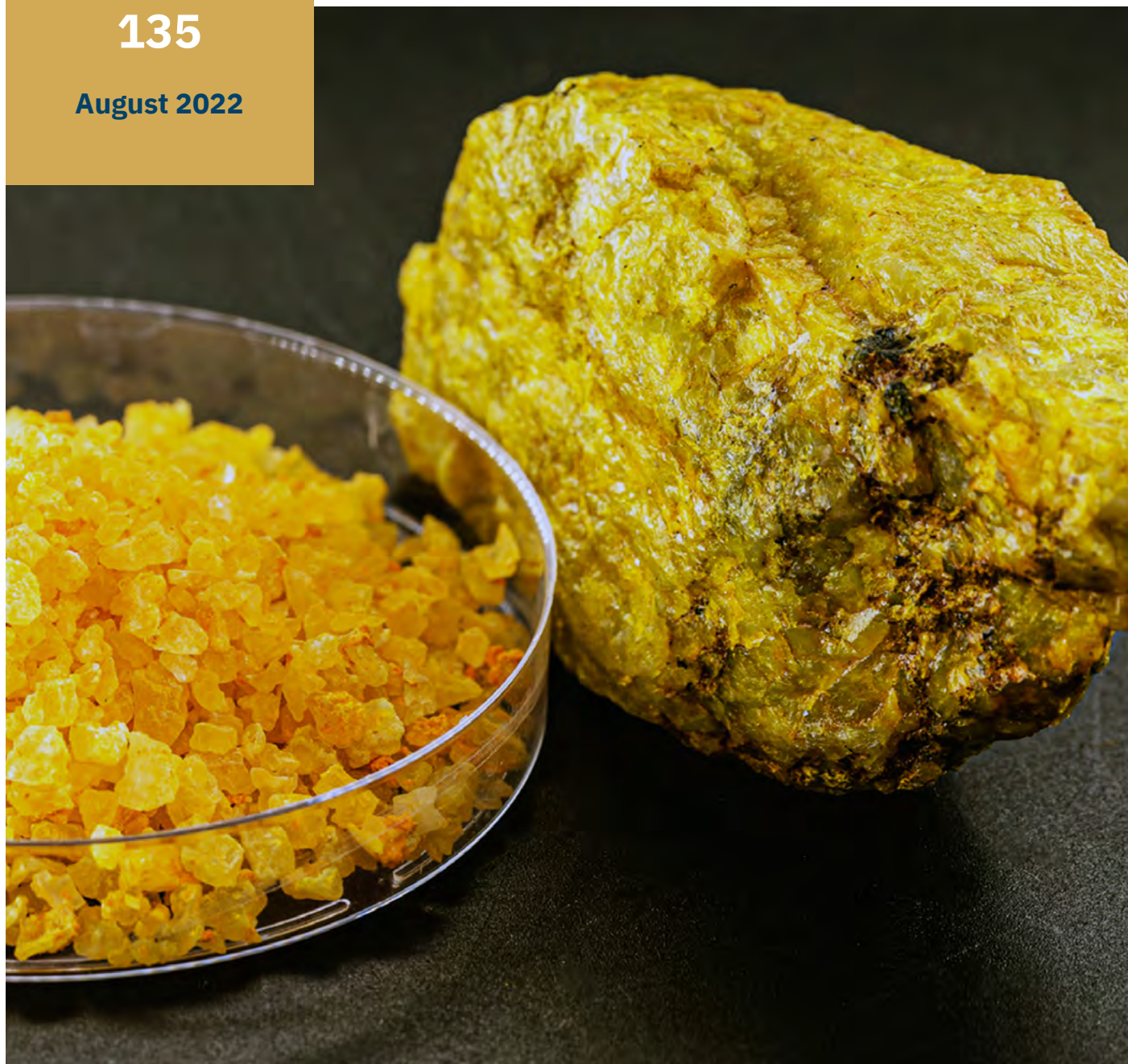


# Policy Insights

135

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## Safety and Security of Nuclear Facilities and Materials in Africa

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African perspectives  
Global insights

# Executive summary

Nuclear power is becoming a prominent item on the African agenda as more countries consider including it in their energy mix. However, there are many risks associated with nuclear materials at different stages of their life, including radioactive material falling into the wrong hands. In Africa, governance mechanisms to ensure the safety and security of nuclear materials are already in place. The most important of these, the Treaty of Pelindaba, establishes Africa as a nuclear-weapon-free zone and prescribes standards to promote cooperation in the peaceful use of nuclear energy, including the physical protection of nuclear materials. The peaceful use of nuclear energy holds immense developmental potential for the continent, but this can only be achieved through strict adherence to safety and security protocols.

## Introduction

Over the past decade, a number of low-profile nuclear incidents have occurred in Africa. Some of these have only been made public long after they initially occurred. In December 2013, for example, the Rössing Uranium Mine in Namibia experienced a structural failure of a leach tank, resulting in a spill. Afterwards, elevated levels of radiation were reported in areas surrounding the mine.<sup>1</sup> In South Africa, the Koeberg Nuclear Power Station released radioactive waste into the environment in three separate incidents between 2014 and 2015. However, the public was not informed at the time. In a parliamentary response in 2019, Public Enterprises Minister Pravin Gordhan said that the radioactive quantities were negligible and fell below the threshold requiring the public to be informed.<sup>2</sup> Additional incidents occurred in 2017 and 2018 at South Africa's Pelindaba nuclear facility, one of which resulted in a shutdown of a radio-isotopes plant. AmaBhungane, a credible investigative journalism unit, reported 'a picture of a breakdown of safety culture at the plant'.<sup>3</sup>

Nuclear power is becoming a prominent item on the African agenda. South Africa is currently the only African country operating a nuclear power reactor, but Egypt is planning to follow suit by the end of this decade with the completion of its nuclear power plant, construction of which is already under way. In addition, at least 16 other African countries are investigating the possibility of starting up nuclear power programmes, namely Algeria, Angola, Burundi, the Democratic Republic of Congo (DRC), Egypt, Ethiopia, Ghana, Kenya, Morocco, Rwanda, Sudan, Tunisia, Tanzania, Uganda, Zambia and Zimbabwe.<sup>4</sup> For all African

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1 *World Nuclear News*, 'Rössing eases in to restart,' January 20, 2014, <http://www.world-nuclear-news.org/Articles/Rossing-eases-in-to-restart>.

2 Marelise van der Merwe, 'Gordhan: Radioactive leaks at Koeberg were negligible,' *Mail & Guardian*, April 1, 2019, <https://mg.co.za/article/2019-04-01-gordhan-radioactive-leaks-at-koeberg-were-negligible>.

3 *News 24*, 'Another nuclear safety scare at Pelindaba as management fumbles,' June 7, 2018, <https://www.news24.com/SouthAfrica/News/another-nuclear-safety-scare-at-pelindaba-as-management-fumbles-20180606>.

4 Pamela Largue, 'Russia starts equipment production for Egypt's El-Dabaa nuclear plant,' *Power Engineering International*, August 6, 2021, <https://www.powerengineeringint.com/nuclear/russia-starts-equipment-production-for-egypts-el-dabaa-nuclear-plant/>.

states that develop nuclear programmes, it is critical that they ensure the safety and security of nuclear materials, including nuclear waste. Apart from concerns about harmful effects on people and the environment in Africa, critics worry that nuclear materials will fall into the wrong hands, either during coups or through the actions of terrorists who are increasingly using such materials for acts of terror.<sup>5</sup> While in the past decade coups in Africa have not been nearly as prevalent as they used to be (over 200 coups and attempted coups took place between independence and 2012, with over 90% of African states having experienced them), there have nonetheless been 40 coups and attempted coups since 2010.<sup>6</sup> Unconstitutional changes of government, conflict and war may bring about instability and potential threats to nuclear facilities, as recent events at the Zaporizhzhia nuclear power plant in Ukraine have shown.<sup>7</sup> As noted in earlier research by SAIIA, 'safety and security of new and existing nuclear programmes, as well as nuclear waste products, is paramount'.<sup>8</sup> Strong capacity to ensure full compliance with continental and international standards and safeguards needs to go hand in hand with nuclear builds and the maintenance of existing facilities.

For all African states that develop nuclear programmes, it is critical that they ensure the safety and security of nuclear materials, including nuclear waste

This policy insight is structured as follows. The first section discusses key continental and international nuclear safety and security documents applicable to African states with nuclear programmes. This is followed by a discussion of the roles, objectives and recent activities in nuclear safety and security of two key institutions: the African Commission on Nuclear Energy (AFCON) and the International Atomic Energy Agency (IAEA), with

Strong capacity to ensure full compliance with continental and international standards and safeguards needs to go hand in hand with nuclear builds and the maintenance of existing facilities

5 Kamen Velichkov, 'Synchronising nuclear governance in SADC member states through regional cooperation,' SAIIA Occasional Paper No. 332, October 2021, <https://saiia.org.za/research/synchronising-nuclear-governance-in-sadc-member-states-through-regional-cooperation/>.

6 Muhammad Dan Suleiman and Hakeem Onapanjo, 'Why West Africa has had so many coups and how to prevent more,' *The Conversation*, February 15, 2022, <https://theconversation.com/why-west-africa-has-had-so-many-coups-and-how-to-prevent-more-176577>.

7 The Zaporizhzhia nuclear power plant in southern Ukraine, the largest nuclear power plant in Europe, was attacked by Russian forces on 3 March 2022, causing extensive damage.

8 Jo-Ansie van Wyk, Yarik Turianskyi and Isabel Bosman, 'African continental institutions: A review,' SAIIA Policy Insight No. 119, October 2021, <https://saiia.org.za/research/african-continental-nuclear-institutions-a-review/>.

a section dedicated to each. The fourth section examines existing concerns, challenges and suggested next steps. It also includes a concise case study of the Moroccan Agency for Nuclear and Radiological Safety and Security (AMSSNuR), which has been prominent in promoting African expertise and cooperation in nuclear safety and security. The policy insight concludes with a summary of its main findings and arguments, as well as practical recommendations on the way forward.

## Key African nuclear safety and security documents

Continently, the most important document is the African Nuclear-Weapon-Free Zone Treaty, commonly known as the Pelindaba Treaty. It was opened for signature in 1996 in Cairo, Egypt, and signed by 47 African states. However, it only entered into force in 2009 once the required 28 ratifications had been obtained.<sup>9</sup> The Pelindaba Treaty establishes the African continent as a zone free of nuclear weapons, while simultaneously providing standards to promote cooperation in the peaceful use of nuclear energy.<sup>10</sup> Of specific relevance to this policy insight is the treaty's Article 10, according to which<sup>11</sup>

[e]ach Party undertakes to maintain the highest standards of security and effective physical protection of nuclear materials, facilities and equipment to prevent theft or unauthorized use and handling. To that end each Party, inter alia, undertakes to apply measures of physical protection equivalent to those provided for in the Convention on Physical Protection of Nuclear Material and in recommendations and guidelines developed by IAEA for that purpose.

Importantly, this establishes a commitment to 'security' and 'protection' (or safety) of nuclear materials, facilities and equipment at all times and provides for two international standards to accomplish this: the Convention on the Physical Protection of Nuclear Material (CPPNM) and the International Atomic Energy Agency (IAEA) recommendations and guidelines.

The first of these standards, the CPPNM, was adopted in 1979 and entered into force in 1987. The convention has a number of objectives: establishing legal obligations for parties in terms of physically protecting nuclear materials during international transportation; criminalising offences relating to the illicit use of nuclear materials; and promoting international cooperation in instances of theft or credible threat of theft of nuclear materials.<sup>12</sup> Furthermore, an amendment to the convention was adopted in 2005, which

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9 NTI, Pelindaba Treaty, n.d., <https://www.nti.org/education-center/treaties-and-regimes/african-nuclear-weapon-free-zone-anwzf-treaty-pelindaba-treaty/>.

10 Van Wyk, Turianskyi and Bosman, 'African continental institutions.'

11 IAEA, African Nuclear-Weapon-Free-Zone Treaty (Pelindaba Treaty), 1996, <https://www.iaea.org/publications/documents/treaties/african-nuclear-weapon-free-zone-treaty-pelindaba-treaty>.

12 IAEA, Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment, n.d., <https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment>.

subsequently entered into force in 2016. According to the IAEA, the CPPNM and its amendment are intended for countries that have active nuclear programmes, those that engage in limited nuclear activities and even those that simply use radioactive materials.<sup>13</sup> Rafael Mariano Grossi, director general of the IAEA, stresses that ‘... we need to have a proper global framework in place to ensure that nuclear and other radioactive material does not fall into the wrong hands.’<sup>14</sup> A total of 43 African states have signed and ratified the CPPNM.<sup>15</sup>

We need to have a proper global framework in place to ensure that nuclear and other radioactive material does not fall into the wrong hands

Parties to the convention and its amendment agree to three important requirements:

- The establishment, implementation and maintenance of a physical protection regime of nuclear facilities and nuclear materials;
- The criminalisation of misuse of nuclear materials, including smuggling, sabotage and threats to the use thereof; and
- The institutionalisation of international arrangements to exchange information and cooperate to ensure protection of nuclear facilities and nuclear materials.<sup>16</sup>

The second of these standards, the IAEA Safety Standards, provide the ‘fundamental principles, requirements and recommendations to ensure nuclear safety’<sup>17</sup> across three sets of documents: the Safety Fundamentals (which determine fundamental safety objectives as well as the main principles of safety and protection), the Safety Requirements (which establish requirements to protect people and the environment) and the Safety Guides (which contain guidance and recommendations).<sup>18</sup> These safety standards straddle a wide range of documents, covering (but not limited to): control of radiation sources; nuclear installation safety; radiation and waste safety; and transport safety.<sup>19</sup> The IAEA

13 IAEA, ‘The Convention on the Physical Protection of Nuclear Material and its 2005 Amendment: Five Questions,’ n.d., <https://www.iaea.org/sites/default/files/21/04/cppnm-and-its-2005-amendment-five-questions.pdf>.

14 IAEA, ‘The Convention on the Physical Protection of Nuclear Material.’

15 The African states that have signed and ratified the convention are: Algeria, Benin, Botswana, Burkina Faso, Cameroon, Cabo Verde, Central African Republic, Chad, Comoros, Congo, Côte d’Ivoire, DRC, Djibouti, Equatorial Guinea, Eritrea, Eswatini, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Libya, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe. See <https://www.nti.org/education-center/treaties-and-regimes/convention-physical-protection-nuclear-material-cppnm/#:~:text=Ten%20States%20ratified%20or%20officially,Malawi%20acceded%20to%20the%20CPPNM.>

16 IAEA, ‘The Convention on the Physical Protection of Nuclear Material.’

17 IAEA, ‘Safety Standards,’ n.d., <https://www.iaea.org/resources/safety-standards>.

18 IAEA, ‘Safety Standards.’

19 IAEA, ‘Learning Management System,’ <https://elearning.iaea.org/m2/course/index.php>.

emphasises that the primary responsibility for safety lies with the person or organisation that is engaging in nuclear activities. More broadly, the regulation of nuclear safety is the responsibility of the national government. Indeed, radiation may transcend national borders and therefore international cooperation is crucial for a global regime of nuclear safety.<sup>20</sup> This last point specifically echoes one of the main requirements of the CPPNM and its amendment. The number of African IAEA members (ie, 45) is similar to the number of African states that have ratified the CPPNM.<sup>21</sup>

Radiation may transcend national borders and therefore international cooperation is crucial for a global regime of nuclear safety

## African Commission on Nuclear Energy

As discussed earlier, one of the key African documents on nuclear governance is the Pelindaba Treaty. It provides for the establishment of AFCONE, which is a continental body tasked with ensuring that states parties to the Pelindaba Treaty comply with its basic provisions.<sup>22</sup> According to Article 12 of the treaty, one aspect of AFCONE's mandate involves 'reviewing peaceful nuclear activities in terms of the IAEA safeguards'.<sup>23</sup> Indeed, the executive secretary of AFCONE, Messaoud Baaliouamer, takes this task seriously, as evidenced in numerous references to nuclear safety and security in his speeches, addresses and statements.

In a 2019 speech to the 63<sup>rd</sup> General Conference of the IAEA, he stated that 'nuclear safety and safeguards and nuclear material accounting and control' had been identified as some of AFCONE's main priorities, in line with the provisions of the Pelindaba Treaty.<sup>24</sup> Earlier in this speech he also emphasised that states parties to the treaty are required 'to maintain the highest standards of physical protection of nuclear material, facilities and equipment, which

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20 IAEA, 'Safety Standards.'

21 The African member states of the IAEA are: Algeria, Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, DRC, Djibouti, Egypt, Eritrea, Eswatini, Ethiopia, Gabon, Ghana, Sierra Leone, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Papua New Guinea, Rwanda, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe. See <https://www.iaea.org/about/governance/list-of-member-states>.

22 Van Wyk, Turianskyi and Bosman, 'African continental institutions.'

23 Nuclear Threat Initiative, African Nuclear-Weapon-Free Zone Treaty, n.d., <https://www.nti.org/education-center/treaties-and-regimes/african-nuclear-weapon-free-zone-anwz-treaty-pelindaba-treaty/>.

24 Messaoud Baaliouamer, 'Statement to the 63rd General Conference of the IAEA,' Vienna, September 16-20, 2019, <https://www.iaea.org/sites/default/files/19/09/gc63-african-union.pdf>.

are to be used exclusively for peaceful purposes'.<sup>25</sup> Baaliouamer then proceeded to outline specific actions that AFCONE was taking in terms of nuclear safety and security in Africa:<sup>26</sup>

- Prioritising the management of radioactive waste on the continent: In line with the provisions of Article 7 of the Pelindaba Treaty, AFCONE is cooperating with the UN Environment Programme to implement regional projects to drive modern management of radioactive waste in Africa.
- Operationalising regional centres of excellence in nuclear security: These centres have already been identified and are being supported by various international partners, including similar centres in Europe, to strengthen and capacitate them so that they can fully implement the provisions of the Pelindaba Treaty.
- Implementing and operationalising national states' Systems of Accounting for and Control of Nuclear Material: This is one of AFCONE's priorities and in 2019 it organised the first joint workshop on this topic with the IAEA's Safeguards Department, with plans to hold other workshops in the future.

In his address to the IAEA General Conference in 2020, Baaliouamer re-emphasised the importance of nuclear safety and security safeguards and reported that AFCONE is focusing on the consolidation of regional ownership to ensure capacity building, nuclear safety analysis and nuclear safeguards service delivery. Specifically, AFCONE is selecting African collaborating centres in these fields; organising events on nuclear safety, security and safeguards in SADC; and organising joint activities in the nuclear arena with the European Safeguards Research and Development Association.<sup>27</sup>

During his address to the IAEA's General Conference in 2021, Baaliouamer once again underlined AFCONE's commitment to ensuring nuclear safety and security in Africa. He reported that AFCONE had organised a webinar on 'Fostering the African Environmental Legislation and Regulations integrating the Provisions of the Pelindaba Treaty related to the Appropriate Management of Radioactive Wastes' on 31 May 2021 and had then organised a joint webinar on 24 June 2021 on 'Nuclear Security in Africa' with the IAEA, the UN Interregional Crime and Justice Institute and the European Commission. Apart from that, AFCONE has also selected two AFCONE regional collaborating centres in the nuclear safety field. Prior to that, AFCONE had organised meetings on 'Nuclear Safeguards in Africa: Status and Way Forward' on 23 November 2020 and on 'Women's Contributions to Building Strong State Systems of Accounting for and Control of Nuclear Materials in Africa' on 8 March 2021.<sup>28</sup>

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25 Baaliouamer, 'Statement to the 63<sup>rd</sup> General Conference.'

26 Baaliouamer, 'Statement to the 63<sup>rd</sup> General Conference.'

27 Messaoud Baaliouamer, 'Statement to the 64<sup>th</sup> General Conference of the IAEA,' Vienna, September 21-25, 2020, <https://www.iaea.org/sites/default/files/20/09/afcone-gc64-en.pdf>.

28 Messaoud Baaliouamer, 'Statement to the 65<sup>th</sup> General Conference of the IAEA,' Vienna, September 20-24, September 2021, <https://www.iaea.org/sites/default/files/21/10/afcone.pdf>.

# International Atomic Energy Agency

Worryingly, the IAEA states that as recently as 2019 there were 189 incidents reported by 36 of its member states. The incidents involved unauthorised activities and events, including trafficking and malicious use of nuclear and radioactive materials.<sup>29</sup> The sheer volume of these incidents in one year illustrates the extent of the problem. The James Martin Center for Nonproliferation Studies (CNS) keeps a database of nuclear and radioactive materials incidents that escape regulatory control. The database identifies a total of eight such incidents occurring in Africa between 2013 and 2019: two in Algeria, one in Burkina Faso, one in Nigeria, one in Sierra Leone and three in South Africa. Four of these were the result of theft, with the materials successfully recovered in only one of the cases.<sup>30</sup> Although these incidents are infrequent on the continent, it must be borne in mind that each has potentially severe consequences because of the dangers posed by nuclear and radioactive materials.

In Africa, the IAEA sees the enhancement of collaboration, both within and between states, in nuclear safety and security as key, with peer reviews and self-assessments playing a central role

The IAEA identifies five broad themes in terms of the drafting of nuclear regulations: nuclear safety, radiation safety, transport safety, waste safety, and emergency preparedness and response.<sup>31</sup> According to the latest IAEA Nuclear Safety Review available at the time of writing, the agency is currently focusing on revising existing safety standards rather than establishing new ones.<sup>32</sup> Specifically, the IAEA has completed the revision of its Safety Requirements publications, having updated these with the lessons learned from the Fukushima Daiichi accident in 2011. It is also updating its Safety Guides.<sup>33</sup> Another important ongoing initiative of the agency is its peer-review and advisory services. Peer-review mission reports include recommendations to states on leadership and management of the existing safety and security culture, after which they can request additional guidance on strengthening these areas as well as advice on conducting self-assessments in the area of safety culture.<sup>34</sup>

29 IAEA, 'IAEA database shows continued incidents of trafficking and loss of control of nuclear and other radioactive material,' February 13, 2020, <https://www.iaea.org/newscenter/pressreleases/iaea-database-shows-continued-incidents-of-trafficking-and-loss-of-control-of-nuclear-and-other-radioactive-material#:~:text=In%202019%2C%20189%20incidents%20were,malicious%20use%2C%20continue%20to%20occur>.

30 Nuclear Threat Initiative, 'Overview of the CNS Global Incidents and Trafficking Database,' October 20, 2021, <https://www.nti.org/analysis/articles/overview-of-the-cns-global-incidents-and-trafficking-database>.

31 IAEA, 'Nuclear Safety Review 2020,' 1, <https://www.iaea.org/sites/default/files/gc/gc64-inf3.pdf>.

32 IAEA, 'Nuclear Safety Review 2020.'

33 IAEA, 'Nuclear Safety Review 2020.'

34 IAEA, 'Nuclear Safety Review 2020.'



In Africa, the IAEA sees the enhancement of collaboration, both within and between states, in nuclear safety and security as key, with peer reviews and self-assessments playing a central role. In 2019 a total of 20 African nuclear regulators conducted such self-assessments.<sup>35</sup> Between 1989 and 2019, South Africa – given its status as the continent’s sole nuclear plant operator (at least at the time of writing) – received a total of 15 IAEA missions. These included Safety Aspects of Long Term Operation (SALTO), Integrated Regulatory Review Service, Emergency Preparedness Review, Integrated Nuclear Infrastructure Review, Operational Safety Review Team, Education and Training Appraisal, and Advisory Mission on the National Regulatory Infrastructure for Radiation Safety.<sup>36</sup>

An especially important factor, taking into account the high number of African states that are embarking on new nuclear power programmes, is capacity building. African member states have an opportunity to request IAEA support for education and training in nuclear safety and security. Working together with the IAEA on new nuclear programmes and nuclear builds is extremely important. SAIIA’s [previous research](#) specifically highlighted Ghana as a case study worthy of emulation by others in view of its meticulous adherence to the IAEA Milestones Approach. The latter included two visits by the IAEA’s Integrated Nuclear Infrastructure Review Missions to assess the development of the country’s nuclear infrastructure and to make recommendations regarding the next steps.<sup>37</sup>

The IAEA’s 2020 Review Report also highlights several noteworthy initiatives and events undertaken for its African member states:

- **January–February 2019:** Regional Schools for Drafting Regulations on Radiation Safety and Nuclear Security for the African region, attended by 12 participants from six member states.
- **April 2019:** Training workshop for the African region in Addis Ababa, attended by 43 participants from 25 countries, featuring training materials developed to promote the Communication and Consultation with Interested Parties by the Regulatory Body, Safety Standards Series.
- **June 2019:** Workshop for the Africa region held in Vienna to support member states in performing their safety and security self-assessments, supplemented by four additional webinars.

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35 Yassine Chaari, ‘Building robust, sustainable, resilient nuclear safety and security infrastructure: African countries collaborate,’ IAEA, October 16, 2020, <https://www.iaea.org/newscenter/news/building-robust-sustainable-resilient-nuclear-safety-and-security-infrastructure-african-countries-collaborate>.

36 IAEA, ‘Peer Review and Advisory Services Calendar,’ n.d., <https://www.iaea.org/services/review-missions/calendar?type=All&year%5Bvalue%5D%5Byear%5D=&location=3435&status=4275&page=1>.

37 Yarik Turianskyi, Jo-Ansie van Wyk, Heba Taha, Hubert Foy and Isabel Bosman, ‘Nuclear power and governance frameworks: Egypt, Ghana and South Africa,’ SAIIA Special Report, March 2021, <https://saiia.org.za/research/nuclear-power-and-governance-frameworks-egypt-ghana-and-south-africa/>.

- **October 2019:** Regional workshop held in South Africa to promote the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, attended by 21 participants from 18 African member states.
- **November 2019:** Training course held in Morocco on establishing a national registry of radiation sources for the Africa region, attended by 27 participants from 11 member states.

The IAEA 2020 Annual Report provides further details on the agency's initiatives in respect of nuclear safety and security in Africa, specifically its Safety of Nuclear Installations, which aim to:<sup>38</sup>

[s]upport Member States in improving the safety of nuclear installations ... through the development and maintenance of an up to date set of safety standards and providing for their effective application ... establishing and enhancing their safety infrastructure through review services ... capacity building through education and training, and by encouraging the exchange of information and operating experience and international cooperation ...

With these aims in mind, the IAEA organised three virtual expert missions to the African continent – to Egypt, Morocco and South Africa – to review the integrated management systems of their nuclear regulatory bodies.<sup>39</sup> As noted earlier, South Africa is the most advanced on the continent in terms of its nuclear programme, while Egypt is following in its footsteps with its own nuclear build. Therefore, the IAEA's decision to arrange virtual expert missions to these two countries is likely to have been informed by how advanced they are in terms of their nuclear power programmes.

Although Morocco does not yet use nuclear power to produce electricity, it recently (in 2021) opened a new Training Centre in Nuclear Science and Technology as an extension of the National Center for Nuclear Energy, Sciences and Techniques.<sup>40</sup> This was done in partnership with the IAEA; therefore, the agency most likely conducted the virtual mission to ensure that everything was done by the book prior to the centre's opening. The new centre will be used to train nuclear scientists in Morocco and other African countries on the safe and sustainable use of nuclear technologies. Morocco is also embarking on other initiatives to promote cooperation between African states in the fields of nuclear safety and security, as detailed below.

AMSSNuR is the Moroccan Agency for Nuclear and Radiological Safety and Security. It was established in 2014 to ensure compliance with regulations governing nuclear and

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38 IAEA, 'Annual Report for 2020,' <https://www.iaea.org/opic/annual-report-2020>.

39 IAEA, 'Annual Report for 2020.'

40 *Nuclear Engineering International*, 'Morocco launches new nuclear training centre,' March 30, 2021, <https://www.neimagazine.com/news/newsmorocco-launches-new-nuclear-training-centre-8635289#:~:text=However%2C%20as%20Morocco%20relies%20on,nuclear%20power%20to%20generate%20electricity>.

radiological technologies and materials, and to guarantee the safety and security of such activities.<sup>41</sup> The agency places a particularly strong emphasis on international and continental cooperation.<sup>42</sup> Between 2017 and 2020 AMSSNuR organised 90 workshops, of which almost one-third – 29 events – had an Africa focus.<sup>43</sup> In 2019 the agency hosted the Third International Regulators Conference on Nuclear Security, which was held on the African continent for the first time.<sup>44</sup> It has also made practical attempts to establish itself as a centre for collaboration and partnership on nuclear safety and security in Africa. In 2019 the agency was designated as the first African IAEA Capacity Building Centre on Emergency Preparedness and Response. In 2020 the agency submitted an application to be designated as an AFCONE Collaborating Centre in Nuclear Safeguards in Africa. Then, in 2021 AMSSNuR submitted a letter of intent to the IAEA to be designated as the first IAEA Collaborating Centre in Nuclear Safety and Security in Africa.<sup>45</sup>

## Concerns, challenges and the way forward

Advocates of nuclear energy often say that Chernobyl (1986) and Fukushima (2011) are the only two major accidents that have occurred in six decades of nuclear power usage across 36 countries.<sup>46</sup> Yet the death toll, long-term health impact and environmental degradation arising from nuclear disasters are alarming. In Chernobyl, 62 people died as a direct result of the blast and acute radiation exposure. The long-term radiation exposure is much more difficult to measure. In 2005 the World Health Organization estimated that between 4,000 and 9,000 had died due to exposure over time. Radiation scientists Fairlie and Sumner estimate the number to be much higher – between 30,000 and 60,000 deaths.<sup>47</sup> Moreover, this does not take into account the long-term ill health that many people, including children, have suffered in the former Soviet Union. The nuclear disaster in Fukushima was smaller in scale. The official death toll was 573, not as a result of the incident but rather due to stress-related and other factors during evacuation from the area.<sup>48</sup>

SAIIA's research suggests that 'it is necessary to ensure the safe and secure handling of nuclear material, plants, reactors and waste disposal, of all existing and new nuclear programmes in Africa'.<sup>49</sup> This is a very important, and often contentious, aspect of nuclear

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41 Agence Marocaine de Sûreté et de Sécurité Nucléaires et Radiologiques (AMSSNuR), 'About', n.d., <https://amssnur.org.ma/vision-presentation-amssnur/>.

42 AllAfrica.com, 'Morocco: Nuclear safety - Morocco stresses the importance it attaches to international, African cooperation,' December 10, 2020, <https://allafrica.com/stories/20201210390.html>.

43 Khammar Mrabit, 'African expertise in nuclear safety and security: Opportunities and challenges,' FNRBA presentation, n.d., <https://www.afcone.org/wp-content/uploads/2021/04/05-FNRBA-Presentation-Dr-K-Mrabit-FNRBA.pdf>.

44 Mrabit, 'African expertise in nuclear safety.'

45 Mrabit, 'African expertise in nuclear safety.'

46 World Nuclear Association, 'Safety of nuclear power reactors,' March 2022, <https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx>.

47 Hannah Ritchie, 'Deaths from Chernobyl, deaths from Fukushima,' Our World in Data, July 24, 2017, <https://ourworldindata.org/what-was-the-death-toll-from-chernobyl-and-fukushima>.

48 Ritchie, 'Deaths from Chernobyl, deaths from Fukushima.'

49 SAIIA, 'Atoms for development advocacy campaign,' n.d., <https://saiia.org.za/project/atoms-for-development/advocacy-campaign/>.

energy which, as discussed in the preceding paragraph, comes with risks. Chernobyl and Fukushima are the most well-publicised nuclear disasters, but unless nuclear programmes are heavily regulated and strict safety and security measures are enforced at all times, there is potential for accidents, human error and malicious activity to occur. For instance, as a by-product of electricity generation from uranium, high levels of toxic radioactive waste are produced. These need to be stored safely and securely as they can cause cancer, blood diseases and bone decay.<sup>50</sup>

As a by-product of electricity generation from uranium, high levels of toxic radioactive waste are produced. These need to be stored safely and securely as they can cause cancer, blood diseases and bone decay

Compliance with strict safety and security standards is therefore paramount, especially to reduce exposure of both people and the environment to nuclear waste, including radioactive materials created as a by-product of uranium mining and extraction, and to ensure responsible management of by-products of nuclear medicine treatment, such as spent fuel rods and other radioactive materials. Such views are also supported by the IAEA. The agency's director general, Rafael Mariano Grossi, has been quoted as saying that 'nuclear [in Africa] definitely has a place at the table. It can play a vital part in countries' energy mix, but it is essential that they have a strong safety and security infrastructure in place'.<sup>51</sup>

According to Dr Kamen Velichkov, an expert on nuclear nonproliferation in Africa and Central Asia, 'there are rising public concerns over the use of nuclear energy in Southern Africa'.<sup>52</sup> He specifically notes two challenges: disposal of spent radioactive materials and transportation of nuclear materials. Regarding the former challenge, he raises the concern that 'the management and control of radioactive sources approaching the end of their economic lifetimes is sometimes unclear, resulting in the risk that such sources may escape regulatory monitoring'.<sup>53</sup> A counter-argument, however, is presented by Knox Msebenzi, of the Nuclear Industry Association of South Africa, who notes that disposal of nuclear waste is 'highly regulated by the IAEA and regional bodies and safely stored in concrete casks upon decommissioning of nuclear power plants'.<sup>54</sup> Regarding the latter challenge, Velichkov

50 Samuel Adams and Stephen Odonkor, 'Status, opportunities and challenges of nuclear power development in Sub-Saharan Africa: The case of Ghana,' *Progress in Nuclear Energy*, Vol. 138, August 2021, [https://www.sciencedirect.com/science/article/pii/S0149197021001827?casa\\_token=QrWVVKebIOAAAAA:ar77Vc\\_InGbLLGtXTTcKc96FUdDYg\\_JBvMTOrztZQAQ8d6LRsfnV4Zpw\\_YOhjpuaBdLj6U](https://www.sciencedirect.com/science/article/pii/S0149197021001827?casa_token=QrWVVKebIOAAAAA:ar77Vc_InGbLLGtXTTcKc96FUdDYg_JBvMTOrztZQAQ8d6LRsfnV4Zpw_YOhjpuaBdLj6U).

51 Yassine Chaari, 'Building robust, sustainable, resilient nuclear safety and security infrastructure.'

52 Velichkov, 'Synchronising nuclear governance in SADC member states.'

53 Velichkov, 'Synchronising nuclear governance in SADC member states.'

54 Knox Msebenzi, 'The Atoms for Africa's development: The case for nuclear power generation in Africa,' SAIIA Policy Briefing No. 244, June 2021, <https://saiia.org.za/research/atoms-for-africas-development-the-case-for-nuclear-power-generation-in-africa/>.

notes that transportation of nuclear materials takes place outside fixed nuclear facilities and has various potential points of vulnerability, such as in-transit stops and changes in the mode of transportation. This view is backed by research from the CNS, whose database shows that nuclear and radioactive materials are particularly vulnerable while in transit. For instance, in 2019 52% of incidents occurred during transportation of such materials.<sup>55</sup> A complication is that numerous stakeholders are involved, such as shippers, carriers, receivers, regulatory authorities and law enforcement agencies. He therefore calls for a 'comprehensive legal framework, with clearly defined roles and responsibilities, as well as effective planning, coordination and cooperation between all stakeholders, to ensure appropriate security during transportation'.<sup>56</sup>

**Governments in Southern Africa are increasingly starting to acknowledge the need for a stronger nuclear safety and security culture, which is important given that governments are key stakeholders driving nuclear builds**

On a more positive note, Velichkov says that governments in Southern Africa are increasingly starting to acknowledge the need for a stronger nuclear safety and security culture,<sup>57</sup> which is important given that governments are key stakeholders driving nuclear builds. Governments are also responsible for ensuring that relevant independent regulatory bodies are established and tasked with ensuring the safety and security of nuclear facilities and materials. Another positive development is the recent establishment by experts from 21 countries of an African Association of Radiopharmacy to strengthen their capacities in the safe preparation and administration of radiopharmaceuticals used in diagnosing, treating and managing cancer and other diseases.<sup>58</sup>

It is also extremely important for African states to work with the IAEA so that the agency can determine that there are no indications of undeclared nuclear activities or materials. This is achieved through a comparison of the consistency of the member state's declared nuclear programme with the conclusions of the IAEA's verification assessments. This involves conducting a comprehensive evaluation, performing a complementary access (if necessary), and addressing all anomalies, discrepancies and inconsistencies. As per the latest 2020 IAEA Safeguards Document, such evaluations were concluded for the following 11 African countries: Botswana, Burkina Faso, Ghana, Libya, Madagascar, Mali, Mauritius,

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55 Nuclear Threat Initiative, 'Overview of The CNS Global Incidents and Trafficking Database.'

56 Velichkov, 'Synchronising nuclear governance in SADC member states.'

57 Velichkov, 'Synchronising nuclear governance in SADC member states.'

58 Amal Elrefaei and Lisa Berthelot, 'First African Association of Radiopharmacy created to help improve diagnosis and treatment of diseases,' IAEA, April 12, 2022, <https://www.iaea.org/newscenter/news/first-african-association-of-radiopharmacy-created-to-help-improve-diagnosis-and-treatment-of-diseases>

Nigeria, Seychelles, South Africa and Tanzania. However, evaluations have not yet been completed for 28 other African countries: Angola, Benin, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, DRC, Djibouti, Eswatini, Ethiopia, Gabon, The Gambia, Kenya, Lesotho, Liberia, Malawi, Mauritania, Morocco, Mozambique, Namibia, Niger, Rwanda, Senegal, Togo and Uganda.<sup>59</sup>

The IAEA is also continuing to work with its African member states to establish national radiation emergency plans. In addition, it is providing ongoing assistance in the form of training, drills and exercises, while also improving the implementation of safety standards and strengthening capacity to respond to nuclear and radiological emergencies.<sup>60</sup> Furthermore, the IAEA recognises the challenges around nuclear waste management on the continent, specifically that 'inadequate waste management regulatory infrastructure, absent or incomplete waste inventories, inappropriate waste management facilities, and a limited number of properly qualified and experienced staff are serious shortcomings in some African countries.'<sup>61</sup> To assist in addressing these challenges, the IAEA, through the African Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology, launched a regional project to assist both the states that have not yet established a nuclear waste management infrastructure and those that have but need to further develop and improve it.<sup>62</sup>

Going forward, technology will undoubtedly play a major role in making nuclear energy safer. Yet the human factor remains as important as ever

Going forward, technology will undoubtedly play a major role in making nuclear energy safer. Yet the human factor remains as important as ever. While the Chernobyl plant's reactor had a design flaw, the actual accident occurred because of a 'remarkable range of human errors and violations of operating rules in combination with specific reactor features, which compounded and amplified the effects of errors', according to the IAEA's post-accident review report.<sup>63</sup> The Fukushima accident occurred as a result of a natural disaster – a tsunami, which the plant was not built to withstand. However, a Japanese investigation also uncovered disagreements and confusion. Better decisions during the

59 IAEA, 'Safeguards Statement for 2020,' <https://www.iaea.org/sites/default/files/21/06/statement-sir-2020.pdf>.

60 Amal Elrefaei, 'Strengthening radiological emergency preparedness in Africa: Second coordination meeting held in Vienna,' IAEA, July 31, 2018, <https://www.iaea.org/newscenter/news/strengthening-radiological-emergency-preparedness-in-africa-second-coordination-meeting-held-in-vienna>.

61 IAEA, 'Radioactive waste management infrastructure in Africa,' n.d., [https://www.iaea.org/sites/default/files/documents/tc/RAF30\\_06\\_0.pdf](https://www.iaea.org/sites/default/files/documents/tc/RAF30_06_0.pdf).

62 IAEA, 'Radioactive waste management infrastructure in Africa.'

63 World Nuclear Association, 'Chernobyl Accident 1986,' April 2022, <https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx#:~:text=The%20Chernobyl%20accident%20in%201986,in%20many%20parts%20of%20Europe>.

crisis could have reduced the severity of the accident.<sup>64</sup> Both accidents were marred by flaws in the design of the nuclear plants as well as human errors.

Technology always improves over time and nuclear technology is no exception. Scientists and technicians are constantly striving to improve the design of nuclear reactors, resulting in improved safety and enhanced performance. Most of the nuclear reactors in use today are Generation II reactors, with some Generation III reactors also in operation (specifically in Japan, with construction under way in other countries as well). Generation III reactors have a more rugged design, a lower possibility of core melt accidents and the ability to produce less waste.<sup>65</sup> Research and development of Generation IV reactors is also under way, which should further improve safety and performance.<sup>66</sup>

## Technology always improves over time and nuclear technology is no exception

Although nuclear plants are constructed with more safety features and there are numerous procedures and regulations in place, it is also important to ensure that ‘human errors’ do not negate technological advances in nuclear safety and security. Tellingly, over half the incidents reported in the CNS database are classified as ‘human failure’, the result of responsible personnel acting carelessly or not following due procedures.<sup>67</sup> J.H. Chung, the president and CEO of Korea Hydro & Nuclear Power Co. Ltd, makes an important point in this regard: the safety and security of nuclear facilities and nuclear materials can fail in an instant if due protocols and procedures are not followed or errors are made. Human resource development is therefore of utmost importance. Not only should only the best-qualified individuals be hired to work with nuclear technologies, but they should also be continuously capacitated through additional training and education.<sup>68</sup> A recent incident at South Africa’s Koeberg nuclear power station is testimony to this. In March 2022, a technician accidentally cut a valve on the reactor known as Unit 1 instead of cutting it on the reactor known as Unit 2 (which was down for scheduled maintenance) in an incident that ‘could have had devastating consequences’.<sup>69</sup> Shortly afterwards and unrelated to the

64 Richard Harris, ‘What went wrong In Fukushima: The human factor,’ NPR, July 5, 2011, <https://www.npr.org/2011/07/05/137611026/what-went-wrong-in-fukushima-the-human-factor#:~:text=What%20Went%20Wrong%20In%20Fukushima%3A%20The%20Human%20Factor%20Japanese%20officials,have%20reduced%20the%20accident's%20severity>.

65 World Nuclear Association, ‘Advanced nuclear power reactors,’ April 2021, <https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/advanced-nuclear-power-reactors.aspx>.

66 World Nuclear Association, ‘Generation IV nuclear reactors,’ December 2020, <https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/generation-iv-nuclear-reactors.aspx>.

67 Nuclear Threat Initiative, ‘Overview of The CNS Global Incidents and Trafficking Database.’

68 Adams and Odonkor, ‘Status, opportunities and challenges of nuclear power development.’

69 Sasha Planting, ‘Latest red flag raised at Eskom’s Koeberg station involves technician making a “critical error”,’ *Daily Maverick*, March 16, 2022, <https://www.dailymaverick.co.za/article/2022-03-16-latest-red-flag-raised-at-eskoms-koeberg-station-involves-contractor-making-a-critical-error/>.

incident, the IAEA team visited Koeberg (March 22-31, 2022) to conduct a SALTO review. A subsequent IAEA statement noted that the country's state utility and nuclear operator should 'comprehensively review and implement all plant programmes relevant for long-term operation of the Koeberg nuclear power station' and 'complete the revalidation of qualification of cables in the containment for the long-term operation period and ensure full functionality of the containment structure monitoring system'.

## Conclusion

Given the interest of at least 16 African states in embarking on nuclear builds or further developing their existing nuclear programmes – either with a view to adding nuclear to the energy mix and generating electricity or using it for research, training, medicinal and agricultural purposes – it seems that the continent will witness a significant expansion of its nuclear infrastructure and activities in the 2020s. When used peacefully, nuclear energy has the potential to help African states achieve their developmental goals ([see Atoms for Development advocacy campaign](#)), including the UN Sustainable Development Goals and the AU's Agenda 2063. Yet it is important to bear in mind the potentially devastating consequences if safety and security protocols are not strictly followed or if nuclear facilities or materials fall into the wrong hands as a result of a violent incident, such as a coup or an act of terrorism. Therefore, safety and security of both existing and planned nuclear programmes are of paramount importance.

Nuclear energy is likely to bring African countries immense socioeconomic benefits, but an extremely cautious and safety-first approach is required as any disaster could spill over into neighbouring states and across the region as a whole

African states should cooperate closely with AFCONE and the IAEA to ensure that all necessary standards, safeguards and regulations are adhered to. In addition, staff working at nuclear facilities and those who handle nuclear materials must be continuously trained and capacitated so that there are no 'weak links' in the chain. Nuclear energy is likely to bring African countries immense socioeconomic benefits, but an extremely cautious and safety-first approach is required as any disaster could spill over into neighbouring states and across the region as a whole.



# Recommendations

- It is essential that all African states, both those that already have nuclear programmes in place and those aspiring to establish them, cooperate with AFCONE and the IAEA in the areas of nuclear safety and security.
- African states that have not ratified the CPPNM should do so without further delay.
- African states should contribute to the IAEA Illicit Trafficking Database to improve nuclear security at the continental and global levels.
- Peer reviews and self-assessments should be undertaken by all African states, irrespective of how large or small their nuclear programmes are, to promote dialogue, cooperation, transparency and the sharing of best practices on the continent.
- Governments of African countries with existing nuclear programmes should ensure that a budget is set aside and time is allocated to training and capacity building of staff working on nuclear sites and with nuclear materials.
- Governments of African countries that are in the planning stages of nuclear development programmes should, as one of the first steps, prioritise the formulation of nuclear safety and security regulations, as well as the training of existing nuclear personnel and students aspiring to work in the industry on matters of safety and security.

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## Cover image

Uranium nitrate called uranyl, with uranium ore, radioactive material (RHJ/iStock)

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