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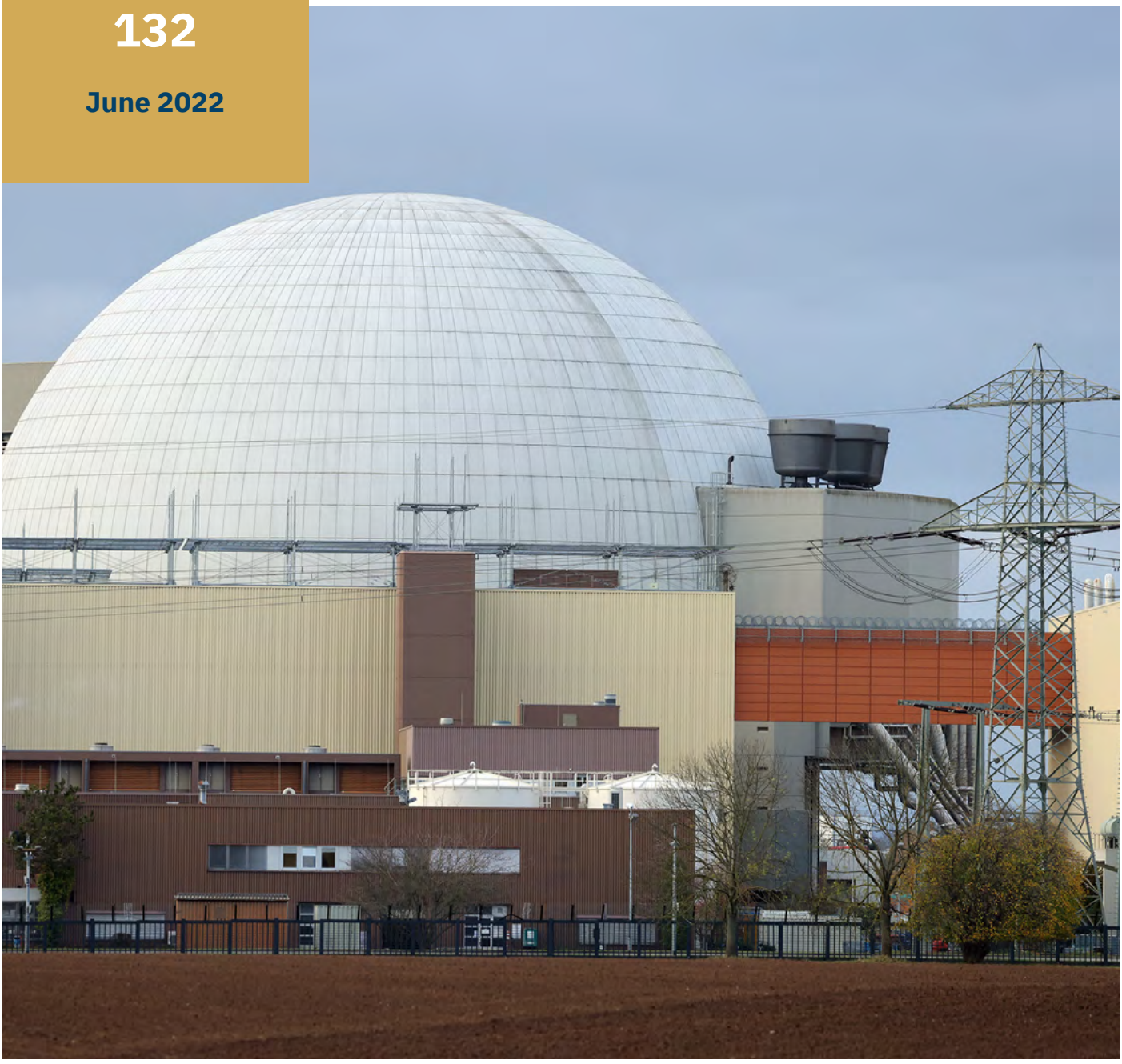

Access to Tech Finance for the Peaceful Application of Nuclear Technology in Africa

DANAE GOVENDER, THABELO MULEYA & ANNA NGARACHU

African perspectives
Global insights

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Executive summary

Nuclear energy can support the development objectives enshrined in the UN's Sustainable Development Goals and the AU's Agenda 2063, and can bolster African countries' energy mix. This policy insight reviews the availability of funding from multinational sources to support the nuclear ambitions of African countries. These ambitions include the peaceful application of nuclear technology such as nuclear scientific training for developmental purposes and nuclear techniques in medicine. It also examines whether nuclear is the most appropriate option for Africa, bearing in mind the cost of the technology and countries' regulatory framework capacity. While there have been advances in medical techniques using nuclear technology on the continent, there may be an incentive for African governments and even the private sector to leapfrog into investing in extensive and cost-effective renewable energy instead.

Introduction: Climate challenge rehabilitates nuclear power's image

Technology finance relates to the demand for and availability of funding for technological innovation, research and development, technological invention and development, and technological business.[1] Aggressive international targets to lower global carbon emissions have brought the harnessing of renewable energy to the fore. The major renewable energy sources are hydro, nuclear and geothermal. As countries seek to reduce the use of fossil fuels, reliance on these renewable energy sources is set to increase.

Huge strides in the efficiency and cost-effectiveness of wind and solar renewable technologies, together with some progress in battery technology, have enabled countries to include new solar and wind builds in their energy mix. However, the inherently intermittent nature of both technologies, coupled with residual energy-storage challenges, limits reliance on these sources. Volcanic areas (such as Iceland) can make good use of geothermal energy, but not many countries have access to abundant geothermal sources. In Africa, geothermal energy production is occurring along the Rift Valley.

Hydro energy has been a major energy source around the globe, but many high-potential dam sites have already been used, and environmental and social challenges make a rapid increase in hydroelectricity problematic. Some countries are therefore considering the use of nuclear energy, particularly since the development of promising new technologies translates into smaller nuclear facilities. As of 10 March 2022, 18 countries had a total of

1 Kis Soon Lee and Hyung Seok Lee, "The Activation of Technology Finance through Support for Small and Medium-Sized Enterprises in Korea", *International Journal of Business and Management* 5, no. 4 (April 2010).

52 new nuclear power plants under construction or were planning to add to (or, in some cases, replace) the 440 currently in service.[2]

In Africa, only South Africa has a nuclear power facility (the Koeberg nuclear power station), with Egypt's El Dabaa nuclear power plant site receiving approval in 2019. At the time of writing, Egypt was awaiting international permission to begin the construction of El Dabaa in the second half of 2022.[3] Owing to repeated droughts interrupting its hydropower supply, Ghana has also turned to nuclear energy and looks set to start operating a nuclear power plant by 2030.[4]

The 2021 COP26 in Glasgow highlighted the resurgence of interest in nuclear power in many quarters.[5] However, nuclear power remains highly controversial and, while it can be an important contributor to a state's energy mix, many challenges remain. Although new technologies allow for smaller, speedily built small modular reactors (SMRs), with some currently under construction, none has yet actually entered service. The size of these reactors makes them faster to construct and their modular nature makes them easily scalable. SMRs and other new technologies under construction are presently being followed with great interest to see if the reality matches the potential. However, in an industry where construction costs are relatively high and in a world plagued by the impacts of the COVID-19 pandemic, the financial viability of these new technologies in Africa (while better than that of traditional plants) remains unproven.[6]

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Nuclear installations of all forms face huge public relations challenges in the wake of the Chernobyl and Fukushima disasters.[7] In 2019 the Environmental Rights Action/Friends of the Earth Nigeria warned the Nigerian government against building nuclear power plants because of safety concerns after the Arkhangelsk-region explosion in Russia.[8] Financing is another challenge – even the smaller new-generation plants have a huge price tag.

2 International Atomic Energy Agency, Power Reactor Information System, "Under Construction Reactors", January 11, 2022.
3 Nadim Kawach, "Egypt to Begin Construction of Nuclear Plant in 2022", *ZAWYA*, January 3, 2022.
4 Isabel Bosman, "Is Nuclear Part of the Answer to sub-Saharan Africa's Electricity Shortage?", *Engineering News*, July 21, 2021.
5 Emma Derr, "COP26: Nuclear Plays a Central Role", Nuclear Energy Institute (blog), November 16, 2021
6 Marton Dunai and Geert De Clercq, "Nuclear Energy Too Slow, Too Expensive to Save Climate: Report", *Reuters*, September 24, 2019
7 "Fukushima Disaster: What Happened at the Nuclear Plant?", *BBC News*, March 10, 2021.
8 Premium Times, "Nigeria: Environmental Rights Action Warns Govt. on Decision to Build Nuclear Power Plants Citing Safety Concerns", *Business & Human Rights Resource Centre*, August 20, 2019.

Many of the usual infrastructure-finance facilities are prohibited from investing in nuclear technologies, leaving buyers to rely on vendor finance that is tied to the selected seller and generally supplied by the seller's national government. The resulting government-to-government financing deals are often problematic, owing to a lack of transparency and geo-political implications.

Finally, in countries that lack an advanced scientific tradition and have yet to develop tested protocols for the management of nuclear facilities, the development of the necessary regulatory environment can prove challenging. However, given the value of nuclear resources for medical, research and industrial purposes, many more states are considering the technology. At the same time, a country's nuclear ambitions can remain stillborn in the absence of transparent and cost-effective financing.

Nuclear: The most appropriate option for Africa?

Despite all-year-round access to sun and wind in most African countries, renewable energy is still insufficient for the continent's needs. Yet there are strong arguments for investing in the development of storage for renewable energy rather than nuclear technology. The falling costs of renewable technology,[9] as well as its climate-mitigating effects, make this an important option to include in an energy mix.

> Nuclear applications have a developmental impact in areas such as agriculture, food security, water resource management, environmental sustainability and human health

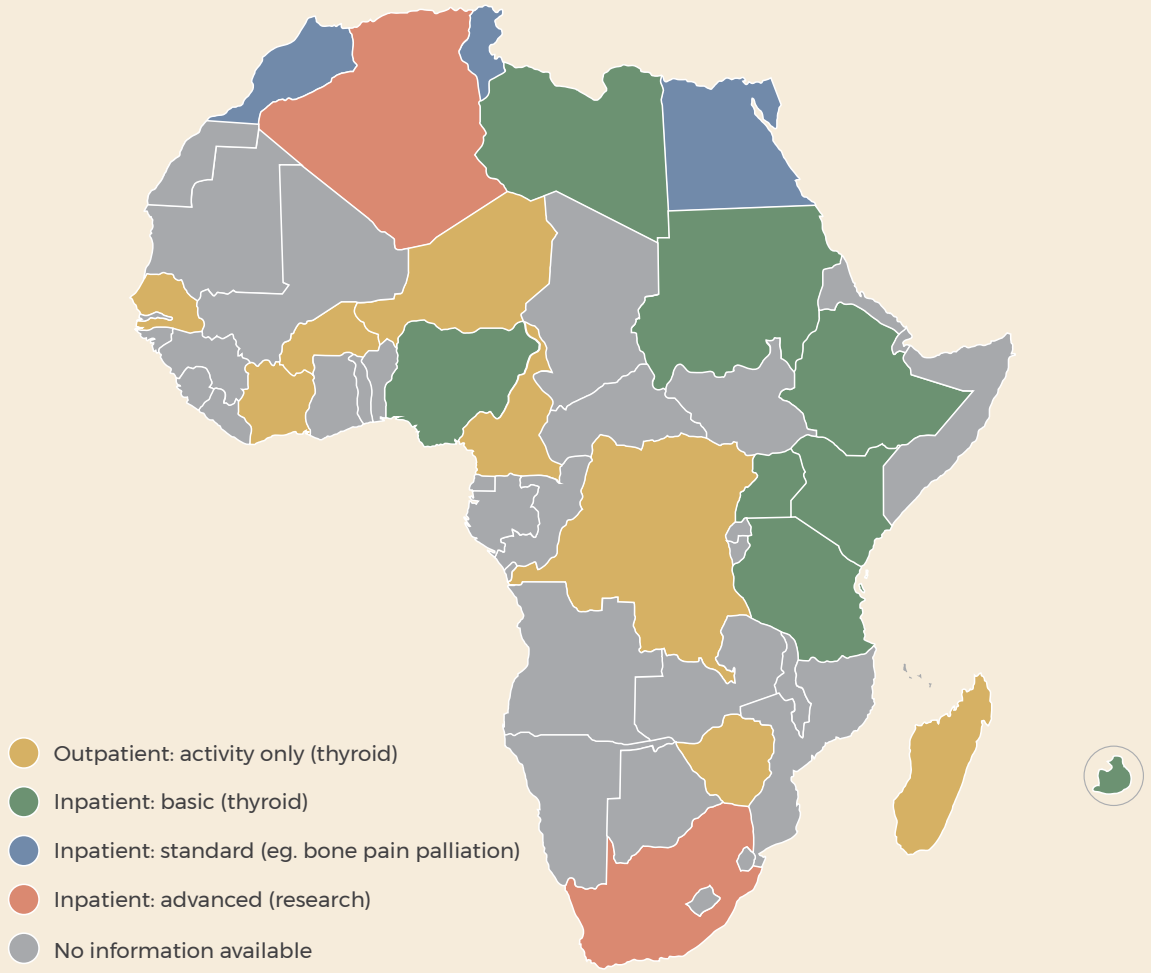
Nonetheless, scientific bragging rights as well as the peaceful applications of nuclear technology add to nuclear's attraction. Nuclear applications have a developmental impact in areas such as agriculture, food security, water resource management, environmental sustainability and human health – all areas in Africa that need bolstering for development.

There has also been increased implementation of nuclear techniques in the medical field. This is linked to the bilateral projects in nuclear medicine established between the International Atomic Energy Agency (IAEA) and some African countries during the 1980s

9 Victoria Masterson, "Renewables Were the World's Cheapest Source of Energy in 2020, New Report Shows", World Economic Forum, July 5, 2021.

and 1990s. A total of 21 African countries are already practising nuclear medicine therapies, while 13 have facilities for inpatients and eight treat outpatients only. Most facilities for radiation therapy on the continent are concentrated in North African countries and South Africa.[10] Radiation and nuclear techniques in medicine have brought about development benefits in developed and developing countries – radiation therapy for oncology patients, for example, contributes directly to UN Sustainable Development Goal (SDG) 3 (good health and wellbeing).[11]

Figure 1 Nuclear medicine therapy activity in Africa



Source: A Grigoryan et al., "Development of Nuclear Medicine in Africa", *Clinical and Translational Imaging* 10 (2021)

10 A Grigoryan et al., "Development of Nuclear Medicine in Africa", *Clinical and Translational Imaging* 10 (2021).

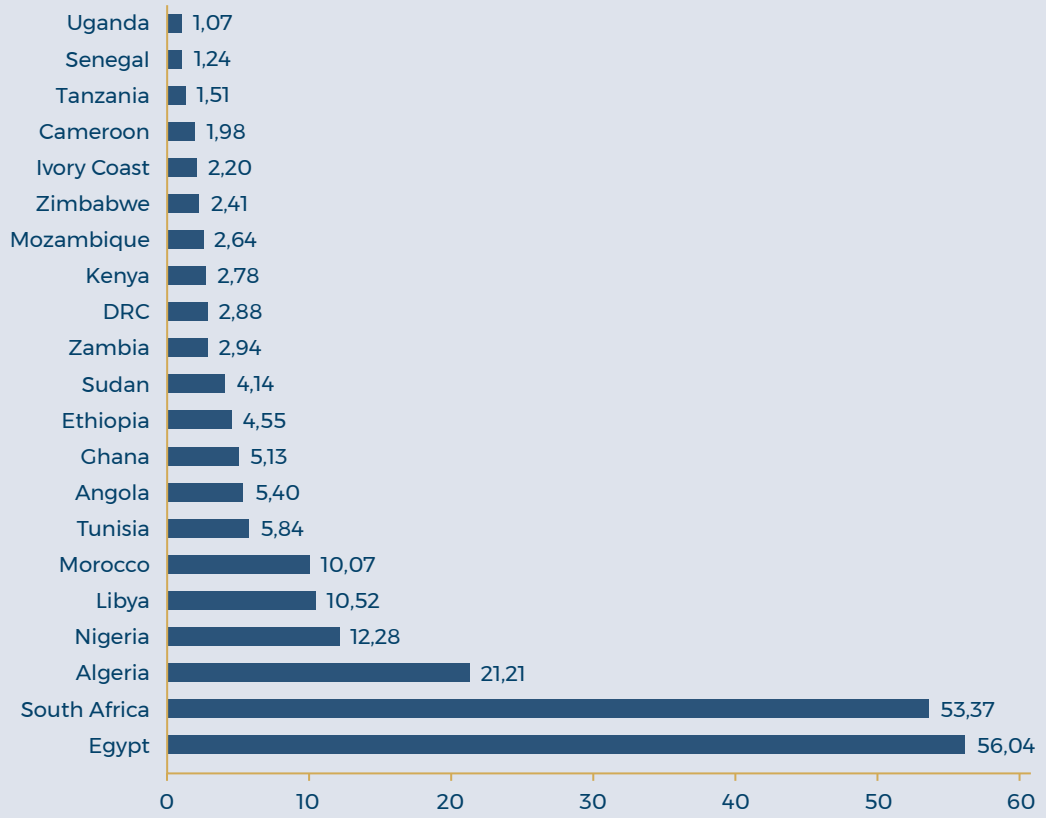
11 Noel Stott and Isabel Bosman, "Nuclear Science and Technology: Driving Africa's Development" (Policy Insight 109, South African Institute of International Affairs, Johannesburg, 2021).

Energy needs in Africa

Figure 2 shows the electricity production capacity of the 21 largest producers in Africa. The total production capacity of the countries listed was 210.2 million kW in 2018.[12] While most of North Africa has access to electricity, sub-Saharan Africa lags behind – approximately 52% of its population lacks access.[13]

As populations and industrialisation are likely to grow proportionally, it is imperative that developing countries secure stable electricity supplies. With the phasing out of carbon-intensive modes of electricity production, one option that is growing in popularity in Africa – despite its current miniscule continental footprint – is nuclear energy. But this option is costly and requires external funding.

Figure 2 Electricity production capacity of the top African producers, 2018 (million kilowatts)



Source: The GlobalEconomy.com, "Electricity production capacity in Africa", https://www.theglobaleconomy.com/rankings/electricity_production_capacity/Africa/

12 The GlobalEconomy.com, "Electricity Production Capacity in Africa", https://www.theglobaleconomy.com/rankings/electricity_production_capacity/Africa/.

13 International Energy Administration, "Access to Electricity", https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity.

Financing nuclear energy projects in Africa

African countries have significant potential solar and wind energy, and extensive oil and gas reserves. This makes it difficult to justify expensive nuclear build projects rather than more extensive and cost-effective investments in solar and wind renewable energy, possibly coupled with efficient gas-fired peaking facilities and energy storage. However, in some countries the construction of nuclear plants may be justified, particularly in areas without reliable access to solar, wind or gas facilities.

Countries such as the UK that already rely on nuclear energy have set up a regulated-asset-based (RAB) model for infrastructure projects. By paying construction companies during the construction of new power plants, the RAB model is said to reduce development risk and secure low-cost financing for such projects. However, consumers contribute to the cost during the construction phase in the short term, in the hope of a reduction in prices in the long term.[14]

This may not be particularly relevant for African countries, which do not have the leeway to increase electricity prices to fund such activities while most of the population still lacks access to electricity. Comparatively, the cost of nuclear is higher (see Table 1), and Africa has the opportunity to leapfrog into more efficient and accessible forms of energy rather than investing in models such as the RAB.

> While nuclear energy may thus be justified in densely populated, sun-free and still environments, it is difficult to see how it can be justified as a major source of energy in Africa

The costs of various forms of energy vary significantly, depending on the precise location, design, capacity and other characteristics of each facility. As outlined in Table 1, the 2021 annual World Nuclear Industry Status Report (WNISR) estimates that solar power generation costs per megawatt hour (MWh) are between $36 and $44, onshore wind power between $29 and $56, and nuclear energy generation between $112 and $189.[15] According to these estimates, nuclear power costs between three and five times as much as renewable energy from solar or wind sources.

14 "UK Adopts Nuclear Energy Finance Plan", *Nuclear Engineering International*, October 29, 2021.

15 Mycle Schneider et al., The World Nuclear Industry Status Report 2021 (Paris: A Mycle Schneider Consulting Project, 2021); World Nuclear Report, Dunai and De Clercq, "Nuclear Energy Too Slow".

While nuclear energy may therefore be justified in densely populated, sun-free and still environments, it is difficult to see how it can be justified as a major source of energy in Africa, particularly given the continent's abundant gas and oil resources. There is also a global move towards renewables that is regarded as a continuum or green transition, particularly in Africa: from fossil fuels (coal and oil) to natural gas (an allegedly cleaner fossil fuel) and then renewables.

TABLE 1 ENERGY SOURCE COST

Energy source	Cost per MWh
Solar power	$36–44
Onshore wind power	$29–56
Nuclear energy	$112–189
Gas peaking	$151–196
Coal	$65–152
Gas combined cycle	$45–74

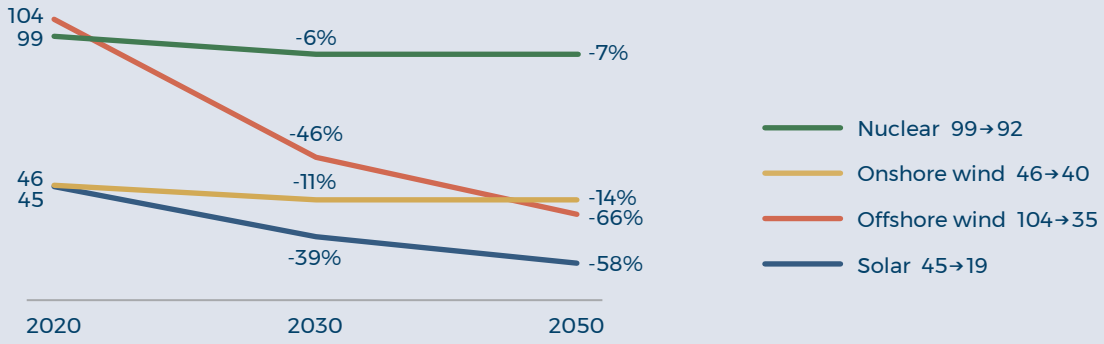
Sources: Mycle Schneider et al., *The World Nuclear Industry Status Report 2021* (Paris: A Mycle Schneider Consulting Project, 2021); Lazard, *Lazard's Levelized Cost of Energy Analysis–Version 15.0* (New York: Lazard, 2021)

The bulk of nuclear power costs are incurred during the set-up phase, and actual running costs are relatively low. However, it is unlikely that the costs of nuclear power will reduce significantly any time soon

The bulk of nuclear power costs are incurred during the set-up phase, and actual running costs are relatively low. However, it is unlikely that the costs of nuclear power will reduce significantly any time soon. Consider the levelised costs (construction and operating costs vs the total electricity a plant produces in its lifetime) for several renewable energy sources, compared with that of nuclear. According to the WNISR, levelised costs have decreased by 88% for solar and 69% for wind in the past decade. In contrast, levelised costs for nuclear have increased by 23%. And although the world's nuclear operating capacity has increased since 2018, nuclear is unlikely to take up a major share of global gross power generation.[16] Perhaps a clear argument is to see how the average cost of nuclear is forecast to change in the coming years, compared to other sources of energy (see Figure 3).

16 Dunai and De Clercq, 'Nuclear Energy Too Slow".

Figure 3 Forecasted average cost of electricity from nuclear and renewables, 2050 ($/MWh)



Source: Schneider et al., *The World Nuclear Industry Status Report*

Financing options and investors for nuclear development in Africa

While the costs of commissioning nuclear power plants are, on average, relatively higher than that of other forms of clean energy sources, entities across the globe (including governments) have worked to reduce commissioning costs or have made funding available for nuclear activities.[17]

According to the World Nuclear Association, nuclear build projects can be publicly or privately financed.[18] The former is the most popular and involves direct funding from government through a combination of equity and debt, as it most often both owns the utility and is closely involved in its operation. Private companies, most commonly large utilities, can fund these projects in a similar way and rely on credit arrangements with lenders, often carrying the full risk of such projects.[19]

The Nuclear Industry Association of South Africa identified six potential options for financing new nuclear power plants, through[20]

> either state funding for the entire project or with state-backed loan guarantees and using reserves and cash flows from state-owned companies; an intergovernmental

17 UK Government, "New Finance Model to Cut the Cost of New Nuclear Power Stations", October 26, 2021; Paul Day, "Nuclear Financing Remains a Major Hurdle for New Plants", *Reuters Events*, February 9, 2021.
18 World Nuclear Association, "Financing Nuclear Energy", October 2020.
19 WNA, "Financing Nuclear Energy".
20 World Nuclear News, "NIASA Sets Out Funding Options for South African New Build", May 18, 2020.

> loan; corporate financing; financing by the plant vendor; project financing using a special investment vehicle; and 'build-own-operate'.

Project financing for infrastructure in Africa comes from public sources, private markets, international development finance institutions (DFIs) and international donors. International donors can provide finance through their aid agencies or, frequently, through their export credit facilities. These facilities provide concessional funding to finance national exports, including the construction of infrastructure projects abroad. To understand these financing opportunities, this policy insight reviews the policies of DFIs from the Global North and South, including the World Bank Group, the African Development Bank (AfDB), and the New Development Bank (NDB, formerly the BRICS Bank).

While the climate crisis has led to a change in sentiment towards nuclear, this has not yet permeated to global funding circles

While the climate crisis has led to a change in sentiment towards nuclear, this has not yet permeated to global funding circles. The World Bank Group does not have a strong interest in nuclear.[21] In addition, when approached, the AfDB confirmed that its policy of not investing in nuclear development, first affirmed in 2011, has not changed.[22] According to the manager of its energy and infrastructure division,[23]

> [t]he AfDB does not fund nuclear energy projects. We have the following brief section in our energy policy, '2.3.6. Nuclear energy: The financing of nuclear plants is not an area of comparative advantage for the Bank. Accordingly, the Bank will not provide financing for these types of plants.'

Similarly, the Development Bank of Southern Africa (DBSA) declared, in its 2021 *DBSA Green Bond Framework*, that proceeds from its green bonds would not be used to finance infrastructure projects that demonstrate risk to society and the environment, where those risks are clear and substantive and cannot be mitigated.[24] Among these projects are those that are carbon intensive, involve high-risk hydropower schemes and/or are of a nuclear nature.[25]

21 William Deo, *Can Nuclear Hit Its Stride in Africa? Power to the People: Evaluating Nuclear as a Bridge to Sustainable Energy in Africa* (Philadelphia: Kleinman Center for Energy Policy, University of Pennsylvania, 2020).
22 Farai Kanonda (AfDB Manager, Energy and Infrastructure), personal communication, November 2021.
23 Kanonda, personal communication.
24 Development Bank of Southern Africa, *DBSA Green Bond Framework* (Midrand: DBSA, 2021).
25 DBSA, DBSA Green Bond Framework.

Regarding the NDB, the 2016 publication titled *Environment and Social Framework* does not specifically include nuclear projects in the 'Environmental and Social Exclusion List' – projects that the NDB does not knowingly support.[26] However, the NDB has not yet financed any nuclear power projects, and the 2020 publication *Sustainable Financing Policy Framework* states that proceeds from the sale of sustainability bonds will not be used to finance the processing of nuclear fuels or activities surrounding nuclear power plants.[27] The authors of this policy insight were unable to secure an interview with relevant NDB staff to discuss any possible evolution in policy.[28]

While the attitudes of the abovementioned DFIs indicate, to a large extent, a reluctance to fund nuclear activities, some financing institutions do engage with nuclear projects. Among these is the US-based International Development Finance Corporation (DFC), which, in July 2020, changed its Environmental and Social Policy Procedures to support nuclear power projects and the energy needs of global allies.[29]

The remaining funding source is bilateral funding, probably from vendor countries. Indeed, Milko Kovachev, head of the IAEA Nuclear Infrastructure Development Section, sees this as the most likely source.[30]

While there are many potential vendors, African countries appear to favour agreements with Russia and China.[31] Such national vendor financing brings its own complications, as competing countries exert political pressure to have their own technology selected. This makes it difficult for a purchasing country to define the project parameters independently and to allow for competitive bidding. Such national funding can also be prone to a lack of transparency, which can give rise to the perception, or the reality, of corruption in the procurement process (as evidenced by the nuclear deal between the Zuma administration and Russia).[32]

In terms of its dealings with the continent, China seems to be pursuing a unique investment model with 'enclave characteristics and including finance, turnkey project development and the importation of labour and equipment from China'.[33] The Chinese government has entered into an agreement with Sudan to finance a nuclear facility, despite the sanctions against the latter. This is China's approach to propel its grand Belt and Road Initiative 'to export technology, including nuclear power and high-speed railway

26 New Development Bank, *Environment and Social Framework* (Shanghai: NDB, 2016).

27 NDB, *Sustainable Financing Policy Framework Governing the Issuances of Green/Social/Sustainability Debt Instruments* (Shanghai: NDB, 2020).

28 Despite multiple efforts at different levels of the organisation, the Tutwa team were unable to secure an interview on the topic of nuclear energy with the relevant staff of the AfDB or the NDB. This analysis has therefore relied on information from their websites and press releases. The AfDB staff referred the researchers to their website and indicated that the policy had not changed.

29 US International Development Finance Corporation, "DFC Modernises Nuclear Energy Policy", Press Release, July 23, 2020.

30 Laura Gil, "Is Africa Ready for Nuclear Energy?", IAEA, September 3, 2018

31 Farai Shawn Matiashe, "Russia, China Willing to Fund Nuclear Projects as Several African Countries Explore Controversial Power Source", *City Press*, April 10, 2020

32 Lionel Faull, "Exposed: Scary Details of SA's Secret Russian Nuke Deal", *Mail and Guardian*, February 12, 2015

33 Rasmus Lema et al., "China's Investments in Renewable Energy in Africa: Creating Co-Benefits or Just Cashing In?", *World Development* 141, no 4 (2021): 1–18.

technologies, to African and European nations'.[34] Indeed, many have called Sudan the gateway via which China is promoting itself across Africa. From 2000–2020 China invested $53.1 billion in all types of energy sources on the continent, including nuclear energy, through China Development Bank and Export-Import Bank of China.[35]

Nuclear power in Africa

Donor countries appear willing to support African countries in the development of research facilities and policies to regulate nuclear facilities. At the 2020 Wilton Park conference, participants agreed that many of the 191 countries that are party to the Treaty on the Non-Proliferation of Nuclear Weapons have acknowledged the importance of nuclear safety and security and want to develop the required infrastructure and competencies. The IAEA is responding to countries' needs by developing the tools and support requested by countries under its Regulatory Infrastructure Development Project (RIDP).[36] Canada, the US and France have contributed funding for the development of regulatory infrastructure in 37 African countries through the RIDP.[37]

Ten research reactors are currently operational in eight African countries (Table 2). These were all built by foreign countries to train nuclear scientists and engineers, and to use nuclear technology to enhance the medical, environmental and agricultural fields. For example, South Africa's SAFARI-1 reactor is used in the detection of heart disease and cancer diagnoses. In addition, Nigeria's NIRR-1 research reactor is used to analyse popularly consumed fish in the country, with the aim of improving health and nutrition.[38]

SAFARI-1 is expected to undergo construction between 2026 and 2032 that will see the original reactor replaced by a multipurpose reactor. The project, which was approved by cabinet, will cost in the region of $800 million and is expected to create 5 000 direct and 26 000 indirect jobs during construction.[39]

African reactors are currently used strictly for environmental and medical research. However, experts have noted that 'the deployment of these reactors [is] often considered as the first step towards a functional commercial nuclear programme'.[40] In addition to those already listed, governments across Africa have, through agreements with leading nuclear nations, shown strong interest in developing commercial nuclear programmes.

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34 Yousif Yahya, "Toward a Nuclear Future? Chinese Investment in Sudan", World Policy Institute (blog), June 16, 2016.
35 Global Development Policy Center, "China's Global Energy Finance", https://www.bu.edu/cgef/#/all/Country.
36 Lenka Dojcanova et al., "37 Countries in Africa to Benefit from Strengthened Regulatory Infrastructure on Radiation Safety and Security of Radioactive Material", IAEA, January 27, 2020.
37 Wilton Park, *In Support of Africa's Agenda 2063: Pathways Forward for Expanding Peaceful Uses of Nuclear Energy and Nuclear Technology in Africa, WP1763*, Conference Report (Steyning: Wilton Park, February 2020).
38 Stott and Bosman, "Nuclear Science and Technology".
39 Ciaran Ryan, "Cabinet Approves Replacement for 56-Year-Old Reactor at Pelindaba", *Moneyweb*, October 21, 2021
40 Abigail Sah et al., "Atoms for Africa: Is There a Future for Civil Nuclear Energy in Sub-Saharan Africa?" (CGD Policy Paper, Center for Global Development: Washington DC, 2018), 5.

TABLE 2 NUCLEAR RESEARCH REACTORS IN AFRICA					
Country	**Facility name**	**Type**	**Capacity (kW)**	**Built by**	**Commissioned/ operational since/first achieved criticality[a]**
Algeria	Es-Salam	Heavy water	15 000	China	1992
	NUR	Pool	1000	Argentina	1989
DRC	TRICO-II	Pool, TRIGA Mark II	1000	US	1959
Egypt	ETRR-1	Tank	2000	USSR	1961
	ETRR-2	Pool	22 000	Argentina	1997
Ghana	GHARR-1	MNSR, Tank in pool	30	China	1994
Libya	IRT-1	Pool, IRT	10 000	USSR	1981
Morocco	MA-R1	TRIGA Mark II	2000	US/France	2007
Nigeria	NIRR-1	MNSR, Pool	30	China	2004[b]
South Africa	SAFARI-1	Tank in pool	20 000	US	1965

a IAEA, *Research Reactors in Africa* (Vienna: IAEA, 2011)

b "LEU Fuel En Route to Nigerian Research Reactors", *World Nuclear News*, October 19, 2018.

Source: Abigail Sah et al., "Atoms for Africa: Is There a Future for Civil Nuclear Energy in Sub-Saharan Africa?" (CGD Policy Paper, Center for Global Development, Washington DC, 2018)

Information on upcoming nuclear investments in Africa is listed below.

Egypt

The El Dabaa plant is a 4.8GW project set to comprise four 1.2GW Russian reactor units. These units will be owned by the Nuclear Power Plants Authority of Egypt, but Russia's Rosatom will develop and deliver the facility. Russia has extended a $25 billion loan to Egypt to cover 85% of the cost of the El Dabaa nuclear power plant currently under construction by Rosatom. This will become Africa's second nuclear power plant with commercial uses.[41] Egypt has undertaken to repay the loan at a rate of 3% per year from 2029.[42]

South Africa

The Eskom-owned, French-designed Koeberg plant was connected to the national grid in 1984 and has an installed capacity of 1 940MW, producing about 5% of South Africa's electricity.[43] In 2021 it was reported that US-based construction company Jacobs had been selected for a $1.2 billion programme to extend the operating life of Koeberg.[44] A substantial portion of Eskom's coal-fired power plants is set to be decommissioned or repurposed after 2030, in conjunction with the pursuit of energy security, and the

41 "Egypt Applies for Construction Permit for $30bn El-Dabaa Nuclear Power Plant", *Energy and Utilities*, July 5, 2021.

42 "Russia, Egypt Adjusted Plans for Construction of El-Dabaa NPP Due to Pandemic", *Tass*, February 2, 2021.

43 Umesh Ellichipuram, "Jacobs Chosen for Koeberg Nuclear Power Station Life Extension Works", *Power Technology*, August 13, 2021

44 Ellichipuram, "Jacobs Chosen for Koeberg".

Integrated Resource Plan 2019 envisions a 2 500MW nuclear build programme.[45] The proposed result is that that national government will not provide any funding to the programme, as it allows vendors to self-finance 100% of the costs. The policy provides for various types of technologies and reactor sizes.[46]

One entity that has expressed interest in developing this 2 500MW is NuScale Power, an advanced nuclear technology company that focuses on the use of nuclear energy for the production of electricity, heat and clean water.[47] In 2020, following the updating of its nuclear energy policy, the DFC signed a letter of intent to support NuScale's bid to develop 2 500MW of power in South Africa, under the country's Independent Power Producer Procurement Programme. It must be noted, however, that 'the letter of intent is not a funding commitment'.[48] In addition, the DFC has an upper limit of $1 billion for new nuclear projects, while the estimated cost of the entire programme would be in the region of $8 billion–$10 billion.[49]

The nuclear cooperation agreement between South Africa and the European Atomic Energy Community, signed in 2013 and adopted in 2018, also provides for mutual beneficial cooperation. The agreement seeks to expand cooperation in 'research and development; use of nuclear applications for health and agriculture; transfer of nuclear equipment and materials and nuclear safety, waste management and decommissioning, nuclear safeguards and emergency responses and preparedness'.[50]

Despite its being defunct, mention of the South Africa–Russia nuclear deal must be made. The deal was reportedly worth $76 billion and was set to see the development of 10 reactors. However, after being tipped off by Russian environmentalists, a pair of South African environmentalists blew the whistle on the secret deal, resulting in a lengthy court battle.[51] Within the context of South Africa's Just Energy Transition, in conjunction with the approximately $8 billion pledged to the country at the recent COP26 climate negotiations, climate-resilient electricity production, including from nuclear energy, may be fast-tracked.[52]

Kenya

Through its National Energy Policy of 2018, Kenya is also looking to include nuclear energy in its energy mix. The policy envisions completion of Kenya's first nuclear power plant by

45 Clarice Wambu et al., "Nuclear Power in Africa: Spotlight on South Africa and Kenya", Cliffe Dekker Hofmeyr, October 13, 2021.
46 Dan Yurman/djysrv, "South Africa Takes Another Run for Nuclear Energy", Neutron Bytes, May 9, 2020.
47 NuScale, "About Us", https://www.nuscalepower.com/about-us.
48 Dan Yurman/djysrv, "NuScale gets Letter of Intent for 2 500MW Project in South Africa from US Development Finance Agency", Neutron Bytes, October 18, 2020.
49 Dan Yurman/djysrv, 'NuScale gets Letter".
50 Parliamentary Monitoring Group, "Agreement between RSA and European Atomic Energy Community for Co-operation on the Peaceful Uses of Nuclear Energy", December 1, 2020.
51 Charles Digges, "South African Women Who Stopped Secret Russian Nuclear Deal Win This Year's Goldman Prize", Bellona, April 23, 2018.
52 Onke Ngcuka, "South Africa Secures Watershed Finance Deal to Reduce Coal Reliance", *Daily Maverick*, November 3, 2021.

2027.[53] In 2020 reports indicated that the $5 billion nuclear plant would be built in Tana River County over a seven-year period, with funding provided by private investors. It was set to have an initial capacity of 1 000MW, with plans to expand this capacity to 4 000MW by 2035. It also noted that Kenya had signed memoranda of understanding with China, Russia, South Korea and Slovakia for capacity development in the nuclear build, with the 'build, operate and transfer' model the type of concession agreement selected.[54]

Due to delays in the granting of the necessary approvals, however, the project is not on track to be completed by 2027.[55] Nevertheless, Kenya has conducted a follow-up review (to the initial 2015 review) into progress in the development of nuclear infrastructure. The follow-up Integrated Nuclear Infrastructure Review mission, which took place from 8–11 June 2021, noted progress in the following areas:[56]

- development of the National Nuclear Policy and the National Policy and Strategy for Safety to enable the government to make informed decisions regarding nuclear power;
- enactment of a national nuclear law and regulatory body;
- assessment of the national legal framework to identify additional laws needing review; and
- enhanced coordination of stakeholders in the development of the nuclear programme.

These developments notwithstanding, additional work is required in terms of a nuclear leadership programme, as well as the ratification of international conventions on the safe use of nuclear energy.[57]

Nigeria

Although Nigeria is Africa's largest oil producer, it is plagued with a high degree of energy poverty, having failed to truly tap into its resources. This is expected to change following the signing of the Petroleum Industry Act, which foresees greater investment in the sector and a larger role for oil and gas in the Nigerian economy.[58] Nigeria is also pursuing the option of nuclear-generated electricity, as it is considered a 'substantially less expensive and less complicated solution'.[59]

The 2009 Russian–Nigerian Joint Committee (JCC) on National Atomic Energy had not made any tangible progress by 2020. Through the initial agreement, JCC's goal was to complete the nuclear plants by 2020. In July 2021 the agreement was reconstituted with

53 Wambu et al., "Nuclear Power in Africa".
54 Brian Ngugi, "Kenya Reveals Sh 540bn Nuclear Power Plant in Tana River", *Business Daily Africa*, August 18, 2020
55 Wambu et al., "Nuclear Power in Africa".
56 IAEA, "IAEA Reviews Progress of Kenya's Nuclear Infrastructure Development", Press Release, June 11, 2021.
57 IAEA, "IAEA Reviews Progress."
58 Hanna Ziady, "Nigeria Is Oil Rich and Energy Poor. It Can't Wait Around for Cheaper Batteries", *CNN Business*, November 3, 2021
59 Claire Volkwyn, "Nigeria Pursues Nuclear Ambitions", *ESI Africa*, July 2, 2021

plans for two power plants 'expected to be twin reactors that will each cost around $10 billion'[60] – the Geregu power plant in central Nigeria and the Itu power plant in southern Nigeria.[61] In 2015 it was reported that the planned reactors would have a capacity of 2 400MW each.[62] According to the secretary to the Government of the Federation, Boss Mustapha, the reconstitution of the JCC was aimed at resuscitating the relationship between Nigeria and Russia on peaceful nuclear applications.[63]

Ghana

Ghana is expected to begin nuclear generation by 2030. According to Dr Stephen Yamoah, the executive director of Nuclear Power Ghana (NPG, which owns the proposed power plant), it has completed the first phase of the three-stage project, which encompasses planning and preparation. Stage two – in which the vendor is expected to be identified, the site agreed on, and most of the contractual arrangements in place – is expected to be completed between 2024 and 2025.[64]

Conclusion

Africa can gain much through nuclear scientific training, as well as the peaceful application of nuclear technologies. These developments are expected to produce ongoing development benefits in developed and developing countries. This will naturally increase the global appetite for this technology, which will require finance for innovation and development. The reliability of nuclear energy and the range of non-energy uses of nuclear power make it more likely that some African countries will rush to include nuclear power in their energy mix where possible.

Africa can gain much through nuclear scientific training, as well as the peaceful application of nuclear technologies

There are, however, several challenges to consider. Nuclear energy is expensive, particularly given the sustained drop in the cost of renewable energies. In addition, nuclear energy's

60 Peter Hansen, "Nigeria Commits Itself to Building Africa's Second and Third Nuclear Power Plants", *Climate Scorecard*, September 9, 2021

61 Hansen, "Nigeria Commits Itself".

62 "Nigeria Selects Sites for 4 800MW Nuclear Power Plants", *Power Technology*, June 17, 2015

63 "Nigeria Reactivates Russian-Nigerian Joint Coordination Committee", *Nuclear Engineering International*, July 20, 2021.

64 "Ghana Expects to Begin Nuclear Generation in 2030", *Nuclear Engineering International*, August 31, 2021

poor reputation and highly publicised safety concerns make it difficult to secure external financing from African and international sources for the huge upfront capital investments required. This intensifies the questions around its popularity and public acceptance.

Nuclear energy is expensive, particularly given the sustained drop in the cost of renewable energies

Notwithstanding nuclear energy's green credentials, the major international and continental development funding institutions have not yet been persuaded to give a green light to investments in nuclear energy. The EU, for instance, has delayed proposals to classify nuclear power under its system for green financing.[65] As a result, African countries seeking to develop a nuclear industry will be heavily reliant on vendor financing.

A combination of global political competition, the huge sums involved, and the secrecy in which all things nuclear are frequently shrouded makes it necessary to carefully structure transparent practices in nuclear procurement to avoid the perception, at least, of corruption. In any event, any African country seeking to include nuclear power in its energy mix and industrial policy will need to establish a strong and trusted regulatory structure, staffed with well-trained officials, and to build strong and positive relations with the international nuclear regulatory establishment.

Most importantly, given the huge energy backlog in Africa and the immense sums required to meet the continent's power needs, it appears that for every MWh of nuclear power installed, 4–5MWh of solar or wind energy can be installed at the same cost. If energy availability is the objective, African countries will be better advised to commit to significant investments in their solar and wind power grid, in addition to the necessary (and costly) enhancements to upgrade their transmission skeleton to accommodate the need to switch between multiple production sites.

To enhance reliability, it might be more prudent to invest in innovative storage programmes (hydro-pumped storage schemes, evolving battery technology, etc.) and in newer gas-fired peaking plants linked to the grid. While powerful vested interests will press for nuclear technology, development-focused governments will be well advised to resist such pressure.

65 "EU Delays Classification of Nuclear Power for Green Financing", *Power Technology*, October 20, 2021.

Recommendations

- African countries seeking to include nuclear power in their energy mix and industrial policy should establish a strong and trusted regulatory structure, staffed with well-trained officials, and build strong and positive relations with the international nuclear regulatory establishment.
- Governments and private vendors and operators considering nuclear investments must be prepared for considerable costs to cover projected waste management and decommissioning nuclear power plants at the end of their cycle.
- African countries should be aware of global and continental geopolitical competition, economic factors and safety concerns when arranging bilateral funding from vendor countries, which are often most concerned with securing projects for their own companies.
- It is necessary to structure carefully transparent practices in any nuclear procurement to avoid a perception of corruption.
- In most African countries there is all-year-round access to sun and wind, but insufficient renewable energy, so there are strong arguments for investing in renewable energy and its storage – which may be a better option than developing nuclear energy, depending on the context.
- Recipient nations of vendor-country finance must use the enhanced electricity generation capacity that results from commercial nuclear power operations as an opportunity to develop their industries so as not to find themselves unable to pay off their loans.

Authors

Danae Govender

is an Economic Research Consultant at Tutwa Consulting Group. He has completed an MCom in Economics at the University of KwaZulu-Natal and has a particular passion for environmental economics and international trade, as well as a flair for econometrics.

Thabelo Muleya

is a Policy Researcher at Tutwa Consulting Group and has worked on various regional and continental projects since joining Tutwa. He holds an LLB (cum laude) from the University of Fort Hare and is currently completing his LLM in International Economic Law.

Anna Ngarachu

is a Senior Economic Researcher at Tutwa Consulting Group with five years' experience in the development sector, having been involved in several regional and continental projects in recent years. She holds an Honours in Economic Science and a Core Credentials of Readiness from Harvard Business School.

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Cover image

The Grohnde Nuclear Power Plant reactor dome as seen 08/11/2021. The 1360 megawatt plant, which is operated by PreussenElektra, is scheduled to shut down at the end of 2021. In all four nuclear power plants across Germany are scheduled to cease operation by the end of 2021 as part of Germany's ongoing exit from nuclear power (Sean Gallup/Getty Images)

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Jan Smuts House, East Campus, University of the Witwatersrand
PO Box 31596, Braamfontein 2017, Johannesburg, South Africa
Tel +27 (0)11 339-2021 • Fax +27 (0)11 339-2154
www.saiia.org.za • info@saiia.org.za