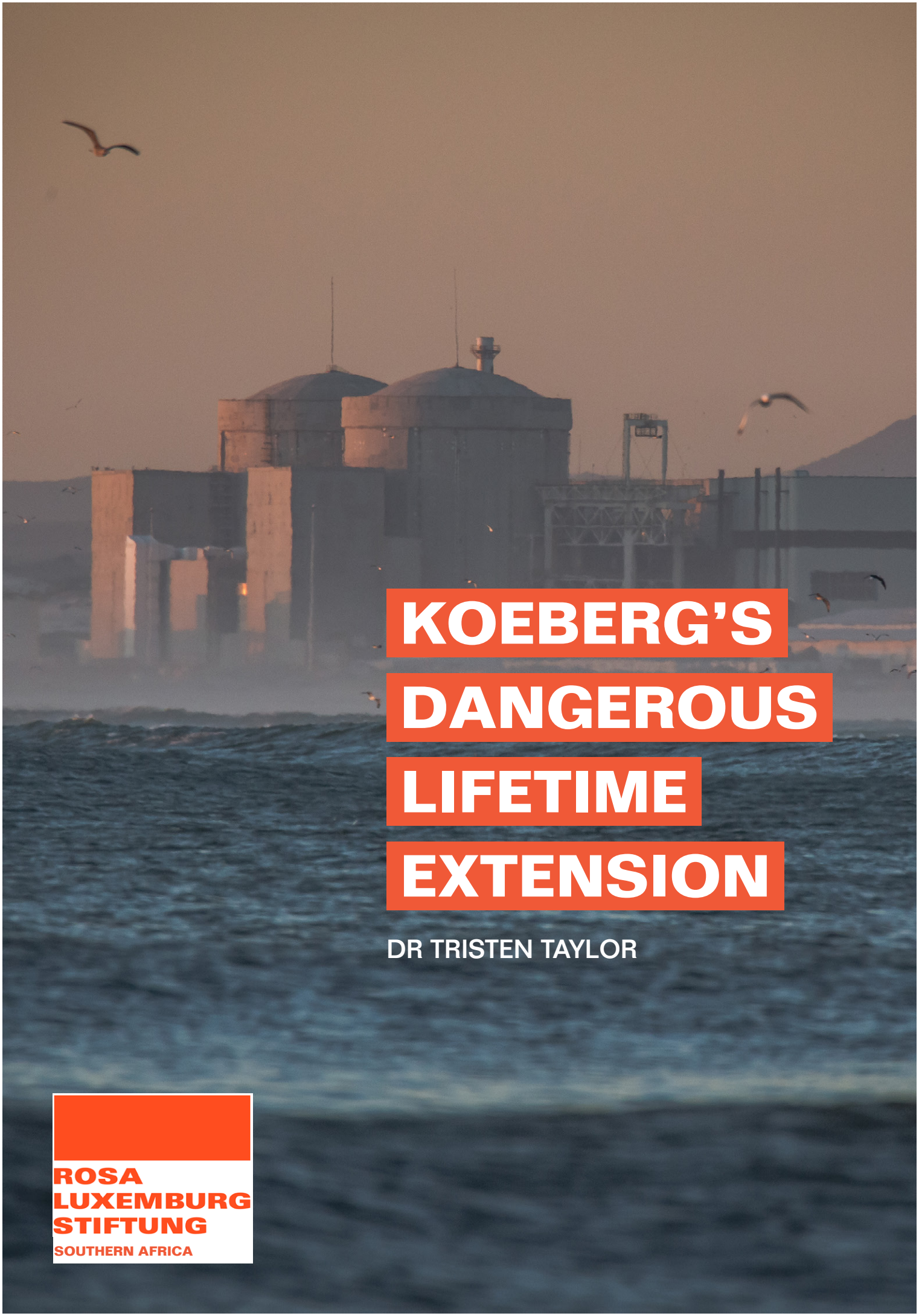


KOEBERG'S DANGEROUS LIFETIME EXTENSION

DR TRISTEN TAYLOR

ROSA LUXEMBURG STIFTUNG
SOUTHERN AFRICA

ABSTRACT

Located 30 km north of Cape Town, the Koeberg nuclear power plant is almost at the end of its 40-year designed lifespan. South Africa's state owned electricity company wants to extend the plant's life for another 20 years and has submitted its safety case to the nuclear regulator. At the end of 2022, Eskom released into the public domain a highly redacted version of that safety case. In March 2022, the International Atomic Energy Agency recommended a series of necessary improvements at Koeberg in order for the plant to be considered safe. Eskom seems to have downplayed or ignored key IAEA findings. This paper argues that the safety of Koeberg cannot be assured and the only reasonable course of action is to shut down Koeberg permanently.

INTRODUCTION

Koeberg is South Africa's only nuclear plant and its 1.8 GW generation potential is a key part of Eskom's ability to provide power to the nation. The 100% state-owned electricity company is in trouble. Constant blackouts (loadshedding) plague the country for up to 12 hours a day. Eskom's energy availability factor was around 90% in the 1990s. Today, the energy availability factor hovers around 54%, meaning that nearly half of its total nominal generation capacity of 46,446 MW is offline.[1]

Eskom's coal-fired power stations are at the end of their lives, which is a problem as coal accounts for 38,773 MW of generation capacity.[2] The completion of the new Kusile coal-fired power station (4800 MW) is years late, partly due to a major accident in 2022 resulting in three of its planned six units taken offline.[3] The similarly new Medupi coal-fired power station (also 4800 MW) is still not fully functional due to a hydrogen explosion.[4] The construction of both was and is hugely over budget. Corruption, organisational chaos and a debt of R423 billion (US$23bn) haunt the company.[5] Loadshedding costs the South Africa's economy an estimated R411bn (US$24bn) a year.[6]

1 Eskom, Weekly System Status Report – 2023 Week 34, 27 August 2023, pg. 3-4, https://www.eskom.co.za/wp-content/uploads/2023/08/Weekly_System_Status_Report_2023_w34.pdf

2 Eskom, "Company information", accessed 2 September 2023, https://www.eskom.co.za/about-eskom/company-information/

3 Onke Ngcuka, "Kusile Power Station units to come online by end of the year, says Ramokgopa", Daily Maverick, 11 September 2023, https://www.dailymaverick.co.za/article/2023-09-11-kusile-power-station-units-to-come-online-by-end-of-the-year-says-ramokgopa/

4 Thabiso Goba, "Fixing Medupi's unit after explosion will take 2 years to repair, says Eskom", EWN, 16 November 2022, https://ewn.co.za/2022/11/16/fixing-medupi-s-unit-after-explosion-will-take-2-years-to-repair-says-eskom

5 Ray Mahlaka, "Government's debt relief for Eskom gives power utility some breathing space", Daily Maverick, 24 August 2023, https://www.dailymaverick.co.za/article/2023-08-24-governments-debt-relief-for-eskom-gives-power-utility-some-breathing-space/

6 Jacques Morisset and Mariano Salto, "This is why climate sceptics should support a just energy transition", Business Day, 25 November 2022, https://www.businesslive.co.za/bd/opinion/2022-11-25-world-bank-this-is-why-climate-sceptics-should-support-a-just-energy-transition/

In order to keep some of the lights on, Eskom needs Koeberg but it is an old plant. Construction finished on the reactors almost 40 years ago: Unit 1 in 1984 and Unit 2 in 1985. Unless the South African National Nuclear Regulator (NNR) grants Eskom a 20-year extension on its operating licence, Koeberg's two 900 MW reactors will have to shut down in July 2024.

While a long-term operation (LTO) programme is a complex and technically demanding operation, the concept behind it is simple. In order to be safe to operate for another 20 years, worn out parts need to be replaced, modifications made to the plant based on the lessons learnt from nuclear accidents and damaged components and structures repaired.

Additionally, vital tests need to be conducted, such as a fast fracture analysis to test the integrity of the reactor vessel itself. Globally, LTOs are not unheard of: for example, France is currently extending the life of 56 reactors, many with the same design as Koeberg's.

The regulatory process is also straightforward. The International Atomic Energy Agency (IAEA) conducted a safety inspection in March 2022. After which, Eskom presented its Safety Case, a 290-page document stating what has been done and needs to be done at the plant, to the NNR in July 2022. The regulator will make a decision in the first half of 2024 to grant a 20-year extension or not.

Despite making a decision to go for an LTO in 2010, the programme has been massively delayed and Eskom is now rushing to make the July 2024 deadline.

PART 1 (A culture of secrecy, meltdown risk) of this briefing paper examines how the nuclear industry's secretive nature contributes to major accidents like Three Mile Island and Chernobyl.

PART 2 (Redacted lies) looks at how Eskom keeps information out of the public domain. For example, the Safety Case was highly redacted for ten months and often refers to documents not publicly available.

PART 3 (Cracking concrete, wet cables and radioactive leaks) assesses the Safety Case, primarily by contrasting it to the IAEA's inspection. Major issues abound such as a cracking outer containment level, radioactive leaks, the absence of critical tests, missing monitoring equipment and inefficient management.

PART 4 (The conditions for a serious accident have arrived) looks at how human resources, political and financial pressure, safety deficiencies, a regulator insufficiently independent and the lack of a Plan B have come together to create the conditions for a nuclear accident.

PART 5 (Playing around with nuclear fire) recommends that the IAEA conducts and on an urgent basis an inspection of the plant. Unless there have been dramatic changes at Koeberg and with Eskom, the regulator should not grant an extension.

For South Africa's atomic luck may not hold.

TABLE OF CONTENTS

PART 1

A CULTURE OF SECRECY, MELTDOWN RISKS

Before civilian nuclear reactors, there were nuclear weapons. During the 1940s, the USA with assistance from Great Britain and Canada developed two atomic bombs, the Manhattan Project, in a climate of uttermost secrecy. The American government, military, intelligence services and the scientists themselves were understandably dedicated to preventing both Nazi Germany and the Soviet Union from first knowing about and then gaining critical information about the programme.

Precisely because nuclear weapons were born in a culture of secrecy, a reluctance to full disclosure exists in the civilian nuclear industry: the apartheid government was extremely secretive about both Koeberg and its nuclear weapons. However, secrecy and withholding data are distinct, unnecessary and potentially catastrophic safety risks.

In *Lessons of Chernobyl: The Cultural Causes of the Meltdown*, the Russian nuclear physicist Sergei Kapitz points out that the initial efforts to develop nuclear power were achieved under the military. Only later were nuclear plants transferred over to civilian control. Kapitz states of that transfer:

> **Little institutional experience had accumulated through the developing years of the nuclear industry, and there was virtually no transfer of knowledge from those operating submarine reactors or producing plutonium to the civilian sector...The obsessive secrecy of the nuclear industry created a dangerous isolation.**[7]

At the heart of a nuclear plant, within the reactor itself, is an inherently unstable process. The splitting of uranium-235 isotopes in a light-water reactor like Koeberg (breeder reactors use different isotopes) produces an incredible amount of energy and starts a powerful force. Once criticality is achieved the atoms will continue to split to the point of meltdown unless the reaction is controlled.

7 Sergei P. Kapitz, "Lessons of Chernobyl: The Cultural Causes of the Meltdown", Foreign Affairs, Vol. 72, No. 3 (Summer, 1993), pg. 8, https://www.jstor.org/stable/20045618

Control is achieved, primarily, through the use of control rods, made of neutron absorbing elements like boron, inserted into the reactor core to slow down the reaction or stop it completely. Water is both used to cool the reactor down and to generate the steam that drives a turbine which then produces electricity.

In order to split atoms reliably and safely, nuclear plants have and will continue to become increasingly complex. Each nuclear accident, large or small, brings about a learning that is incorporated into existing and new plants.

The first nuclear accident was in May 1945 at Los Alamos, the site of America's nuclear weapons programme. Out of a total of an estimated 174 accidents[8] from 1947 to 2014, six were reactor core meltdowns and 24 were major accidents. The total number of reactors providing electricity to the grid ever built, including those under construction, is 667.[9] Accidents involving either partial or complete meltdowns are:

- **1952: Chalk River, Idaho, USA. Partial meltdown.**
- **1969: Lucens, Vaud, Switzerland. Partial meltdown.**
- **1978: Three Mile Island, Pennsylvania, USA. Partial meltdown.**
- **1986: Chernobyl, Kiev Oblast, USSR. Complete meltdown.**
- **1989: Saint-Laurent, Saint-Laurent-Nouan, France. Partial meltdown.**
- **2011: Fukushima, Fukushima Prefecture, Japan. Complete meltdown.**

Learnings from accidents, increased regulatory oversight and advancements within the nuclear industry itself have resulted in new reactors, such as the European Pressurised Reactor (EPR). These modern reactors are more complicated than their predecessors: better redundancies and greater defence in depth against meltdown, malfunctions, leaks, electrical faults, cracks in containment vessels, improved early warning systems and core catchers.

Put another way, there is no regulator anywhere in the world today that would approve the building of a new nuclear plant of the same design as Koeberg. The French CP1 900 PWR series, to which Koeberg belongs, is simply less safe than modern nuclear plants.

To be clear, Koeberg is not of the same design as Chernobyl or Fukushima and as such one cannot and should not directly compare the plants. However, this does still mean that a major accident could happen: the causes and chain of events leading up to such an accident would be, due to the design and type of reactor, different at Koeberg. Such a major accident would require the evacuation of people around Koeberg.

8 Spencer Wheatley, Benjamin Sovacool, Didier Sornette, "Of Disasters and Dragon Kings: A Statistical Analysis of Nuclear Power Incidents & Accidents", Cornell University, 7 April 2015, pg. 1, https://arxiv.org/pdf/1504.02380.pdf The authors define an accident as "We define an 'accident' as an unintentional incident or event at a nuclear energy facility that led to either one death (or more) or at least $50,000 in property damage."

9 Carbon Brief, "Mapped: The world's nuclear power plants", 8 March 2016, https://www.carbonbrief.org/mapped-the-worlds-nuclear-power-plants/

The meltdown at Chernobyl resulted in a 30 km radius exclusion zone being set up around the plant. No one is allowed to live within the zone. Agriculture and the raising of livestock are banned. The zone is and will remain so on any meaningful timeline unsafe for permanent human habitation.

The Japanese government placed a 20 km radius exclusion zone around the Fukushima plant after the accident. By 2021, the Japanese government had spent 12.1 trillion yen (R1.59 trillion) on dealing with the consequences of the disaster.[10] This is about as much as South Africa's total annual tax revenue.

The distance from the centre of Cape Town to Koeberg is 30 km. From Koeberg to Sunset Beach, just north of Milnerton, it is 20 km. For all intents and purposes, the greater Cape Town area would become a complete catastrophe in the case of a meltdown breaching the containment vessels and the subsequent release of radioactivity. Parts of the city and the surroundings would be uninhabitable, some areas permanently so on any meaningful timeline.

Sweden's Civil Contingency Agency recommends everyone under the age of 40 and within a 100 km radius would need to take iodine tablets immediately after a major accident to reduce the likelihood of thyroid cancer.[11] Very very few people in a 100 km radius around Koeberg have iodine tablets, which only have a preventative effect on thyroid and not any other cancer.

South Africa's National Nuclear Regulator sets the initial evacuation zone at a five kilometre radius around Koeberg, which could be expanded to 16 km.[12] Both the Chernobyl and Fukushima experiences show 16 km to be inadequate and neither is it clear why Eskom doesn't provide scenarios for 20 km, 30 km and even 50 km radiuses. A responsible owner, operator and regulator would model the absolute worst cases and have plans in place for each scenario.

Of course, not every nuclear accident is a complete or partial meltdown. There are a variety of other accidents: for example, at the Paks-2 reactor (Tolona county, Hungary) in 2003 inadequate cooling caused significant damage to the fuel assemblies.[13] The reactor had to be shut down for over a year. There are potential accidents discovered and unexpected repairs required. Like with any piece of machinery and especially with complicated tech, the older a plant gets the more likely it is to break down.

Unplanned outages due to accidents and other safety issues at Koeberg have already caused significant constraints to electricity supply, resulting in increased loadshedding. More could

10 Reuters, "Nuclear challenges await Japan after Fukushima water release", 24 August 2023 https://www.reuters.com/world/asia-pacific/more-nuclear-challenges-await-japan-after-fukushima-water-release-2023-08-24/#:~:text=BALLOONING%20COSTS&text=About%2012.1%20trillion%20yen%20had,reviews%20government%20expenditures%2C%20has%20said

11 Swedish Civil Contingency Agency, "Nuclear Accidents", 9 March 2022, https://www.krisinformation.se/en/hazards-and-risks/nuclear-accidents

12 National Nuclear Regulator, "Emergency Planning & Preparedness", accessed August 2023, https://nnr.co.za/regulation-and-licensing/emergency-planning-and-preparedness-2/

13 International Atomic Energy Agency, OECD-IAEA Paks Fuel Project, 2010, pg. 1

happen if the LTO goes poorly. Without a rigorous safety programme and the necessary upgrades done at the highest standard, the life extension would probably lead to the very same situation it is trying to avoid: less electricity for the national grid.

And there's a disturbing history of accidents over the last 19 years at Koeberg. The National Energy Regulator of South Africa (NERSA) investigated in 2006 six major incidents at Koeberg that happened between November 2005 to March 2006, ranging from a fire under a key transmission line and a deficient backup safety system. NERSA concluded that the accidents were the result of negligence, poor management, bad maintenance and the breaching of licence conditions. Eskom rejected the findings.[14]

The then Minister of Minerals and Energy, Lindiwe Hendricks, stated in March 2006 that 13% of senior professional engineers, 15% of technical managers and 16% of non-technical managers had left Koeberg over the previous two years. The eight vacancies for senior professional engineers were, according to her, filled "through the development of junior professional engineers".[15]

In a separate 2005 incident, a loose bolt was left in the generator of Unit 1, causing severe damage to the generator. The damage required shutting down the unit and lengthy repairs. The Minister for Energy at the time, Alec Erwin, falsely claimed sabotage. Eskom claimed in late 2006 that it wasn't a bolt that caused the damage but undefined "loose magnetic material". Just before the accident, the generator's protective mechanism registered overheating but the control room wasn't alerted because of a fault in the alarm system.[16]

Ninety-one workers at the plant in 2010 were contaminated with the radioactive isotope cobalt-58 (half-life of 70 days).[17] Airborne contamination (iodine-131, half-life of eight days) was detected at Koeberg in 2021: the contamination was the result of a routine test of the ventilation system.[18] [19]

A worker cut the wrong safety valve during routine maintenance in 2022, cutting the valve at Unit 1 instead of Unit 2. At the time, Eskom said that the "significant error" could have had "devastating consequences".[20]

14 Sonal Patel, "Whistling in the dark: Inside South Africa's power crisis", POWER, 1 November 2008, https://www.powermag.com/whistling-in-the-dark-inside-south-africas-power-crisis/

15 Melanie Gosling, "'Loss of skills' blamed for Koeberg shut down", IOL, 8 March 2006, https://www.iol.co.za/news/south-africa/loss-of-skills-blamed-for-koeberg-shut-down-268662

16 Michel O'Conner, "Koeberg: It wasn't the bolt", News24, 14 September 2006, https://www.news24.com/fin24/koeberg-it-wasnt-the-bolt-20060914

17 World Nuclear News, "Contamination incident at Koeberg", 22 September 2010, https://world-nuclear-news.org/Articles/Contamination-incident-at-Koeberg

18 Lameez Omarjee, "Eskom routine check detects air 'contamination' weakness at Koeberg", News24, 8 November 2021, https://www.news24.com/fin24/economy/eskom-routine-check-detects-air-contamination-weakness-at-koeberg-20211108

19 National Nuclear Regulator, 9th National Report By South Africa On The Convention On Nuclear Safety, 2023, pg. 15-16, https://nnr.co.za/wp-content/uploads/2023/02/RSA_CNS-Report-2022.pdf

20 Lameez Omarjee, "Human error at Koeberg nearly led to 'devastating consequences'", News 24, 17 March 2022, https://www.news24.com/fin24/economy/human-error-at-koeberg-nearly-led-to-devastating-consequences-20220317#:~:text=The%20incident%20was%20reported%20in,have%20had%20%22devastating%20consequences.%22

Eskom's claim that Koeberg has operated safely over the past 38 years is questionable.

But there is, as mentioned above, a problem with increasing the safety of nuclear plants in general: to become more safe the plants have to become more complex. They require additional electronics, components, safety routines and structural elements. The eminent organisational systems theorist Charles Parrow states in his book Normal Accidents:

> **We have produced designs so complicated that we cannot anticipate all the possible interactions of the inevitable failures; we add safety devices that are deceived or avoided or defeated by hidden paths in the systems. The systems have become more complicated because either they are dealing with more deadly substances, or we demand they function in ever more hostile environments or with ever greater speed and volume.**[21]

In other words, as we build more complicated reactors and put in retrofits to old ones we increase the number of parts and interactions that can go wrong. So, for example, installing a computerised digital control system alongside an analogue system creates a redundancy, which is a good thing. If one system goes down, the other is a back up. However, the computerised system brings its own faults, such as a possible software error, that could cause a malfunction, which is important as both systems could fail simultaneously. Also, different systems monitoring the same process can, due to errors or design differences or interference, produce contradictory information. Operators and technicians will have to be trained on both systems, which is an additional demand on financial and human resources.

Therefore, in order to minimise the risks that arise out of increased complexity, additional oversight, attention and technological improvements are required. These improvements can and probably will bring about unexpected issues that will have to be addressed, most likely with additional complexity. Nuclear power is a technology that will continue to require additional complexity to do the exact same function as it has always done: boil water.

But one cannot reduce the possibility of an accident to zero and history has proven that things can go very wrong within a reactor. A common denominator of each and every accident is that the owners and operators of the plant did not expect or think that the accident could occur. If a rational operator and/or owner thought it could occur, they would have avoided the particular situation. For example, if a valve is discovered to be faulty and would or could cause an accident, the valve would be replaced and an accident averted.

Apart from gross mismanagement and/or incompetence, major nuclear accidents are often the result of situations that are A) deemed impossible or highly unlikely to occur or B) not even imagined. For example, the operators at Chernobyl thought that the design of an RBMK reactor

21 Charles Parrow, Normal Accidents (Basic Books: 1984), pg. 11-12.

precluded the possibility of a meltdown and the designers of Fukushima considered the plant's elevation (10 metres) was higher than a possible tsunami. Both were wrong.

The Russo-Ukrainian war is a current example of the improbable occurring within the nuclear industry. The Soviet designers, builders and operators of the Zaporizhzhya nuclear power plant never expected that A) the Soviet Union would collapse in 1991 and B) there'd be a war between Ukraine and Russia that involved fighting in and around Europe's largest nuclear power plant.

Moreover, it has been assumed that in a war the combatants would steer clear of nuclear plants: tank rounds and radioactive fuel rods do not mix well. That assumption has now proved to be false.

Operating a nuclear reactor is an attempt to control an unstable process, keeping the nuclear reaction in check. An infinite multitude of possibilities for something to go wrong. Everything from a meteorite strike to undiscovered cracks in containment vessels to a scenario as-of-yet unthought of. This is precisely why the highest standards of nuclear safety have to be in place at all times. There cannot be a day off.

So there is a calculus that every society either with nuclear reactors or seeking to have them has to face. Is the chance of a major accident, with all the damage that entails, worth it? Is the risk small enough to justify operating a reactor? And what is the chance? Academic research after Fukushima indicates that the probability of a significant nuclear accident is greater than previously thought. Three different methodologies, for example, turn up similar results:

- The Max Planck Institute in Germany stated in 2012 that "Based on the operating hours of all civil nuclear reactors and the number of nuclear meltdowns that have occurred, scientists at the Max Planck Institute for Chemistry in Mainz have calculated that such events may occur once every 10 to 20 years...some 200 times more often than estimated in the past."[22] [23]

- Minh Ha-Duong and V. Journé stated in their 2014 journal article *Calculating nuclear accident probabilities from empirical frequencies* that "The probability of having at least one nuclear accident is 66.6% in a five-year sample. For a 30-year sample, we found that the probability of having at least one major accident was 63.2%, and a 25.8% probability of having at least two. Our results are in agreement with previously published studies."[24]

22 Max Planck Institute, "Probability of contamination from severe nuclear reactor accidents is higher than expected", 12 May 2012, https://www.mpg.de/5809418/reactor-accidents

23 J. Lelieveld, D. Kunkel and M. G. Lawrence, "Global risk of radioactive fallout after major nuclear reactor accidents", Atmos. Chem. Phys., 12, 4245–4258, 12 May 2012, https://doi.org/10.5194/acp-12-4245-2012

24 Minh Ha-Duong and V. Journé, "Calculating nuclear accident probabilities from empirical frequencies", Environment Systems and Decisions, 2014, pg. 10-11, https://hal.science/hal-01018478/document

- Spencer Wheatley, Didier Sornette and Benjamin Sovacool stated in 2015 that "In dollar losses we compute a 50% chance that (i) a Fukushima event (or larger) occurs in the next 50 years, (ii) a Chernobyl event (or larger) occurs in the next 27 years and (iii) a TMI [Three Mile Island] event (or larger) occurs in the next 10 years."[25]

The South African government and Eskom accept this risk, rightly or wrongly, and are now attempting to make Koeberg's life extension as safe as possible. The question is have they? This is the key and overriding question for both detractors and proponents of nuclear power. Any advantages of having Koeberg supply power to the grid for the next 20 years are completely subordinate to the question of safety. Koeberg could produce cheap and reliable electricity for the coming two decades, as Eskom states, but that scenario is completely meaningless if the plant is unsafe.

If either the nuclear operator or the regulator in any country is prepared to compromise on safety, that country has no business whatsoever in running nuclear power plants. And secrecy and the withholding of information are compromises on safety. The world's third worst nuclear disaster was the Kyshtym disaster in the USSR. Of this Kapitz writes:

> **In 1957 a storage facility for the highly radioactive residue of plutonium-producing plant blew up. It was a chemical, rather than a nuclear, explosion, but as a result a huge amount of radioactivity was thrown into the atmosphere and a large area near Kyshtym, to the east of the Urals was thoroughly contaminated. Although known to many insiders, the episode was concealed by the Soviet government. If the Kyshtym explosion and its consequences had been widely studied and understood, the Chernobyl tragedy might have been, if not prevented, at least mitigated.**[26]

A year before Three Mile Island, another plant (Davis–Besse in Toledo, Ohio) of the same design discovered the same problem that caused the Three Mile Island accident. The company that built the reactors for both plants, Babcock & Wilcox, knew about the design flaw at Davis-Besse, having received reports with operating solutions from two company engineers. However, Babcock & Wilcox did not share this information with Three Mile Island. The engineers had recommended sharing their findings with operators of Babcock & Wilcox reactors and if the information was not withheld, the Three Mile Island accident quite possibly would have been averted.[27]

Clearly then, secrecy and the withholding of information is not in the interest of nuclear safety. The general attitude within the industry is that 'we are the experts, leave it to us, but don't worry you can and should trust us'. But this attitude, as illustrated above in the case of the Soviet

25 Spencer Wheatley, Benjamin Sovacool and Didier Sornette, "Of Disasters and Dragon Kings: A Statistical Analysis of Nuclear Power Incidents & Accidents", Cornell University, 7 April 2015, pg. 1, https://arxiv.org/pdf/1504.02380.pdf

26 Sergei P. Kapitz, "Lessons of Chernobyl: The Cultural Causes of the Meltdown", Foreign Affairs, Vol. 72 No. 3 1993, pg. 8, https://www.jstor.org/stable/20045618

27 B. Drummond Ayres, "Engineers Warned Builder of Danger Year Before Three Mile Island Accident", New York Times, 19 July 1979, https://www.nytimes.com/1979/07/19/archives/engineers-warned-builder-of-danger-year-before-three-mile-island.html

Union, results in the nuclear industry dangerously isolating itself from society.

Given the nuclear industry's history of meltdowns, releases of radiation, fires, spills and other accidents, there is no prima facie reason why the industry should be trusted. The industry needs oversight and not just from wholly independent regulators. Any accident is also a failure of nuclear regulators to identify problems and proactively force operators to solve those problems.

What is additionally required is public oversight, which necessitates the open disclosure of information about every reactor, including regulator reports and decisions. No civil society organisation, member of the public, nuclear scientist or academic institution can make a full analysis of a particular reactor's safety if they do not have all the relevant information. In effect, Eskom and the NNR need to prove that Koeberg is safe, not merely state it.

Two types of information are often presented as areas where there should not be open disclosure. One is valid and the other isn't.

1) Physical and cyber security. This is a safety issue. One does not want the exact details of how the plant is guarded from external attack in the public domain. External actors could use this information to attack the plant for some hitherto unknown reason. However, this information should be narrowly identified. For example, the exact response to a violation of airspace restrictions above a nuclear plant shouldn't be in the public domain. The extent of the airspace restrictions, something like no unauthorised airborne vehicles are allowed within 10 km of the plant, and the rationale behind those restrictions should be in the public domain.

2) Protection of commercial information. The notion is that the details of a company's proprietary technology can be withheld on the basis that a competitor would use that information to enhance its own technology. However, the consequences of a nuclear accident are so severe that they outweigh any company's claim to commercial secrets. Furthermore and in the case of Koeberg, another CP1 900 PWR will not be built anywhere in the world. How could there be details of an obsolete technology worth keeping out of the public domain?

There are two key and interrelated documents regarding Eskom's application to the NNR for life extension. The first is the International Atomic Energy Agency's 2022 report on the viability of Koeberg's planned life extension. The second is Eskom's 2022 submission to the NNR on the safety of the LTO, which is partly a response to the IAEA's report.

Both of these documents were initially withheld from the public.

PART 2

REDACTED LIES

Eskom's projected cost of the LTO is R20 billion (US$1bn) and the projection hasn't changed since 2010. Simply put, Eskom is lying about the cost unless it is grossly incompetent. Any reasonable person knows that R20bn in 2010 is not R20bn in 2023 precisely because of inflation, which alone gives the figure of R36.4bn.

Most of the parts of the LTO, such as buying the steam generators, come from overseas and paid for in euros or dollars. Any reasonable person understands that €1 gets you R9.72 in 2010 gives a different cost calculation than August 2023's exchange rate of about R21 to the euro.

The French have embarked upon a massive life extension programme for their entire fleet of 56 reactors, including ones of the exact same design as Koeberg. The estimated cost is about €1.7bn per reactor (2016 euros), which suggests that somewhere around a total of R70bn might be a reasonable figure for Koeberg's two reactors.[28]

Unlike Eskom, the French are installing core catchers so it could be less than R70bn but nowhere close to R20bn. In the case of a meltdown, a core catcher (made from thermally-resistant concrete ceramic) would, in theory, prevent the molten fuel from leaving the containment structure. Additionally, the French are making other significant ugrades on plants with the same design as Koeberg's.[29] Upgrades to cooling systems, backup generators and electrical systems that Eskom seems not to be making. The aim of the French is to bring the safety features of the reactors as close to its new design, the European Pressurised Reactor, as possible. Eskom and the NNR appear not to be following this approach.

28 Cour des comptes, 2016 Annual Public Report, pg.24, https://www.ccomptes.fr/sites/default/files/EzPublish/20160210-Annual-Public-Report-English-summaries-Observations.pdf

29 Autorité de sûreté nucléaire, Generic Phase of the Fourth Periodic Review EDF's 900 MWe Reactors, March 2021, pg. 75-77, https://www.asn.fr/content/download/177423/file/Rapport%20d%27instruction%20de%20l%27ASN%20pour%20les%20RP4%20-%20r%C3%A9acteurs%20900%20MWe.pdf

There seems to be only three options on why an accurate cost assessment has not been disclosed. 1) Eskom is lying about the cost of the LTO, it knows that the R20bn figure is wrong but it is not disclosing the real figure to the public. 2) Eskom somehow believes the R20bn figure is correct. 3) Eskom has no proper idea of what the LTO will cost and is thus using the R20bn as a generic placeholder.

If 2) and 3) are correct, then Eskom is utterly unfit to run a nuclear plant. Keeping tabs on what has been spent to date, what will be spent according to contracts already signed and some kind of projection of future costs is hardly beyond human ability. We should be able to ask Eskom on the first of every month what is the current and projected cost of its most demanding nuclear operation after the initial construction of Koeberg.

In fact, up-to-date cost accounting represents the absolute minimum level of competency required to operate something as inherently dangerous as a nuclear reactor. Therefore, it is an unlikely proposition that Eskom doesn't know that its R20bn LTO cost projection is wrong.

So the first option seems the most likely. Eskom knows its figure is wrong but isn't disclosing the real figure for some reason. Maybe it knows that the cost is high enough to cause the economic case for the LTO to fall apart? Maybe it doesn't want to spook the bond markets? Parliament? But and for whatever cause, Eskom appears not to be disclosing the complete truth on a very basic question.

The proposition that Eskom is not trustworthy is a legitimate one. This is a substantial problem when examining Eskom's safety case for the LTO.

Eskom's *Safety Case for Long-Term Operation of Koeberg Nuclear Power Station* (hereafter "Safety Case") is a lengthy document, coming in at 290 pages. When it was first released to the public in January 2023, it was heavily redacted. Large parts of the document were blacked out.

Eskom has never explained why sentences, paragraphs, table columns, whole pages and sections were blacked out. However, it does seem that the redactions had nothing to do with security issues. How do we know this? Eskom states right at the beginning of the Safety Case that "The nuclear security report will be in a separate and confidential submission."[30]

So the substantive details on nuclear security are in another document, which won't be released to the public. The security submission is either currently with or will be with the NNR. Which rather begs the question why then redact parts of the Safety Case if they have nothing to do with security?

30 Eskom, Safety Case for Long-Term Operation of Koeberg Nuclear Power Station, 2023, pg. 11, https://www.eskom.co.za/wp-content/uploads/2023/01/331-618_Rev1a-Safety_Case.pdf

Eskom never intended to disclose the Safety Case to the public but was required to do so by the NNR. Eskom's original intention was to release only the *Public Information Document for the Long-Term Operation of Koeberg Nuclear Power Station* (hereafter "Public Information Document") for general consumption. This 83-page document provides few actual details about the LTO and leaves the reader with the impression that everything is fine at Koeberg and there are no significant problems in implementing the LTO. Eskom states that "In conclusion, it has been demonstrated that there is no undue risk to safety, health, or the environment by continuing the operation of Koeberg for an additional 20 years."[31]

In late October 2023 and as a reaction to an NGO, Save Bantamsklip, launching legal actions to obtain an non-redacted version of the Safety Case, Eskom quietly put the full Safety Case on its website.[32] Eskom did not inform the media and, hence, very few people knew about it. The irony is that the non-redacted version isn't in substance all that different from the redacted version. As Eskom found it possible to publish the non-redacted version, the blacking out of sections was nothing but secrecy for the sake of secrecy itself.

As we have seen in the previous section, one of the causes of the Chernobyl meltdown and subsequent poisoning of thousands of square kilometres was excessive secrecy. And it is certainly excessive to be secretive about whether Koeberg is safe or not.

When there is an accident, there is a tendency to withhold information from the public such as the level of radiation released. This happened, at least in the initial stages, at the Chernobyl, Fukushima, Three Mile Island and Windscale (Cumbria, UK) disasters. In the case of the 1957 reactor fires at Windscale, The Telegraph reported in 2007 that:

> **While it was front-page news, the scale of the disaster was played down by officials. The government asked Sir William Penney, one of Britain's foremost authorities on nuclear weapons, to investigate to Windscale fire, but his report was heavily censored and spun to blame personnel rather than the plant…The government was equally tight-lipped about the radioactive fallout – although the authorities banned the sale of milk from local farms.**[33]

The area in which milk could not be consumed because of iodine-131 contamination, which raises the chance of developing thyroid cancer, covered 500 km^2.

Despite now being non-redacted, the Safety Case still withholds 289 subsidiary documents from the public. These documents are referred to in the Safety Case constantly. For example,

31 Eskom, Public Information Document for the Long-Term Operation of Koeberg Nuclear Power Station, 2022, pg. 6, https://www.eskom.co.za/wp-content/uploads/2022/09/English-PID-for-LTO.pdf

32 Max Matavire, Eskom under fire for concealed Koeberg report, Business Day, 22 August 2023, https://www.businesslive.co.za/bd/national/2023-08-22-eskom-under-fire-for-concealed-koeberg-report/

33 Roger Highfield, "Windscale fire: 'We were too busy to panic'", The Telegraph, 09 October 2007, https://www.telegraph.co.uk/news/science/science-news/3309842/Windscale-fire-We-were-too-busy-to-panic.html

the *KBA0022OTS0000001 Operating Technical Specification*, which is not included in Eskom's publicly available application. Nor can it be found using a Google search. The only hit is the Safety Case itself.

Why is this document important? Eskom states:

> **KBA0022OTS0000001 (Operating Technical Specification (OTS)) [156] defines the normal operating limits necessary to remain within the reactor design assumptions, defines the operability requirements of safety functions, and prescribes the actions required if normal operating limits are exceeded or a required safety function is inoperable. The OTS is mainly used as an instruction manual by the plant operators to safely guide and operate the plant within operational limits.**[34]

Again, a pretty important document and not attached to the Safety Case and, to reiterate, a Google search only turns up the Safety Case itself. So what are the operational limits and what happens if those are exceeded?

So for a member of the public wanting to assess the safety case, as is her right, these 289 documents might as well not exist. There is an information void.

We have Eskom's word that Koeberg is safe but what does that mean? Can we really take the word of an organisation that has stated a multitude of deadlines across its fleet and then not met them? There won't be loadshedding but then there is? The LTO costs 20 billion? That purposely withheld information for no real reason from the public?

We do have, however, another word: the International Atomic Energy Agency's independent assessment, the *Report of the Safety Aspects of the Long Term Operation Mission (SALTO)* to the Koeberg Nuclear Power Plant Units 1 and 2, hereafter referred to as "SALTO".

The assessment was completed in March 2022 and the SALTO is the latest independent review of Koeberg. The International Atomic Energy Agency (IAEA) is the technical body tasked with ensuring nuclear safety across the world. The team that assessed Koeberg included nuclear experts from all over the globe and was a follow-up to a 2019 IAEA investigation. SALTO is a big deal. Yet, this crucial report wasn't included in Eskom's publicly available application.

In fact, the IAEA didn't release the SALTO into the public domain, again that culture of secrecy, but the main opposition party, the Democratic Alliance (DA), gained a copy in October 2022. The DA used a Promotion of Access to Information Act (PAIA) request.[35]

34 Eskom, Safety Case, pg. 103. Bold added.

35 Kevin Mileham, "IAEA report confirms that the Koeberg life extension project is in crisis", Democratic Alliance, 18 October 2022, https://www.da.org.za/2022/10/iaea-report-confirms-that-the-koeberg-life-extension-project-is-in-crisis

The SALTO provides 15 recommendations and suggestions regarding aspects of the LTO. Some of these come with serious warnings like "Without complete implementation of ageing management programmes for civil SSCs [structures, systems and components], preservation of safety functions cannot be ensured."

So how does Eskom's Safety Case stack up to the IAEA's SALTO?

PART 3

CRACKING CONCRETE, WET CABLES AND RADIOACTIVE LEAKS

As mentioned before, there is a caveat regarding the following analysis. Since the Safety Case is heavily redacted, it is impossible to give a complete assessment of whether or not Eskom has addressed the IAEA's recommendations and suggestions. However, the information available in the Safety Case does provide significant cause for concern.

The following two tables list all 15 of the IAEA's recommendations and suggestions. A recommendation is very serious and points to inadequate conformance to IAEA Safety Requirements. A suggestion is about how to improve safety in conformance with IAEA Safety Requirements. Put simply, a recommendation is about something that needs to happen but hasn't. A suggestion is about how to make a thing considerably safer. Eskom needs to adhere to both recommendations and suggestions: seen in the light of preventing an accident, a suggestion is not an optional extra. Moreover and unless Eskom deals with both, the IAEA cannot determine Koeberg's safety. Or as the IAEA states, "The [IAEA] SALTO team encouraged the plant management to facilitate implementation of all remaining activities for safe LTO."[36]

36 International Atomic Energy Agency, Report of the Safety Aspects of the Long Term Operation Mission (SALTO) to the Koeberg Nuclear Power Plant Units 1 and 2, 2022, pg. 3, https://press-admin.voteda.org/wp-content/uploads/2022/10/50_Koeberg_SALTO-mission-report-final.pdf

IAEA RECOMMENDATIONS

Issue number and fundamental problem	IAEA recommendation
D-4: The plant has not revalidated the environmental qualification of qualified cables for LTO.	The plant should complete the revalidation of environmental qualification for qualified cables.
E-2: Containment structure monitoring system is not fully functional.	The plant should ensure full functionality of the containment structure monitoring system.
Source: International Atomic Energy Agency, SALTO, pg. 53-56, 61-63	

IAEA SUGGESTIONS

Issue number and fundamental problem	IAEA suggestion
A-1: Management of the LTO programme is not effective to timely complete all actions to prepare for LTO.	The plant should consider ensuring effective management to the LTO programme to timely complete all actions.
A-2: The safety analysis report (SAR) has not been adequately updated for LTO and ageing management.	The plant should consider updating the safety analysis report for safe LTO.
B-1: Completeness and consistency of scope setting of SSCs [structures, systems and components] for ageing management and LTO are not ensured.	The plant should consider ensuring completeness and consistency of ageing management scope of SSCs for LTO.
B-2: The plant programmes are not comprehensively reviewed and implemented for LTO.	The plant should consider comprehensively reviewing and implementing all plant programmes for LTO.
C-1: Information used for AMR [ageing management review] of mechanical SSCs is not consistently managed and documented	The plant should consider consistently managing and documenting information for AMR of mechanical SSCs.

Issue number and fundamental problem	IAEA suggestion
C-2: AMPs [ageing management programmes] for mechanical SSCs are not complete.	The plant should consider completing the AMPs for mechanical SSCs.
D-1: The plant has not completely implemented a comprehensive cable ageing management programme.	The plant should consider completing the implementation of the cable ageing management programme.
D-2: The plant has not revalidated environmental qualification for some SSCs for LTO.	The plant should consider completing the revalidation of environmental qualification for all the SSCs in the scope of the environmental qualification programme.
D-3: Electromagnetic compatibility [EMC] has not been completely assessed.	The plant should consider completing an assessment of electromagnetic compatibility.
D-5: A proactive approach to technological obsolescence management is not fully implemented.	The plant should consider completing the implementation of a proactive approach to technological obsolescence.
E-1: The plant has not comprehensively revalidated the TLAAs [time limited ageing analyses] for concrete structures.	The plant should consider improving revalidation of TLAAs for concrete structures.
E-3: Ageing management programmes for civil structures are not fully developed and implemented.	The plant should consider completing and implementing the ageing management programmes of civil SSCs.
Source: International Atomic Energy Agency, SALTO, pg. 20-52, 55-61, 63-66	

INEFFECTIVE MANAGEMENT

Suggestion A-1: Ineffective management of the LTO programme points out that the life extension needs to be done in a timely manner and speaks to significant delays in ongoing processes. Vital actions had not yet started. The IAEA states that "Management of the LTO programme is not effective to timely complete all actions to prepare for LTO."[37]

Eskom and the IAEA held a virtual meeting on 18 June 2021 to prepare for the IAEA's mission to review Koeberg and the LTO. The IAEA's mission finished on 31 March 2022 and, according to the IAEA, Eskom was slated to submit the Safety Case to the NNR in June 2022. Eskom managed to finish compiling its Safety Case in July 2022, finished its weak Public Information Document in August 2022, and only released the redacted version of the Safety Case to the public in January 2023.

With the reactor licences expiring in July 2024, Eskom's schedule was and still is quite tight for the LTO, which is a complicated, highly technical and very demanding process. As stated previously, the LTO is the most difficult endeavour Eskom has embarked upon since the construction of Koeberg. The IAEA also observed that "The plant does not provide margins for delays in any ongoing activities."[38]

One of the biggest repairs required for the LTO is the replacement of the steam generators, which is a condition that plagues ageing nuclear plants in general. Steam generators need to be replaced and the old ones require safe and specialised storage due to their radioactivity.[39] The procedure for replacing steam generators is well-established. Plant operators know that replacing steam generators has to be done for an LTO and there is plenty of experience across the world.

While the task takes a substantial amount of effort from manufacturing to installation, each generator weighs approximately 380 tons and is about 20 metres long, the process is achievable and relatively common. Koeberg needs to replace all the steam generators, three in Unit 1 and another three in Unit 2.

How long does a reactor have to be taken offline in order to swap out the generators? The obvious answer is how ever long it takes to make the plant safe. That said, a few examples:

- Replacements at the Mihama plant (Fukui Prefecture, Japan) took a considerable amount of time. Mihama Unit 2 needed 359 days to replace two steam generators in 1993. Mihama 1 took 519 days to also replace two. The long time was connected to the fact that a serious accident in 1991, requiring emergency shutdown of the reactor, occurred within

37 International Atomic Energy Agency, SALTO, pg. 9

38 International Atomic Energy Agency, SALTO, pg. 20

39 Jin Ho Son, Tae Young Kong, Ho Yeon Yang, Seong Jun Kim, Eun Ji Lee, Wo Suk Choi, Woon Kwan Chung and Hee Geun Kim, "Estimation of radiation dose resulting from the recycling of large metal wastes from decommissioning nuclear power plants in Korea", Engineering Energy Science, 20 October 2021, https://doi.org/10.1002/ese3.995

a steam generator in Unit 2.[40]

- At the other end of the scale, the 1994 replacement of three steam generators at the Gravelines power station (Nord, France) was done in 37 days. Gravelines is the same design as Koeberg.[41]
- In 2022, The Watts Bar plant (Tennessee, USA) swapped out four steam generators in four months. The steam generators were first ordered from Westinghouse in 2016 and were on site in 2018.[42]

The ongoing replacement of steam generators at Koeberg has been a massively delayed and torturous affair. Eskom's board decided to go for a life extension in 2010 and put out a tender for steam generators in 2012.[43] The tender came down to two bidders: the French nuclear company Areva and the American & Japanese company Westinghouse, respectively Koeberg's builder and designer.

Areva was awarded the tender in 2014 on the basis that it could achieve the job three months faster than Westinghouse, who had put in a bid R140 million (US$4.6m) cheaper. After which, Westinghouse took Eskom's decision to court. Eventually, at the end of 2016, the Constitutional Court ruled in favour of Eskom and Areva.[44]

Then the problems really started. The delivery date for the steam generators was February 2018 and the deadline for installation of all six was at the end of 2019. Installation was pushed out to 2021 for Unit 1 and 2022 for Unit 2. Areva was having manufacturing quality problems with the steam generator forgings. These were sent to Areva's Chinese partner for examination. Shanghai Electric Nuclear Power Equipment Company decided to start from scratch owing to Areva's poor workmanship. Areva went bankrupt in 2017 and was taken over by the French state's nuclear enterprise, Électricité de France (EDF), and Areva's reactor business became Framatome.[45] [46]

40 ISOE European Technical Centre, CEPN Information Sheet No. 30, April 2002, pg. 2, https://www.isoe-network.net/publications/pub-resources/isoe-information-sheets/etc-information-sheets/211-etc-30/file.html

41 ISOE European Technical Centre, CEPN Information Sheet No. 30, April 2002, pg. 2, https://www.isoe-network.net/publications/pub-resources/isoe-information-sheets/etc-information-sheets/211-etc-30/file.html

42 Nuclear Engineering International, "Swapping steam generators at Watts Bar", 5 April 2023, https://www.neimagazine.com/features/featureswapping-steam-generators-at-watts-bar-10737329/

43 Government Communication and Information System, "Steam generators arrive at Koeberg power plant", 30 September 2020, https://www.sanews.gov.za/south-africa/steam-generators-arrive-koeberg-power-plant

44 Linda Ensor, "Eskom, Areva win technical knockout in Constitutional Court nuclear ruling", Business Day, 21 December 2016, https://www.businesslive.co.za/bd/companies/energy/2016-12-21-eskom-areva-win-technical-knockout-in-constitutional-court-nuclear-ruling/

45 Lubomir Mitev, "China's Shanghai Electric To ManufractureEquipment For South Africa's Koeberg", NucNet, 26 March 2015, https://www.nucnet.org/news/china-to-manufacture-equipment-for-south-africa-s-koeberg

46 Chris Yelland, "Steam generators for Koeberg: 'the most expensive transport of scrap metal in the history of humankind'", Daily Maverick, 5 October 2020, https://www.dailymaverick.co.za/article/2020-10-05-steam-generators-for-koeberg-the-most-expensive-transport-of-scrap-metal-in-the-history-of-humankind/

The first steam generator arrived in South Africa in 2020, the last in 2022, and the process to begin replacement was slated for early 2022. Delay after delay then followed. Eskom is now seeking an extension from the NNR on the licensing end date for Unit 2 to November 2025 on the basis that it was commissioned one year (1985) after Unit 1.[47] [48]

Fourteen years to replace steam generators...the average time to build a new nuclear plant is just under ten years.[49]

Eskom's inefficiencies became startlingly clear when Framatome came to Koeberg in early 2022 to begin work on Unit 2's steam generators. The original plan was to refurbish Unit 2 first. However, the storage building for the old and radioactive steam generators hadn't been built yet. Framatome left, citing safety issues, and Eskom had to pay a R950m (US$51m) penalty. The replacement process was delayed until December 2022, starting with Unit 1. Eskom managed to bring Unit 1 back online on 13 November 2023. The replacement of the steam generators took 338 days. That's only 21 days shorter than at Mihama Unit 2, which had the consequences of a nuclear accident to deal with.[50] [51]

A search of the Safety Case for the phrase 'ineffective management' does not produce any results.

An extremely important area of concern for the IAEA is that a time limited ageing analysis was not yet complete at Koeberg for the reactor pressure vessel internals, which provides the critical safety functions of protecting the reactor core, maintaining stability for the insertion of control rods and providing passage for coolant to flow.

In specific, the IAEA was looking for a fast fracture analysis. As reactors age, neutron radiation embrittlement of reactor pressure vessel internals increases and, if bad enough, could result in a catastrophic fast fracture under certain circumstances. Thus, it is vital to know the state of neutron embrittlement.

47 Victoria O'Regan, " Koeberg power station's Unit 1 set to be finally back online by November — Eskom" , 11 August 2023, https://www.dailymaverick.co.za/article/2023-08-11-koeberg-power-stations-unit-1-set-to-be-finally-back-online-by-november-featherstone/

48 Chris Yelland, "Steam generators for Koeberg: 'the most expensive transport of scrap metal in the history of humankind'", Daily Maverick, 5 October 2020, https://www.dailymaverick.co.za/article/2020-10-05-steam-generators-for-koeberg-the-most-expensive-transport-of-scrap-metal-in-the-history-of-humankind/

49 Marton Dunai and Geert De Clercq, "Nuclear energy too slow, too expensive to save climate: report", Reuters, 24 September 2019, https://www.reuters.com/article/us-energy-nuclearpower-idUSKBN1W909J

50 Staff writer, "The ugly truth behind Koeberg's delays", MyBroadband, 13 August 2023, https://mybroadband.co.za/news/energy/504120-the-ugly-truth-behind-koebergs-delays.html

51 Mandisa Nyathi, "Six-year contract with Framatome is bleeding Eskom's finances", Mail & Guardian, 4 April 2023, https://mg.co.za/environment/2023-04-04-six-year-contract-with-framatome-is-bleeding-eskoms-finances/

But the IAEA says that Eskom hadn't even contracted the analysis at the time of the SALTO assessment (March 2022).[52] [53] [54]

Understanding the ageing process within the reactor vessel is vital to know if Koeberg will last another 20 years. As for the status of the analysis itself, Eskom states in a table outlining progress for the LTO that it is awaiting fast fracture analysis, estimated delivery in January 2024. This should have been done before the IAEA's visit so it could be independently assessed.[55]

And there's nothing new about the dangers and possibilities of major failures in the core and steam generators. Charles Parrow points out that:

> **For all nuclear power plants, the steam generator and the core embrittlement problems are awesome. Small failures can interact and render inoperative the safety systems designed to prevent a steam generator failure from being catastrophic. Trivial events can place stress on the embrittled core in ways unimagined by designers.**[56]

Eskom's Safety Case seems not to mention the IAEA's concern about margins for delays and nor does it seem to provide scenarios for delays in the implementation of LTO activities in general. Given Eskom's history of missed deadlines, in particular the multitude of construction delays at the Medupi and Kusile coal-fired power stations, this is worrying and will, perhaps, lead to even more problems at Koeberg.

The steam generator saga rather proves the point that Eskom and Koeberg's management has not been up to the task of keeping to schedule and that the IAEA's concern is well-founded. And management failures are only the start. Other serious problems are brewing.

THE CONTAINMENT STRUCTURE'S MONITORING SYSTEM DOESN'T WORK

The IAEA's Recommendation E-2 states that The plant should ensure full functionality of the containment structure monitoring system. This recommendation is intimately connected to Suggestion E-1: The plant should consider improving revalidation of time limited ageing analyses for concrete structures and Suggestion E-2: The plant should consider completing and implementing the ageing management programmes of civil structures, systems and components.

The recommendation and the suggestions are all connected to the same fundamental problem: cracks and corrosion in the containment building, which would, if it holds up, prevent radiation and

52 International Atomic Energy Agency, SALTO, pg. 20

53 International Atomic Energy Agency, Assessment and management of ageing of major nuclear power plant components important to safety: PWR vessel internals, 1999, pg. 57, https://www-pub.iaea.org/MTCD/publications/PDF/gnppa-cd/PDF-Files/SpecGuide/te_1119_prn.pdf

54 G.R. Odette and G.E. Lucas, Embrittlement of Nuclear Reactor Pressure Vessels, JOM, 53 (7), 2001, pg. 18, https://link.springer.com/article/10.1007/s11837-001-0081-0

55 Eskom, Safety Case, pg. 196

56 Charles Parrow, Normal Accidents, Basic Books, 1984, pg. 60

radioactive materials leaving the plant in the case of a serious accident. The containment building is the last barrier. The first and second barriers are respectively the cladding around the nuclear fuel itself and the reactor coolant system.[57]

If there is a partial or complete meltdown and the three barriers fail, the possibility of a Fukushima or a Chernobyl-style accident increases dramatically. About the cracks and corrosion, Eskom states:

> **Due to significant chloride loading into the containment civil structure from the atmosphere at Koeberg [situated right on the sea] that was not anticipated during the design stage, the external surfaces of the containment buildings have suffered from chloride ingress that causes rebar corrosion. Since the year 2000, various investigations, tests, and evaluations have been dedicated to the required recovery. The first was removing loose and spalled surface areas, followed by repairs. Several repair projects have been completed to date. However, it is clear that these efforts are temporary and not a permanent solution. An investigation by a group of international experts concluded that the only permanent solution was to protect the internal rebar and tendons through impressed cathodic protection.**[58]

The next two sentences, perhaps something about the permanent solution or lack thereof, are redacted. Cracking containment vessel concrete hasn't just occurred because of the weather but also because Eskom delayed maintenance. In 2017, Eskom admitted that:

> **It is noted that in the past, there have been significant delays to repair concrete degradation with the net result that large patches amounting to approximately 10% of the containment building surface area have delaminated and chloride ingress extends past the rebar cover depth.**[59]

Eskom states in the October 2023 Safety Case that the cracks will only be properly fixed in 2025.

Moreover, there's an adjacent issue of great concern. The last time an integrated leak rate test was done on the containment building was in 2015. This test checks the leak-tightness and the structural integrity of the building in relation to the degradation of reinforced concrete. What Eskom does is increase the pressure inside the containment building to replicate the loss of coolant around the reactor.[60] An integrated leak test happens every ten years. The current plan seems to be that Eskom will do an integrated leak test on Unit 1 during a 200 day outage starting on 24 July 2024, three days after the licence expires, and make repairs if necessary. Eskom

57 Eskom, Public Information Document, pg. 57

58 Eskom, Safety Case, pg. 85. Bold added

59 Eskom, Plant Engineering: Life Of Plant Plan: Containment Buildings, KBA 0022 N NEPO LOPP 164 Rev 1, 2017, pg. 23, https://koebergalert.org/2020/11/10/eskom-releases-koeberg-decommissioning-strategy/

60 Eskom, Safety Case, pg. 121

wants a 20-year licence before a critical test on a vital structure with a known defect and threat is due, rather begging the question why hasn't another test been done? Assess the safety of the last barrier? There's no guarantee that an accident will not occur between now and July 2024.

Eskom's view in the Safety Case, based on the 2015 integrated leak test and a temporary solution, is that "the current condition of the buildings is deemed to have sufficient integrity, and the design of the buildings remains fit for purpose and suitable for long-term operation."[61]

Of interest in this regard is that the IAEA points out that some remedial measures regarding identified safety measures needing immediate attention during the last outages, including Unit 2's containment structure in 2018 and 2020, were still marked as pending on Koeberg's SAP database. Either the database wasn't being updated, hardly a comforting thought, or the pressing remedial measures weren't done, which is an even less comforting thought.[62]

The containment building isn't the only place with concrete cracks, as outlined in Suggestion E-3: The plant should consider completing and implementing the ageing management programmes of civil structures, systems and components. The IAEA states that:

> **Leakage through leakage collection system of spent fuel pool of unit 2 was observed irregularly during the plant life, it has even stopped for a few years. An investigation was performed, but the root cause of the leak and disappearance of leak could not be found.**[63]

Water from the spent fuel pond is very radioactive and if the system has leaked before, it could leak again, especially as the cause is not known. The Safety Case seems to ignore this issue. Moreover, the IAEA is worried about the organisational element of monitoring the spent fuel point. The SALTO states that "The various activities related to monitoring of spent fuel pool are currently performed by different departments whose analysis are not integrated."

Highly radioactive water also leaks, according to the IAEA, from the unlined sumps of Nuclear Auxiliary Building 2, which, amongst other things, houses backup reactor safety systems.[64] The IAEA states:

> **Leakages have been noted in sumps of the Nuclear Auxiliary Building 2, e.g. sumps located in N281 and N032 which belong to the Nuclear Islands Vents and Drains System (RPE). White residue and deposits are observed along cracks in the concrete on structural elements around or below these sumps. In both cases the sumps are unlined, and their contents are highly radioactive. The procedure to address unlined sumps is not completed yet.**[65]

61 Eskom, Safety Case, pg. 122

62 International Atomic Energy Agency, SALTO, pg. 64

63 International Atomic Energy Agency, SALTO, pg. 64

64 International Atomic Energy Agency, SALTO, pg. 64

65 International Atomic Energy Agency, SALTO, pg. 64

The Eskom Safety Case only mentions sumps twice: one points out that ageing of the plant causes degradation of sumps and the other a vague reference to sumps now having waterproof casings.[66] Presumably, these are the sumps the IAEA speaks of. But why hadn't the casings been done prior to the IAEA SALTO mission, especially since the contents of the sumps are highly radioactive? What are the white residue and deposits? Where is safety first?

One of the problems is that nowhere in the non-redacted segments of the Safety Case is there a table or such clearly stating each one of the IAEA's concerns, what Eskom did about them and when. If the concern had not been met, reasons and a clear timeline given as to when and how the concern will be addressed. The reader has to scratch around for answers.

Given that the DA released the IAEA report in October 2022 and the Safety Case was only made available in January 2023 and re-released in October 2023, there was ample time for Eskom to draft a table or supplementary document outlining what it did and when. When this briefing's author repeatedly approached Eskom to provide the above and a copy of the Safety Case without redactions, the state-owned enterprise refused to answer.

Clarity and open disclosure run contrary to a culture of secrecy.

The recommendation about the containment building is alarming, remembering that a recommendation means that Eskom is not adhering to IAEA safety standards, and the basic problem is that Eskom cannot reliably monitor what is happening inside the containment building. The monitoring system involves four parts: strain gauges, thermocouples, pendulums and invar wires.

The problem starts with the thermocouples, which monitors the temperature inside the containment building. At present, the thermocouples are not functioning on Unit 1 and accurate temperature values are not discernable.[67] Without such, the strain gauges, pendulums and invar wires cannot be accurately evaluated. Basically, these instruments measure the strain on and the lateral & horizontal displacement of the containment walls, all of which are vital to know what will happen during an accident.[68] Will the containment building handle a rise in pressure?

If the building can't, the consequences could be severe. At Fukushima, the pressure rose higher than the buildings could handle in Units 1, 3 and 4. The pressure led to the release of radioactive gases and hydrogen explosions. At Three Mile Island, the operators had to vent radioactive gases to prevent over-pressurising the containment structure.

66 Eskom, Safety Case, pg. 161

67 International Atomic Energy Agency, SALTO, pg. 61

68 Eskom, Plant Engineering: Life Of Plant Plan: Containment Buildings, KBA 0022 N NEPO LOPP 164 Rev 1, 2017, pg. 9

In terms of Koeberg, the IAEA states that:

> **Some strain gauges of containment dome of unit 1 are partially out of service and the strain gauges of unit 2 are out of service or are providing erratic values…Four pendulums in unit 1 named P2-A, P4-A, P1-B and P3-B show non-realistic behaviour compared to strain gauge evaluations in the same area...one possible cause of the non-realistic behaviour is concrete repairs in this area with the consequence of corrosion effects...these pendulums need to be intrusively examined, refurbished and re-set, which is not completed.**[69]

That Eskom could have let this vital monitoring system deteriorate to such an extent speaks volumes as to its lack of attention to safety. In the Safety Case, Eskom states that it will fix the cables and connectors for Unit 1's thermocouples in Outage 127 and that a "Purchase request is initiated." Outage 127 is slated to start 24 July 2024, after the licence deadline expires, and hopefully it will have actually purchased the parts by then.

The main point is that Koeberg does not have a fully functional containment structure monitoring system, which is mentioned in the following table from the Safety Case:

Moreover, Eskom is going to do something about a vital monitoring system only after the LTO is implemented. But the IAEA says that "The plant should ensure full functionality of the containment structure monitoring system." Presumably that means now and not at some future point. The IAEA also states:

> **The operating organization shall establish surveillance programmes for ensuring compliance with established operational limits and conditions and for detecting and correcting any abnormal condition before it can give rise to significant consequences for safety.**[70]

In the Public Information Document, Eskom states that "The SALTO assessment confirmed that the continued safe operation of Koeberg was supported, including LTO."[71]

Clearly not.

69 International Atomic Energy Agency, SALTO, pg. 61

70 International Atomic Energy Agency, SALTO, pg. 61

71 Eskom, Public Information Document, pg. 3

WHO KNOWS WHICH CABLE GOES WHERE?

Koeberg is suffering from a range of electrical problems: in particular, a cabling mess and electromagnetic compatibility. Some of the threats to safety should have been obvious and it is hard to imagine why Eskom did not address them. For example and even on Eskom's own admission, there's a problem with wetted cables.[72] Eskom states:

> **Of concern is the long-term operation of wetted XLPE-insulated power cables. These cables can develop water trees, and as these water trees progress, they can result in cable failure.**[73]

Nuclear power plants have hundreds of kilometres of cables, which are ubiquitous across safety systems. Cable degradation is a well-known issue for ageing plants, especially in harsh environments where there are high levels of moisture, heat and/or radiation. The cables can be in hard-to-reach areas. In the SALTO, the IAEA states that:

> **Currently the plant has not performed a detailed assessment regarding the use of cable specific qualification standards, represented samples, material specific parameters (e.g. material formulation, validity of activation energy, etc.), installed environment, work condition such as temperature (environmental temperature and self-heating effects), exposure dose rate, etc.…Without a complete revalidation of environmental qualification of cables, the ability to perform their safety functions cannot be demonstrated.**[74]

The above is the basis for the IAEA's Recommendation D-4: The plant should complete the revalidation of environmental qualification for qualified cables. A couple of things seem a bit off with Eskom's response to the issue of cabling. In 2009, Eskom conducted a study that said "large-scale plant cabling and switchboard replacements and refurbishments could be required for LTO."[75]

Eskom started the cable ageing management programme in 2013, which according to the IAEA had not been completely implemented. The IAEA found enough problems to issue a recommendation: i.e. Koeberg was not up to international safety standards. Some of the problems included not being able to identify individual cables, the clumping together of cables as they pass through fire walls, overloaded cable trays, poor illumination in some cable corridors and the addition of a new cable in some places was a complicated task.[76]

72 Eskom, Safety Case, pg. 129

73 Eskom, Safety Case, pg. 129

74 International Atomic Energy Agency, SALTO, pg. 9 & 53

75 Eskom, Safety Case, pg. 125

76 International Atomic Energy Agency, SALTO, pg. 53

But in the Safety Case everything changes. Eskom now argues that ageing cables aren't a big enough deal for the NNR to reject the LTO application.

One of the lesser-known nuclear accidents was at the Browns Ferry nuclear plant (Alabama, USA) in 1975. Due to human error and an unknown design failure, one of the cable trays caught fire, which then damaged the cables involved in the control of Unit 1 and 2. Both units had to enter shutdown quickly and cooled to avoid a meltdown.[77]

The fire damaged approximately 1600 cables of which 628 were related to safety. The accident racked up a total estimated US$300 to 500 million (1976 dollars).[78] That's about US$1.6 to 2.6 billion (R30 to R48bn) in today's money. So cabling is a big deal and the potentially disastrous consequences have been known since at least Browns Ferry.

Eskom does mention an environmental qualification for harsh environments in the Safety Case, including cabling. The first reference is to a manual, Environmental Qualification Maintenance Manual for Equipment Located in Harsh Environments, that isn't provided. A manual is not a plan. The SALTO also refers to this same manual: so we know that it comes from 2021 and that it didn't meet up to the IAEA's standards.[79]

However, it is not clear if Eskom meets the IAEA's recommendation to revalidate completely the environmental qualification of cables. Eskom does mention that it will check a representative sample of cables, but that is only happening in the current Unit 1 outage.[80] Which begs the question why is cable sampling only happening now when Eskom knew from 2009 that there could be a problem? If the cable ageing management programme has been working so well, why did it take a decade to begin testing a sample of the cables? Hopefully, the sampling meets the IAEA's worry that:

> **...a detailed assessment of the represented samples has not [been] considered: material specific parameters (e.g. material formulation, validity of Activation Energy, etc.), installed environment, work condition such as temperature (environmental temperature and self-heating effects), exposure dose rate, etc."**[81]

Electromagnetic compatibility (EMC) is important, particularly for the instrumentation and control of safety features. EMC is the control of systems to prevent electromagnetic interference (EMI), which can negatively impact safety systems. EMI has caused significant problems in nuclear plants before: for example, false dosimeter readings, instrument model failure, reactor scram

77 United States Nuclear Regulatory Commission, Bulletin 75-04A: Cable Fire at Browns Ferry Nuclear Power Station, 3 April 1975, https://www.nrc.gov/reading-rm/doc-collections/gen-comm/bulletins/1975/bl75004a.html

78 Joseph H. Talbert, "Remembering the Browns Ferry fire, 40 years on", Nuclear Engineering International, 22 March 2015, https://www.neimagazine.com/features/featureremembering-the-browns-ferry-fire-40-years-on-4578707/

79 International Atomic Energy Agency, SALTO, pg. 55

80 Eskom, Safety Case, pg. 127

81 International Atomic Energy Agency, SALTO, pg. 53

(emergency shutdown), plant trip and false readings in the control room.[82]

In Suggestion D-3, the IAEA indicates that a complete mapping of EMC needs to be done. Eskom seems to ignore this suggestion. EMI is only mentioned twice in the Safety Case and the only statement of any substance is "Electronic interference is dealt with in the design and operations of the facility as well as the security protocols at Koeberg."[83]

That's not a complete mapping. Eskom simply does not have enough data to make the statement above to prove EMC of equipment associated with safety. The IAEA points out that Eskom knew of this deficiency but in 2015 decided not to do a mapping.[84]

AN EXPIRED SOFTWARE LICENCE AND NO PLAN B

Ageing plants like Koeberg require a proactive approach to obsolescence. The plants and their components were designed to last 40 years and things just plain wear out. Older plants need more repairs and replacement of components. Not just the big ticket items like steam generators but a host of smaller things like valves, pipes, connectors, etc.. Sometimes the original manufacturer of a part no longer exists or has stopped making a particular part.

Being proactive about what's going to need replacing and when and who sells replacements is vital to ensuring a safe life extension. Dealing with obsolescence is not something to be done just for licensing, it is a practice that must happen for another two decades. Yet, the IAEA is concerned about this practice at Koeberg, stating (Suggestion D-5) that there is a "Lack of proactive management of technological obsolescence."[85]

Westinghouse, the designer of Koeberg, has a piece of software that keeps track of the expected lifespan of different components in a nuclear plant. The POMS (Proactive Obsolescence Management System) software has a database of 12 million equipment records and 30,000 vendors, which are contacted every year to check on parts availability. Over 170 nuclear units across the world are members of the POMS network.[86] Of POMS and Koeberg, the IAEA states:

> **The plant previously adopted the POMS as a tool for a proactive approach. The licence of POMS expired, and the plant is in the process of acquiring a new service for the obsolescence management tool. The plant does not have access to any tool to proactively identify obsolescence.**[87]

82 Electric Power Research Institute, Assessment of Electromagnetic Interference Events in Nuclear Power Plants, 2011, pg. 18-38, https://restservice.epri.com/publicdownload/000000000001022984/0/Product

83 Eskom, Safety Case, pg. 73

84 International Atomic Energy Agency, SALTO, pg. 50

85 International Atomic Energy Agency, SALTO, pg. 56

86 Westinghouse, "POMS: Proactive Obsolescence Management System", factsheet,https://www.westinghousenuclear.com/Portals/0/flysheets/DES%20POMS%20Sheet%20050523.pdf?ver=LrVz6cKll5Ae0A3az1mcMA%3D%3D

87 International Atomic Energy Agency, SALTO, pg. 56

Eskom let the licence expire. On a piece of software, run by the very same company that designed Koeberg, that tracks which parts will need replacing and when. A software that has a large database of vendors. And Eskom had no alternative in place. None. Ineffective management flying blind.

The Safety Case makes no mention of either POMS or a similar obsolescence management tool. It does say that Eskom now has an unspecified proactive Technological Obsolescence Programme that it is implementing.[88] What software the programme is using (if any) or any other substantive details about the programme aren't provided.

Problems with software cuts across the IAEA's report. The Condition-Oriented Maintenance SYstem (COMSY) is a Framatome product that is designed for the management of ageing plants and LTO projects. When the IAEA visited Koeberg, it found the COMSY software unavailable due to "technical reasons. As a consequence it was not possible for the team to confirm COMSY's capabilities and real data."[89]

The IAEA pointed out that this and other documentation problems meant that the plant's safety couldn't be determined. Additionally, Koeberg has problems with database management, meaning that Eskom cannot properly assess the impacts of hot wires in the cabling system.[90]

There's a meta-problem for the entire LTO and it involves planning. What happens if the LTO isn't granted? What then? In this scenario, Eskom has two severe problems. The first is a substantial loss of electricity generation, 1.8 GW, equivalent to two stages of loadshedding. The second is that the decommissioning process would need to start if the plant could not be brought back to life at some point in the future. A successful LTO kicks the costs of decommissioning down the road.

One of the alternatives floating around outside of Eskom is that renewable energy power stations equivalent to Koeberg's 1.8 GW could be built nearby, using the plant's connection to feed into the grid. Given that the costs of wind and solar have fallen dramatically and that they don't emit greenhouse gases, the obvious alternative to Koeberg is a compensatory renewable energy build using Koeberg's transmission infrastructure.

However, Eskom has given no indication that it has made or even considered such a plan. Not even as a fallback if the NNR doesn't grant the LTO. For Eskom, it is an LTO or bust.

Nowhere is this more apparent than in the decommissioning strategy. Koeberg Alert, a Cape Town based NGO, was able to use PAIA to force Eskom to release its 2020 decommissioning plan. The document is remarkably sparse and, with entire sections blank, is at the very best a working document of significant generality. Eskom calls it a "'living' strategy document, which

88 Eskom, Safety Case, pg. 120

89 International Atomic Energy Agency, SALTO, pg. 6, 8, 35

90 International Atomic Energy Agency, SALTO, pg. 6, 8, 35

requires periodic reviews and updates in terms of technology, funds, responsibilities and national policies."[91]

What is clear from the available sections is that Eskom is not prepared to decommission the plant in 2024 and the overwhelming assumption is that there will be an LTO extension for both units. The money does not exist for decommissioning: Eskom marks an estimated R16.2bn (US$87m) as a liability on its books and not as ring-fenced funds.[92]

Eskom says the costs would come from its pool of funds, yet its debt is R423 billion (US$23bn).[93] Moreover, Eskom also stated that, as of 2020, "there is no national fund in place for spent fuel management."[94]

There's no Plan B.

PART 4

THE CONDITIONS FOR A SERIOUS ACCIDENT HAVE ARRIVED

Nuclear plants are complex systems. They exist in a matrix of a vast number of physical elements such as steam generators, containment vessels, pipes, valves, gauges, broom closets and so on. There are electrical components such as wires, light bulbs, control panels, switches, computers, software, etc.. Forces are throughout the plant: for example, electromagnetic interference, the flow of water through the cooling system, radioactive decay and air pressure.

91 Eskom, Plant Engineering: Life Of Plant Plan: Containment Buildings, KBA 0022 N NEPO LOPP 164 Rev 1, 2017, pg. 36

92 Chris Yelland, "SA taxpayers exposed to nuclear waste disposal and decommissioning liabilities", ESI Africa, 22 February 2021, https://www.esi-africa.com/industry-sectors/generation/sa-taxpayers-exposed-to-nuclear-waste-disposal-and-decommissioning-liabilities/

93 Ray Mahlaka, "Government's debt relief for Eskom gives power utility some breathing space", Daily Maverick, 24 August 2023, https://www.dailymaverick.co.za/article/2023-08-24-governments-debt-relief-for-eskom-gives-power-utility-some-breathing-space/

94 Eskom, Plant Engineering: Life Of Plant Plan: Containment Buildings, KBA 0022 N NEPO LOPP 164 Rev 1, 2017, pg. 18, 34

And then there is the inherently unstable nuclear reaction at the heart of it all. The main operation of the plant is to control the chain reaction: how to start the reaction, keep it going safely and how to shut it down. That's what the control rods and cooling systems are for. If the reaction goes too fast, gets out of control, it can run away and then you are in the territory of explosions, meltdowns and the catastrophic releases of radiation. Basically, you are hanging onto the tiger's tail and can't ever let go.

The components, structures, forces and the reaction interact with each other to one degree or another. A nuclear plant is a vast high-risk interlocking system and a disturbance in one of its multitude of parts could lead to a cascading set of disturbances throughout the plant. The whole point of the safety sub-systems is to prevent a disturbance cascading into a serious accident. However, safety mechanisms can and have failed. In the 2006 'loose bolt' accident at Koeberg, the safety alarm system failed, contributing to the severe damage to the generator.

The physical attributes of a plant do not exist in a vacuum. A nuclear plant is also connected to the physical environment: for example, earthquakes, freak storms, tsunamis, droughts and corrosive sea water. Jellyfish are a particular problem for Koeberg. A bloom of jellyfish clogged up the plant's seawater intake system in 2005. This unexpected disturbance caused a 40% reduction in power output.[95] The problem returned in 2020 with such force that Unit 1 tripped and was offline for days.[96]

A plant's staff, operators and management are another sub-system interconnected with the plant. Humans can and do err and their actions are part of the unfortunate series of events leading up to an accident. The human element doesn't stop at Koeberg's gates: Eskom, the government, the NNR, the economy and broader society all impact upon Koeberg. Disturbances at Eskom in general can impact the plant.

Because of these interlocking actions, the smallest unforeseen event can set off a series of events that leads to a very serious situation. At the North Anna plant (Virginia, USA) in 1980 a worker got his shirt stuck in a breaker whilst cleaning a floor. He ripped the shirt free and unknowingly activated the breaker, shutting off the current to the control rod mechanism. The reactor went into automatic shutdown. No one had designed the plant with a stuck shirt in mind.[97]

Another accident starting from the trivial occurred at the Rancho Secco I reactor (California, USA) in 1978. A worker was changing a light bulb in a control panel. When he accidentally dropped the bulb, it caused a short circuit in some sensors and controls. The reactor scrammed but because some of the sensors weren't working the operators didn't know what was happening with the core, which was rapidly cooling. This dangerous situation put intense pressure on the

95 Staff reporter, "Jellyfish plague hobbles Koeberg", IOL, 11 May 2005, https://www.iol.co.za/news/south-africa/jellyfish-plague-hobbles-koeberg-240851

96 Paul Burkhardt, "Koeberg revamp enters critical stage as power cuts ravage economy", Bloomberg, 11 January 2023, https://www.businesslive.co.za/bloomberg/news/2023-01-11-koeberg-revamp-enters-critical-stage-as-power-cuts-ravage-economy/

97 Charles Parrow, Normal Accidents, pg. 43

reactor vessel walls. Luckily, it was a new reactor and the core wasn't damaged. A U.S. Nuclear Regulatory Commission official later pointed out that an older vessel could have cracked. If the vessel had cracked, there would have been loss of coolant and a meltdown.[98]

Eskom has managed to put itself in a situation where the likelihood of an accident has increased. There are accidents that require a reactor to be taken offline for repairs. Enough of these accidents, the LTO becomes pointless. Koeberg won't generate electricity reliably and cause loadshedding. As Koeberg needs to produce power to generate revenue, the plant becomes a major financial drag. Expensive repairs will be required. And each 'minor' accident has the potential to develop into a major one.

Major accidents cause the permanent or long-term closure of the plant. For example, the new steam generators could fail. Mitsubishi installed two new steam generators at the San Onofre plant (California, USA) in 2010 and 2011 as part of an LTO. Because the generators broke down due to a design flaw, 11 months after installation, San Onofre had to be permanently shut down. A complete financial disaster.

A partial or complete meltdown would be catastrophic, to say the least. If the containment vessel is breached, the cataclysm would drag down not just the Western Cape but the entire country. Given the state of South Africa's economy and infrastructure, it is hard to see how we could cope. Japan is one of the wealthiest nations on the planet, highly industrialised and doesn't suffer from South Africa's social and governance problems. Even so, it is still struggling to deal with the ongoing consequences of Fukushima.

The last president of the USSR, Mikhail Gorbachev, wrote in 2006 that:

> **The nuclear meltdown at Chernobyl this month 20 years ago, even more than my launch of perestroika, was perhaps the real cause of the collapse of the Soviet Union five years later. Indeed, the Chernobyl catastrophe was an historic turning point: there was the era before the disaster, and there is the very different era that has followed.**[99]

Koeberg has several concerning weaknesses. There are significant problems with the physical state of the plant. A great deal of repairs, modifications and improvements are required and the Safety Case doesn't provide much confidence.

There is also a human resources crisis. An estimated 250 to 300 skilled employees left Koeberg between 2021 to 2022 and, although an exact figure is difficult to obtain, Koeberg employs about 1800 people. After 27 years at Eskom, the chief nuclear officer, Riedewaan Bakardien, left last year for a job at a Canadian power company. In 2016, Bakardien was temporarily suspended along with another senior Eskom employee for questioning the LTO's viability. The skills exodus

98 Charles Parrow, Normal Accidents, pg. 45

99 Mikhail Gorbachev, "Turning point at Chernobyl", Daily Times, 17 April 2006, https://www.gorby.ru/en/presscenter/publication/show_25057/

prompted the chief operating officer, Jan Oberholzer, to state that it was a risk to the LTO.[100] [101]

Jan Oberholzer retired in April 2023 and then was brought back on a short-term contract to oversee the LTO. He tendered his resignation in mid-July. Eskom is now on its 14th chief executive officer in ten years. The last CEO to retire was Andrè de Ruyter. In December 2022, the mineral resources & energy minister Gwede Mantashe accused him of high treason and then there was an attempt on his life: someone put cyanide in his coffee at Eskom's headquarters. De Ruyter resigned between those two bizarre events. Another five high-level resignations occurred in 2022 and Eskom's board was restructured yet again. From 2010 to 2023, Eskom has had seven chairmen of the board.[102] [103] [104]

On 8 December 2023, Eskom finally managed to appoint de Ruyter's replacement. Dan Marokane will start work no later than 31 March 2024.[105]

With allegations of entrenched corruption, an inability to generate enough electricity, a fleet of old and unreliable coal-fired power stations, a lack of grid capacity and ever worsening finances haunting it, Eskom is a deeply troubled and secretive organisation in an ongoing crisis that began with the 2005 'loose bolt' accident at Koeberg and which has no foreseeable end.

The relationship between Framatome and Eskom has deteriorated. They have over 100 contractual disputes: for example and in 2022, the Constitutional Court upheld Framatome's R650m (US$35m) claim against Eskom. This is in addition to the R950m (US$51m) fine for not building storage facilities for the old steam generators.[106]

On top of these problems, Koeberg and Eskom are under intense political pressure. Both the national and the provincial Western Cape governments have issued statements about the need for the LTO to speed up, to make the July 2024 deadline. Without Koeberg's power, loadshedding will be even worse than it is. Jacques Morisset and Mariano Salto, senior World Bank economists, estimated that loadshedding cost the economy R411bn (US$24bn) last year.[107]

---

100 Sasha Planting, "Koeberg's skills exodus puts extension-of-life project further on the back foot", Daily Maverick, 11 July 2022, https://www.dailymaverick.co.za/article/2022-07-11-koebergs-skills-exodus-puts-extension-of-life-project-further-on-the-back-foot/

101 World Nuclear News, "Study outlines current and future role for Koeberg", 31 March 2017, https://www.world-nuclear-news.org/Articles/Study-outlines-current-and-future-role-for-Koeberg

102 Nicole Fritz, "Who would put up their hand to lead when their life could be in danger?", Business Day, 12 January 2023, https://www.businesslive.co.za/bd/opinion/columnists/2023-01-12-nicole-fritz-who-would-put-up-their-hand-to-lead-when-their-life-could-be-in-danger/

103 Denene Erasmus, "Pressure is unbearable, says generation boss Mathebula as he quits Eskom", Business Day, 15 November 2022, https://www.businesslive.co.za/bd/national/2022-11-15-pressure-is-unbearable-says-generation-boss-mathebula-as-he-quits-eskom/

104 Eskom, "Eskom Leadership", 2023, https://www.eskom.co.za/heritage/museum/gallery/previous-eskom-leadership/

105 Denene Erasmus, "Dan Marokane appointed as Eskom CEO", Business Day, 8 December 2023, https://www.businesslive.co.za/bd/national/2023-12-08-dan-marokane-appointed-as-eskom-ceo/

106 Luke Fraser, "Eskom hit with nearly R1 billion fine", Business Tech, 2 April 2023, https://businesstech.co.za/news/energy/677283/eskom-hit-with-nearly-r1-billion-fine/

107 Jacques Morisset and Mariano Salto, "This is why climate sceptics should support a just energy transition", Business Day, 25 November 2022, https://www.businesslive.co.za/bd/opinion/2022-11-25-world-bank-this-is-why-climate-sceptics-should-support-a-just-energy-transition/

South Africa's next national election is in 2024 and it is a toss-up whether the ruling African National Congress (ANC) will get 50%. An unsuccessful or delayed LTO and the resultant loadshedding will not help the ANC's electoral fortunes: the sooner both Koeberg's units are connected the better.

A plant with serious safety issues, human resources crises at both Eskom and Koeberg, intense political and economic pressure, a culture of secrecy, no Plan B, a desperate need for generation. That's the confluence of factors that define the LTO and the making of an accident. A series of minor accidents will make Koeberg a financial drag and will cause loadshedding, which are the outcomes the LTO is supposed to prevent. A major accident will force the closure of the plant and the start of the expensive and unprepared for decommissioning process. Partial or complete meltdown would be catastrophic even if the containment structure holds.

What will the National Nuclear Regulator do? If it rejects Eskom's application, there will be financial consequences for the country. There will also be financial consequences for the NNR itself: 76% of its funding comes from authorisation fees.[108] If Koeberg doesn't get the LTO licence from the NNR, the regulator goes broke.

Given the current political and economic circumstances, the NNR is also under pressure and the question is how independent is the NNR. Can it make a reasoned independent decision?

The IAEA assessed the NNR in its 2013 *Mission Report On The Integrated Nuclear Infrastructure Review* (INIR) and made recommendations. In the IAEA's opinion, the NNR is not sufficiently independent from national government and the laws the NNR operates under need to be changed. The IAEA states:

> **Considering that the Minister of Energy is also in charge of the promotion of nuclear energy and, given the structure, the designation of the Board members and the process to approve the NNR's budget, the INIR team is of the view that there is no adequate separation between the regulatory functions and the promotional activities, thus calling into question the effective independence of the NNR.**[109]

On this point, the National Nuclear Regulator Act 1999, Act 47 of 1999, and Regulations states:

> **If the Minister [of the Ministry of Mineral Resources and Energy] and the board fail to resolve their disagreement, the Minister makes the final decision, in consultation with the relevant Minister.**[110]

108 National Nuclear Regulator, Annual Report 2020/21, pg. 42, https://nnr.co.za/wp-content/uploads/2023/01/NNR_Annual-Report_2021-Final.pdf

109 IAEA, Mission Report On The Integrated Nuclear Infrastructure Review (INIR), 2013, pg. 32, https://www.iaea.org/sites/default/files/documents/review-missions/inir-report-south-africa-080213.pdf

110 Republic of South Africa, National Nuclear Regulator Act 1999, Act 47 of 1999, and Regulations, Part 49 (2), https://nnr.co.za/wp-content/uploads/2018/07/NNR-ARISTA-disc-clich%C3%A9_3_PRINT.pdf

While the National Nuclear Regulator Act is currently in parliament to be amended, the changes will not increase the regulator's independence. In fact, the regulator will be even more beholden to the ministry.

In February 2022, the minister for mineral resources and energy, Gwede Mantashe, removed civil society's representative on the NNR's board. Peter Becker of Koeberg Alert Alliance was removed, according to Mantashe, because "If you resist nuclear and you [are] a board member, I fire you, simple." In May 2023, the Western Cape High Court upheld its January 2023 ruling that the firing of Becker was "unlawful, unconstitutional and invalid".[111]

Becker is an opponent of Koeberg's LTO.

PART 5

PLAYING AROUND WITH NUCLEAR FIRE

Koeberg has done its job. For almost four decades, the plant has provided electricity without a major accident. The capital costs have been paid off. We could safely shut down the plant and avoid the risk of a major accident. Instead and as shown above, Eskom is committed to an LTO in a plant with serious concerns.

At this juncture, the only way we can have any confidence in the LTO is if the IAEA returns to do an in-depth inspection well before the July 2024 deadline. Unless there has been a dramatic improvement within the plant and at Eskom, the Koeberg nuclear power station should be either decommissioned or put into a cold shutdown.

A partial or complete meltdown happens about once a decade. Koeberg could be this decade's.

111 Victoria O'Regan, "Court castigates Gwede Mantashe on axing of anti-nuclear activist, denies leave to appeal", Daily Maverick, 28 May 2023, https://www.dailymaverick.co.za/article/2023-05-28-court-castigates-gwede-mantashe-on-axing-of-anti-nuclear-activist-denies-leave-to-appeal/

ACKNOWLEDGEMENTS

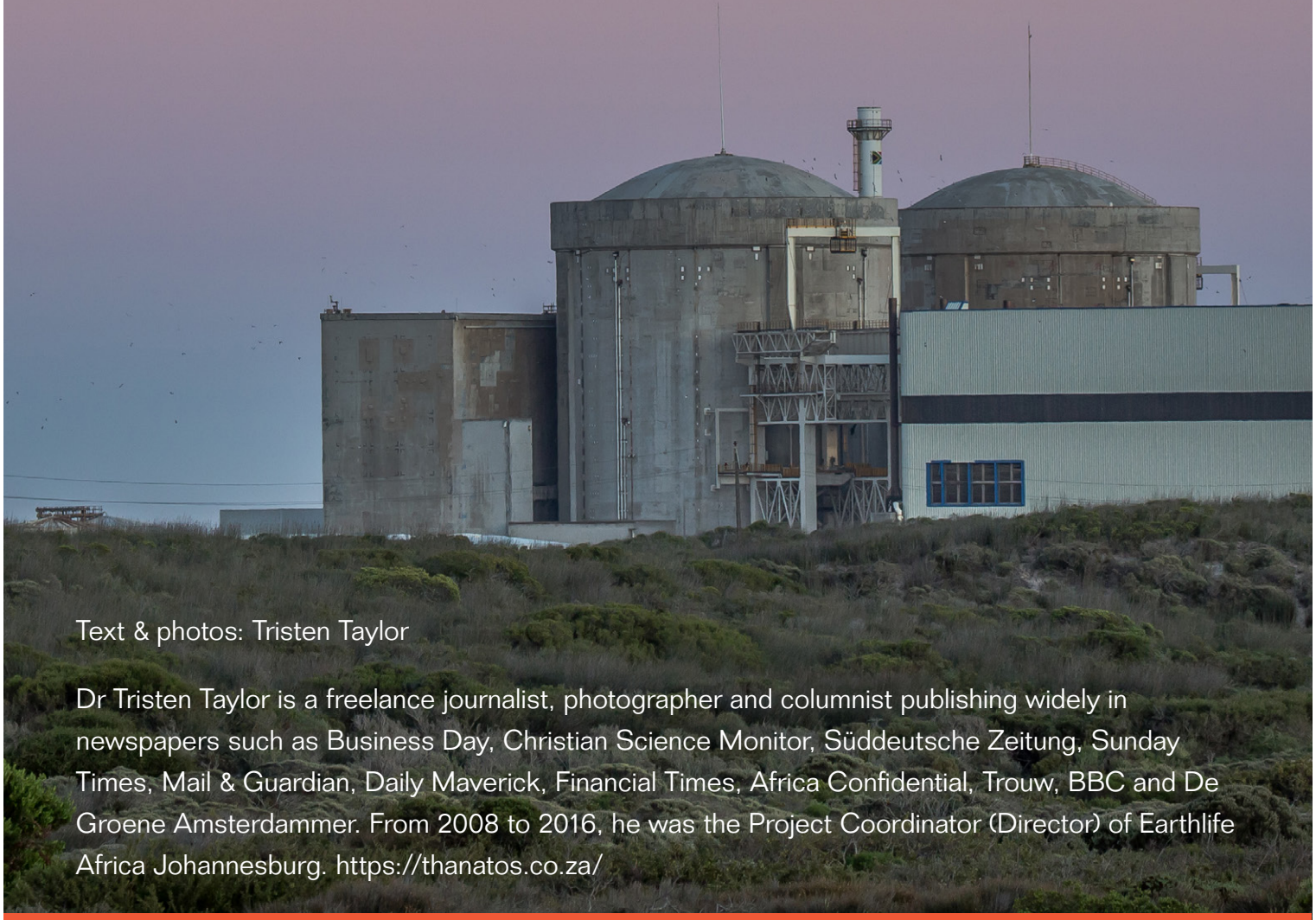
Many thanks to the following for reviewing this paper. Any errors are solely my responsibility and not theirs.

Dr Gerhard Heiligenthal, nuclear physicist and expert on nuclear safety

Roland Ngam, Rosa Luxemburg Foundation

Professor Steve Thomas, emeritus professor of Energy Policy, University of Greenwich

Dr. Hartmut Winkler, Department of Physics, University of Johannesburg



Text & photos: Tristen Taylor

Dr Tristen Taylor is a freelance journalist, photographer and columnist publishing widely in newspapers such as Business Day, Christian Science Monitor, Süddeutsche Zeitung, Sunday Times, Mail & Guardian, Daily Maverick, Financial Times, Africa Confidential, Trouw, BBC and De Groene Amsterdammer. From 2008 to 2016, he was the Project Coordinator (Director) of Earthlife Africa Johannesburg. https://thanatos.co.za/

ROSA LUXEMBURG STIFTUNG
JOHANNESBURG
237 Jan Smuts Avenue | Parktown North 2193
P O Box 3156 | Parklands 2121
Telephone: +27 (0) 11 447 5222/5224 | E-mail: info@rosalux.co.za | Website: www.rosalux.co.za