskom did not deliberate on the concerns of the NNR. This was thought to be due to the repeated fears of anti-nuclear activists over the weathering and erosion of the reactor containment buildings (Polity News24Wire 2024). Eskom subsequently issued a third 295-page revision of the Safety Case for LTO in October 2023 (Eskom 2023a; 2023b).

The LTO project threatened to derail in early 2024 when it became clear that Eskom had also failed to provide crucial information regarding a tsunami and seismic survey, which was required for licence renewal. The seismic study had to be published, and the public had to have sufficient time to respond. In February 2024, Eskom indicated that it would need an additional month or two to complete the survey; however, the NNR noted that March 2024 would be the latest possible date for reception of the study, if it was to review the licence application before the existing licence expired. Furthermore, an opportunity for public scrutiny and comment on the study would need to be provided (Ebrahim & Paton 2024).

7 The report includes comments next to the redacted parts, showing the reasons for the redactions (Eskom 2023a).

A seismic evaluation dated 31 May 2022 (National Nuclear Regulator 2022) and a factsheet updated in August 2022 (Eskom 2022a) are the only documents publicly available. Briefly, the documents point to very detailed seismological studies done between 1970–1974. The factsheet briefly explains that South Africa is considered a relatively stable region for earthquakes, as it is located away from boundaries between tectonic plates. It does refer to the so-called Milnerton Fault, which runs close to Koeberg, and how it was decided that a seismic raft design earthquake protection system, called a "nuclear island", should be built under the reactor containment and auxiliary buildings. In the case of a severe earthquake of magnitude seven on the Richter scale occurring at the point of the offshore Milnerton Fault closest to Koeberg, the "nuclear island", consisting of rafts and pedestals supported by 1,829 aseismic bearings, would move, while the nuclear power station itself would remain stable (Eskom 2022a). As far as tsunamis were concerned, Eskom simply notes that there is no evidence that a tsunami has ever hit the West Coast of South Africa (Eskom 2022a). Nonetheless, during the site selection for Koeberg, tsunamis and tidal waves were considered; therefore, the terrace on which Koeberg is built is eight meters above sea level (Eskom 2022a).

Ultimately, Eskom came up with another plan to try to secure a new operating licence before July 2024. Because Koeberg's units were commissioned on different dates (Unit 1 in July 1984 and Unit 2 in November 1985), Eskom applied to the NNR for each unit to operate under separate licenses. In January 2024, the NNR decided to grant Eskom separate operating timelines. However, Koeberg would still have only one licence (Omarjee 2024a). The NNR made the decision after a safety assessment showed that the separation of the units would not impact the power station's safety (Omarjee 2024a). This did not mean, however, that the new operating licence was approved. It simply meant that Unit 2 could continue operating if a decision was not made on extending the operating licence by the time Unit 1's operating timeline expired (July 2024) (Omarjee 2024a). A final round of public hearings was completed on 8 June 2024. During these hearings, communities and environmental activists voiced broad safety issues and concerns raised by the IAEA. Residents at the hearings also raised the issue of an evacuation plan and traffic congestion in the event of a serious radiation leak, to which city officials responded that the safety plan was updated regularly and followed best international practices (Roelf 2024).

By early July 2024, the NNR received a request from Cape Town city officials for extra time to decide. After working with the NNR and Eskom for two decades to limit urban growth to areas outside the 5–16 km emergency zone around Koeberg, city officials were fretting over land use in a key northern development node where housing complexes were mushrooming and over their operational ability to respond to a potential nuclear accident (Roelf 2024). According to a city spokesperson, Priya Reddy, city and private investors have bought vast tracks of land, which would be "effectively sterilised from development and unlikely to be used for new neighbourhoods, should Koeberg continue operating" (Roelf 2024). Meanwhile, the anti-Koeberg/anti-nuclear fraternity made sure that they were heard, as discussed in the next section.

6.5 Anti-Koeberg activism

Activism against Koeberg dates to when it was still being planned and constructed. A few property owners set up a non-profit organisation called Stop Koeberg in about 1980, which evolved into Koeberg Alert (KA) in 1983. Both entities intended to halt the construction of Koeberg. KA later became the Koeberg Alert Alliance, consisting of organisations and individuals concerned about Koeberg's current reactors. The alliance opposes the building of new nuclear reactors at Koeberg and actively spreads information about issues around nuclear power and Koeberg's latest status. It regularly lobbies decision-makers, engages with nuclear-related public participation processes, and organises anti-nuclear campaigns (Koeberg Alert Alliance n.d.).

Following the prolonged outage of Unit 1 that had dragged on since January 2021, Eskom decided to investigate matters at Koeberg. The unit was initially taken offline for repairs after an increasing leak rate was observed on one of its steam generators. A decision was made to keep the unit offline for its routine maintenance and refuelling, initially planned for February 2021. The unit was expected to return to service in May 2021 (Eskom 2021). However, it was plagued with delays, which resulted in significant slippage on the return-to-service date. The outage also exacerbated the level of load-shedding that Eskom implemented at the time (Arnoldi 2021). In June 2021, Koeberg General Manager, Velaphi Ntuli, was suspended over performance issues (Omarjee 2024a), and Eskom Chief Nuclear Officer, Riedewaan Bakardien, was tasked with overseeing operations at the power station. The Koeberg Alert Alliance was unhappy with this and raised concerns that Bakardien would not be able to give his full attention, amid all his other responsibilities, to those aspects of Eskom's nuclear operations that might be neglected (Arnoldi 2021).

The Koeberg Alert Alliance further noted that the Eskom investigation proved that there was a lack of nuclear expertise within Eskom and too much reliance on too few people. What concerned them further was that it could be reasonably expected that an underperforming plant manager would also neglect maintenance, repairs, and emergency readiness. "Any problems in these areas may only come to light in the event of a malfunction of one of the nuclear reactors, with potentially catastrophic results", which means that the apparent message to the new person appointed to the position would be: "keep the plant running or face suspension" (Arnoldi 2021). This was deeply problematic as it would make the new manager conflicted. Eskom merely assured the public that there were no nuclear safety concerns at Koeberg (Arnoldi 2021). Ntuli was eventually cleared of the allegations and was reinstated as the general manager of Koeberg in November 2023. Eskom regarded his expertise and experience as "crucially needed", especially in securing an extended operating licence for Koeberg (Omarjee 2024a). Meanwhile, in August 2020, the Koeberg Alert Alliance used the PAIA to make two requests following notification of structural problems at Koeberg by "a concerned insider", who claimed that there was a large crack in one reactor's concrete dome (World Nuclear News 2021). This followed an admission by Eskom in 2017 that about 10% of the surface area of the containment building had fractured into layers (delaminated) and that "chloride ingress extends past the rebar cover depth" (Overy 2024).

The first PAIA request pertained to cracks and damage to the stainless steel used in the plant structures (World Nuclear News 2021). Eskom responded by providing two heavily redacted reports. The first, titled "Plant Engineering Life of Plant Plan", was compiled in 2018 and revealed a 110m crack around the containment dome housing Unit 2's reactor and some deficiencies and malfunctioning of certain plant components (Matavire 2023b). It also referred to repairs carried out until 2018 (World Nuclear News 2021). A second report dated 2022, titled "Time Limited Ageing Analysis", covered the entire plant and identified various components, their degree of defectiveness, and the remedial actions required to repair them. Components that needed attention were listed as reactor pressure internals, cables, and pressure spray nozzles, which were cracked because of ageing (Matavire, 2023a). The proposed LTO extension was also covered in terms of the reactors' suitability to operate beyond their designed lifespan (Matavire 2023b).

Koeberg Alert Alliance's Peter Becker found the 2018 report to be "deeply disturbing and contradict[ory to] claims of safety" and pointed out that the extent of the damage or the associated costs of the repairs should not be kept hidden from the public (World Nuclear News 2021). Becker called for transparency from Eskom at a time when Koeberg's proposed LTO and additional nuclear power station builds were being debated. Eskom responded that it was well-aware of the risk of corrosion of civil structures at Koeberg. As such, a variety of quarterly and annual testing had been done at the containment buildings since construction. These tests consistently proved that the structures could withstand "the most severe accident" (World Nuclear News 2021). Furthermore, 10-year Integrated Leak Rate Tests (ILRT) "have shown conclusively that the design functions of the containment buildings are met" and that "the test results were compared with international plants of similar design and found to be in line with industry norms" (World Nuclear News 2021). Eskom further noted that, where necessary, repairs to the concrete containment domes have been implemented "to reinstate areas of the external facades where spalling and delamination occurred due to reinforcement corrosion" (World Nuclear News 2021). The NNR, in turn, also confirmed that Koeberg was complying with regular tests as required and that, "despite the concrete cracking and delamination observed on the outer surface, the containment structures remain currently effective for protecting the environment from radiation during accident conditions". It furthermore stated that Koeberg was under continuous monitoring to ensure compliance with nuclear safety requirements at all stages of operation (World Nuclear News 2021).

In December 2021, the Koeberg Alert Alliance and the Southern African Faith Communities Environment Institute (SAFCEI) organised a protest on Bloubergstrand, a seaside suburb approximately 18 kilometres from Koeberg. The protest was directed against the Koeberg LTO project and intended to raise awareness about its operational and safety issues. It also emphasised Eskom's lack of transparency in providing the Koeberg Alert Alliance with a heavily redacted report after its 2020 PAIA request. About 50 protesters questioned Koeberg's safety and called for public participation in the decision-making processes, as, according to Becker, the project had a "moral component, a society component, an intergenerational ethics component" (Metelerkamp 2021). Protest participants were encouraged to sign an online petition to shut Koeberg down completely when its operating licence expired in 2024. The petition called on Eskom to acknowledge that the Koeberg nuclear power station would never be as safe as modern nuclear power station designs; to commit to shutting down the station in 2024; not to run the station after 2024 while it lacked modern safety features such as a core catcher[8]; to avoid unnecessary load-shedding that would result from efforts to extend the station's life; not to spend billions of rands upgrading a station

8 A core catcher, which is made from thermally resistant concrete ceramic, "is placed underneath a reactor and is designed to prevent molten radioactive fuel (corium) burning through to the bottom of the reactor and into the wider environment in the case of a core meltdown" (Overy 2024).

from the 1970s and to instead divert the funds allocated for extending the station's lifespan to support community-owned renewable energy; and to work on a permanent solution for the disposal of over 1,000 tons of high-level nuclear waste at the Koeberg site (Metelerkamp 2021). Eskom responded that it was complying with all requirements set out in legislation and would abide by all the safety requirements identified by the NRR and any procedural requirements of public engagement (Metelerkamp 2021).

Gwede Mantashe's dismissal of Peter Becker from the board of the NNR in 2022 was another unsavoury affair and highlighted the difficulties that Eskom was facing in keeping Koeberg operational until 2045. By law, a community representative must be appointed to the board by the minister. Becker had been appointed but opposed the LTO project because of Koeberg's proximity to Cape Town, where 4 million people live, and concerns about the disposal of nuclear waste and because he had a preference for wind and solar renewable-energy projects . Mantashe, by contrast, was a vocal supporter of the nuclear industry. He first suspended Becker in July 2022, but after Becker sued him, the suspension was turned into a dismissal from the board. Mantashe cited a conflict of interest and said that Becker brought the board into disrepute by publicly objecting to its decisions (Bloomberg 2022). Becker turned to the courts, and in May 2023, the Western Cape High Court found that Mantashe's axing of Becker was unconstitutional (O'Regan 2023). The Appeals Court confirmed this ruling in June 2024. The latter court found that Mantashe wrongly believed that the NNR board was supposed to "advocate for nuclear power" (Cronjé 2024).

In January 2023, the NNR started the required public consultation process. The public was asked to submit comments on Koeberg's LTO; however, they could not access the Safety Case Report. The NNR instead released the PID, which excluded technical information. According to the Koeberg Alert Alliance, the PID "reads a bit like a sales brochure for nuclear power" (Koeberg Alert Alliance 2023b). Civil society organisations did not accept the PID, and this affair, coupled with the previous, heavily redacted reports and Eskom's unsatisfactory responses, led the civil society groups to accuse Eskom and the NNR of colluding to deliberately withhold vital safety information from the public (Koeberg Alert Alliance 2023; Matavire 2023a). According to Rodney Anderson of Save Bantamsklip, white residue and deposits observed along the cracked walls of the Koeberg containment structures (which were considered to be "very worrying radioactive leaks") sparked fear over the LTO project (Matavire 2023a). Eskom stubbornly refused to provide the unredacted reports, citing "the protection of third parties and sensitive national security information as reasons" (Matavire 2023b). Affected communities and civil society organisations stopped participating in the public consultation process and demanded the complete suspension of the comment period until they received more information (Koeberg Alert Alliance 2023a). Anderson subsequently submitted a PAIA application to Eskom as the author of the report on the state of the containment domes and to the NNR as the custodians of nuclear safety for the unredacted version of the report. Eskom responded by providing the report, but once again, about half of it was redacted. Anderson then turned to legal assistance to write formal appeals to both Eskom and the NRR, which detailed why the heavy redactions were not aligned with the PAIA and why it was important for the missing information to be released into the public domain (Koeberg Alert Alliance 2023a). Finally, in September 2023, the threat of legal action forced Eskom to release most of the previously redacted information (Koeberg Alert Alliance 2023b). While three sections in one of the reports remained redacted—due, according to Eskom, to concerns about the physical security arrangements at Koeberg, third-party information, and the personal details of non-Eskom employees being jeopardised—more information did come to light (Matavire 2023b).

Last but not least, analysts and activists had concerns about another controversial issue. A Heinrich Boll Foundation research report compared Koeberg's LTO with LTOs at similar Generation-II pressurised water reactors (PWRs) at French nuclear power stations. The French nuclear regulator insisted that all Generation-II reactors in France undergoing LTO projects should be upgraded, in line with the new safety requirements, to comply with modern safety standards. This involved three main safety improvements. First, all reactors undergoing LTO had to be better able to control and mitigate extreme hazards such as fire, explosion, flooding, and earthquakes. Second, "the safety of spent fuel storage pools needs to be improved". And third, core catchers had to be retrofitted to mitigate the consequences of a core meltdown. The French also applied additional regulatory safety standards, such as that integrated leak tests should be conducted on reactor containment buildings every five years "to ensure they will not leak radioactive material and gases if the reactor vessel is breaching during an accident" (Overy 2024). Integrated leak tests should be undertaken every five years. Also, the licences for Generation-II PWRs in France would only be extended for 10 years. Thereafter, a comprehensive safety, ageing, and materials assessment would be conducted on each PWR (Overy 2024).

In the case of Koeberg, Eskom merely declared, contrary to the opinion of Framatome, that Generation-II safety standards are adequate. The NNR did not challenge Eskom's stance and did not insist on the retrofitting of core catchers at Koeberg, despite these being regarded as critical to the safety of commercial nuclear reactors in other parts of the world. Furthermore, in contrast to the French reactors, integrated leak tests would be undertaken only every 10 years at Koeberg, meaning that, following the last test in 2015, the next test would only be in 2025, after the NNR had either made its decision about renewing Eskom's licence or closed down the plant due to the lapse of its licence in 2024. Moreover, Eskom was asking for a 20-year LTO licence extension, as opposed to the French reactors' 10-year LTO licence extensions (Overy 2024). This was a significant cause for concern given the issues related to the cracks in the reactor containment structures.

6.6 Conclusion

It is clear from the above discussion that the Koeberg nuclear power station has been shrouded in controversy in recent years. Despite a good safety track record over its 40-year operation, the LTO project has been the very definition of crisis management. Poor planning, consistent blunders by both Eskom and Framatome, human errors, financial disaster, load-shedding, persistent safety concerns, delayed reports, a fuel contract that lapsed, a very worrisome 110 m crack in a reactor containment structure, and admitted leaks, *inter alia*, leave one questioning whether Koeberg is a ticking nuclear time-bomb. The foregoing discussion certainly leans towards the reality that conditions conducive to disaster exist. As aptly pointed out by Taylor (2003), "the IAEA [had] serious safety concerns. Eskom [was] under tremendous political pressure to finish the LTO. A dangerous culture of secrecy prevent[ed] scrutiny. And experienced employees [were] leaving in droves." In addition, the project overrun costs significantly exceeded the R20 billion that was initially foreseen, massively exacerbated by two enormous penalties that the courts awarded to Framatome.

The substantial delays in the critical Koeberg life-extension project could be blamed on several serious blunders and delays by Eskom and Framatome and on the NNR dragging its feet about the licensing renewal. Despite all the delays, however, the IAEA expressed satisfaction with the progress made in ageing management at Koeberg, and in July 2024, Unit 1's licence was extended to 2044. In addition, the LTO for Unit 2 was completed by the end of 2024 and successfully synchronised with the national grid (ESI Africa 2025). This progress signified an important milestone in the Generation Operation Recovery Plan (Arnoldi 2024), restoring approximately 5% of South Africa's total electricity to the grid for the foreseeable future and contributing to Eskom's goal of increasing its generation capacity by 2,500 MW by March 2032 (ESI Africa 2025).

Ultimately, though, one is left with the question of whether South Africa really needed Koeberg's life to be extended by another 20 years, given the persistent safety concerns and the haphazard handling of the LTO project. There is a tendency to think that South Africa would be plunged into much worse load-shedding or even a national blackout were Koeberg to be decommissioned and that it would adversely affect the city of Cape Town, but as the CSIR shows in a 2023 study, the national grid can run without Koeberg, especially given the increased renewable energy penetrating the grid. Also, Eskom has indicated that the Western Cape has electricity stability without Koeberg (Kemp 2023; Koeberg Alert Alliance 2023b). Despite these concerns, what the successful LTO has done is fostered new optimism for the State's plans to add nuclear energy capacity to the goal of 2,500 additional MW of power after 2030 (DMRE, 2024). Among other things, investigations have been launched into rolling out small modular nuclear reactors at old coal power stations (Omarjee, 2024b), reviving the Pebble Bed Modular Reactor programme, and embarking on new builds (World Nuclear News 2024). However, widespread pessimism and concerns persist. As voiced by Professor of Physics, Hartmut Winkler: if the "much smaller and far more straightforward" Koeberg upgrade has not gone well, how would the sector fare with a large fleet of new nuclear plants, which they ambitiously advocate for? (Winkler 2022). Only time will tell.

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Conclusion

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Over the next few decades, African states will increasingly be marked by high levels of migration, urbanisation, and population growth, trends likely to culminate in the largest and most intense developmental challenge in human history. Of overriding concern will be the delivery and availability of reliable and clean electricity, clean water, and nutritious food. When considered through the prism of (human) development, access to reliable electricity has often been touted as the most urgent need. Energy is the lifeblood of modern national economies. It is also, as alluded to in this book, indispensable for national self-defence and security, while providing those possessing a preponderance of wealth in energy sources and resources with significant geopolitical advantages. African economies and other developing economies continue to be plagued by the scourge of energy poverty. Whatever the merits or demerits of civilian nuclear energy, African leaders have often viewed this technology as a viable solution to address their soaring energy needs. In fact, as is often stressed in this book, the future African landscape is likely to be marked by increased interest in and reliance on nuclear energy. An increased African nuclear footprint is already evident, and an expansion in African states' reliance on civilian nuclear energy is not farfetched, especially in light of remarkable developments in civilian nuclear technology.

While civilian nuclear energy undoubtedly offers myriad advantages and opportunities to African economies, as explored in these pages, the authors of this volume have generally been careful to emphasise that nuclear energy provides a trade-off and not a solution. The diversity of views and perspectives put forward in this volume attest to the fact that civilian nuclear energy remains a deeply controversial topic and energy source, a reality conveyed by the title of the book. Notwithstanding this, the great virtue in airing different views and identifying issues and challenges is that it gives us the intellectual space to reflect on how best to manage—and, as some scholars in this volume would argue, *not* discard—Africa's increased reliance on civilian nuclear energy. Other scholars are of the view (see especially Chapter 6) that a future without nuclear energy is indeed possible. Ultimately, open dialogue and critical conversations about Africa's nuclear future is indispensable for steering the continent's nuclear ship to safe waters, an undertaking central to the aims and objectives of this volume. If managed with soberness and wisdom, civilian nuclear energy can provide a net benefit to the continent's developmental aspirations. The success of this endeavour is then inextricably linked to efficient, transparent leadership on the continent.

In assessing the potential benefits accruing from Africa's turn to civilian nuclear energy, Wandile Shezi and Prof. Anna-Mart van Wyk conclude that nuclear energy holds the potential to spur regional socio-economic development while addressing global climate change objectives. Regional and continent-wide attitudes, the authors strongly contend, should be based on a bedrock of scientific research and not on subjective fears and perceptions. Nuclear technology is also not a one-trick pony. The adoption of and reliance on civilian nuclear energy is likely to induce several positive economic spin-offs, ranging from national economic development to improved standards of living. To harness the benefits likely to accrue from nuclear technology, SADC member states should prioritise the harmonisation of regional energy policies, and should have fulfilment of the SAPP's mandate through the building of necessary infrastructure front and centre.

Isabel Bosman, whilst appreciative of the developmental and other benefits by civilian nuclear energy, urges that the peaceful uses of nuclear science and technology are highly dependent on—and should be seen as complementary to—the non-proliferation and disarmament regimes. The right to the peaceful uses of nuclear science and technology is enshrined in several legal instruments, the NPT being the most important one. The latter treaty not only emphasises the need for nuclear disarmament and the obligation of states parties to non-proliferation but also paves the way to the inalienable right to peaceful uses of nuclear science and technology among members in good standing with the Treaty. Although accession to the NPT is near universal among African countries, the continent endeavoured to add an additional layer in the form of the Treaty of Pelindaba, which underscores the non-proliferation and disarmament obligations of the NPT. Bosman further notes that greater impetus is required to increase the number of states party to the Treaty of Pelindaba and recommends that public education about the peaceful uses of nuclear science and technology and, concomitantly, the legal framework that exists to protect and guarantee this right should be prioritised. Accordingly, African's increased nuclear footprint needs to develop in step with the existing continent-wide and international legal regimes governing nuclear issues.

Although Prof. Eben Coetzee makes a case for the adoption of civilian nuclear energy and, importantly, SMRs and micro-reactors, he notes that scant attention is paid to the geopolitics of nuclear energy in Africa, a shortcoming likely to bring devastating consequences to African agency, security, and development. Not unlike the Cold War, civilian nuclear energy projects are today harnessed by the leading powers in service of grand international order-building objectives, mostly focused on tearing down the US-led Western liberal order and reconstructing an order based on Chinese and Russian interests and values. Civilian nuclear energy projects thus constitute a powerful weapon in the hands of Chinese and Russian SOEs. This behaviour is not unusual, however. Throughout history, great powers have attempted to use all available means to augment their relative positions and to build an order reflective of their values and interests. Civilian nuclear energy projects will likely entrap African countries in decades-long alliances with authoritarian states, alliances that will shape and define this century's international order. Tellingly, Coetzee emphasises that African leaders must approach their prospective nuclear partners with eyes wide open, appreciating that geopolitical pressure will accompany *all* prospective nuclear partners.

This reality necessitates that African countries and their leaders deeply reflect on the type of society they envision for themselves and their neighbours and, more broadly, the future international order.

Dr Tom Vaughan and Prof. Joelien Pretorius provide a critical lens through which to view the role of the three regional organisations with a nuclear mandate in Africa, and place particular emphasis on these organisations' roles in negotiating and practising Africa's "non-nuclear" nuclearity. This nuclearity is practised through peaceful uses of nuclear energy, exercise of Africa's postcolonial identity in nuclear forums, and demonstrations of how Africa's agency relates to nuclear desire, thus fetishising nuclear energy as the solution to developmental needs and the path to a rightful place in the global order. The authors conclude that the kind of agency implicit in this role is likely to lead to a contradictory nuclear future that does nothing more than reify existing nuclear hierarchies and perpetuate a world with nuclear weapons. By calling for greater attention to alternative African nuclear futures, the authors aim to provoke debate about the need to think beyond the categories of the NPT that serves to fan nuclear desire to cement the horizon in this issue-area for Africa's ordering agency.

Prof. Jo-Ansie van Wyk identifies and explores several examples of nuclear sacrifice zones in Africa, presenting these in the context of nuclear necropolitics and the attendant physical and symbolic features of nuclear landscapes, i.e., the "bare life" and "slow violence". The dark side of the nuclear fuel cycle, especially in the form of decades-long uranium mining in Africa, is presented as a nuclear necropolitical practice, one that has been evident since the dawn of the nuclear age and continues into the present. There remains a growing appetite for uranium today. In the post-colonial environment, uranium mining has been presented as a path to development, but these extractivist practices only create a new type of colonialism, i.e., nuclear colonialism, where violence continues but in the form of "slow violence". While uranium mining operations have yielded several benefits, high operational costs have often led to their termination, subsequently entangling communities in the realities of the "bare life". "Slow violence" also manifests in poor health and environmental degradation in uranium mining areas. Further, necropolitical practices and outcomes are discernible in radioactive waste disposal in Africa. Taken together, the effects of nuclear necropolitics are interregional and intergenerational and can, at best, only be managed rather than altogether terminated or reversed. Managing this precarious situation is, however, dependent on a stable political environment, accountable government, law enforcement, and transparency. In short, on this nuclear issue as with others, effective leadership is key.

In a critical assessment of the development and future of the continent's lone nuclear power station, Koeberg, Prof. Anna-Mart van Wyk outlined the various challenges that the beleaguered power station has faced and continues to face. A strong case is made for decommissioning the power plant. Although the focus is on the South African case, the chapter also provides strong grounds for considering the issues of managing nuclear power stations in the context of Africa's increasing nuclear footprint. There is much to be learnt from the South African case for African countries interested in traversing the nuclear path. Additionally, given Eskom's claim that electricity generation can remain stable without Koeberg, the chapter also directs African leaders interested in nuclear energy to consider the role of renewables in their country's energy mix.

In the main, the primary aim of the book has been to interrogate the politics of nuclear energy in Africa and, concomitantly, the potential benefits and pitfalls of Africa's potential turn to nuclear energy. Several key findings emerge:

- There is a strong case to be made for adopting nuclear energy as a means of addressing Africa's soaring energy needs. However, in some contexts (cf. Chapter 6) nuclear energy might not be preferable, especially where poor governance, mismanagement, and corruption are endemic.
- Misinformation about nuclear energy remains rampant. In some cases, the benefits of nuclear energy are wholly ignored, while its dark side (including Africa's nuclear sacrifice zones) is simply brushed aside.

- The case for nuclear energy, especially as it relates to its indispensability to power national grids, is by no means settled. More research is required to assess whether adopting the nuclear route is desirable and necessary in different contexts. Such research must consider how the development of SMRs might alter prevailing assumptions and calculations about nuclear energy.
- Increased reliance on nuclear energy in Africa must proceed within the ambit of the well-developed legal and institutional architecture already prevalent in Africa.
- While undoubtedly boasting many potential benefits, nuclear energy projects are deeply political in nature and cannot be separated from twenty-first century geopolitics. Importantly, African leaders must remain vigilant about the geopolitical baggage that accompanies nuclear energy projects.
- African nuclear desire could reify nuclear hierarchies and perpetuate a world with nuclear weapons.
- Advanced nuclear reactor and SMR development has the potential to allay many of the fears traditionally associated with nuclear energy.
- There is and remains an immense opportunity for South African SMR companies to service the nascent African and global market for SMRs.
- Nuclear energy remains a trade-off and not a solution. This reality should be foregrounded when African leaders and societies consider how best to address the scourge of energy poverty and unlock development.

Finally, in drawing a conclusion from these varied perspectives, one is compelled to acknowledge that, despite the myriad issues and challenges raised in this volume, civilian nuclear energy is a technology that must continue. In short, the potential gains accruing from civilian nuclear energy—in Africa and other developing economies—far outweigh the losses. As noted above, a new generation of advanced nuclear reactors will likely address several—though not all—of the issues, fears, and challenges raised in this volume. At the heart of ensuring a safe and successful African nuclear future, I argue, are the twin requirements of a community of scholars willing to lay bare the benefits, opportunities, and dark side of nuclear energy, and African leaders devoted to managing the continent's nuclear future with the necessary (technical) care, wisdom, and strategic foresight. This book represents a step in that direction.

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UJ Press

African Political Science and International Relations in Focus Series

Nuclear energy remains a deeply contentious issue. With several African states considering turning to nuclear energy to address their soaring energy needs and amid a global resurgence in nuclear energy projects, paying careful attention to the politics of nuclear energy is warranted. Importantly, civilian nuclear energy presents a trade-off, not a solution. While it is undoubtedly the case that nuclear energy can (and, as some argue in this book, should) spearhead the continent's fight against energy poverty, the dark side of civilian nuclear energy projects looms large. This book provides a timely engagement with Africa's unfolding nuclear landscape, emphasizing that substantial issues, risks, constraints, challenges, opportunities and benefits will mark the continent's turn to nuclear energy.

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ISBN 978-1-997468-70-7
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