SIPRI Policy Paper

39

November 2013

AFRICA AND THE GLOBAL MARKET IN NATURAL URANIUM

From Proliferation Risk to Non-proliferation Opportunity

IAN ANTHONY AND LINA GRIP

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE

SIPRI is an independent international institute dedicated to research into conflict, armaments, arms control and disarmament. Established in 1966, SIPRI provides data, analysis and recommendations, based on open sources, to policymakers, researchers, media and the interested public.

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE
Signalistgatan 9
SE-169 70 Solna, Sweden
Telephone: +46 8 655 97 00
Fax: +46 8 655 97 33
Email: sipri@sipri.org
Internet: www.sipri.org

Africa and the Global Market in Natural Uranium

From Proliferation Risk to Non-proliferation Opportunity

SIPRI Policy Paper No. 39

IAN ANTHONY AND LINA GRIP

STOCKHOLM INTERNATIONAL
PEACE RESEARCH INSTITUTE

November 2013

Printed in Sweden

ISSN 1652–0432 (print)
ISSN 1653–7548 (online)
ISBN 978–91–85114–81–8

Contents

Preface

Commercial activities related to mineral extraction are expected to contribute to the future economic development of many African countries. Malawi, Namibia, Niger and South Africa already supply uranium to the world civil nuclear industry, and there may be more than a dozen African countries where uranium extraction could play a significant role in national economic performance in the future. At the same time, African countries have made a strong commitment to support and promote nuclear disarmament. In the case of uranium, there may be a conflict of interest between national economic development and global security if supplies contribute to existing and potential nuclear weapon programmes.

This Policy Paper offers useful guidance on how proliferation risk can be reduced. Achieving inclusive and sustainable economic growth, and implementing effective measures to strengthen international security through disarmament and non-proliferation, require African countries to work in partnership both with each other and globally. The recommendations focus on pragmatic measures that would not be costly, and that would build on processes that African countries are already initiating and supporting to strengthen cooperation at regional and international levels.

I am grateful to the authors for writing this timely and highly policy-relevant report. The study was made possible by the generous support of the Norwegian Ministry of Foreign Affairs and the MacArthur Foundation, for which SIPRI is very grateful. The study would not have been possible without a successful partnership with the Institute for Security Studies in South Africa, and in particular the contributions made by Noel Stott and Amelia Broodryk. Thanks are due to reviewers at workshops in September 2013 in Vienna and in Copenhagen, and in particular to Anton Khlopkov for his thoughtful and valuable comments. I would like to acknowledge the cooperation and support of Elena Sokova at the Vienna Center for Disarmament and Non-proliferation and Cindy Vestergaard at the Danish Institute for International Studies for their help and support. Thanks are also due to Dr David Cruickshank of the SIPRI Editorial and Publications Department for editing this publication.

Professor Tilman Brück
Director, SIPRI
Stockholm, November 2013

Summary

African countries already contribute a significant share of the uranium used in the peaceful nuclear industry worldwide. This share may grow in the future, but at the moment the market price of uranium has put a number of projects on hold. This creates an opportunity to review and strengthen measures to reduce proliferation risks associated with uranium extraction in Africa.

African countries have made a clear choice that their uranium should never be used to make nuclear weapons—either by those countries that already have nuclear arsenals or those that may seek them in the future. If uranium is supplied to a country with an existing arsenal of nuclear weapons, or if it is supplied to a country with a complex nuclear fuel cycle, the risk of diversion away from peaceful use can never be reduced to zero. However, the management of uranium extraction should take account of both non-proliferation and nuclear security aspects.

Whenever uranium is supplied to a country that has a complex nuclear fuel cycle, there is a need for a systematic proliferation risk assessment. African countries should develop a full understanding of their extractive industries, to avoid the risk that uranium will be supplied from unconventional sources—for example, as a by-product of other mining activities. At the sites where uranium is being mined and while it is being transported, there is a need for proper and up-to-date physical security arrangements.

Extractive industries, including uranium extraction, represent an important economic asset for African countries that should contribute to the development of national economies. The need to manage and reduce proliferation risk must be balanced against the commercial importance of uranium extraction. Neither interest should be compromised. Therefore, non-proliferation measures need to be adapted to local circumstances and should not go beyond what is necessary to manage identified risks.

At the national level, a single focal point for issues related to uranium extraction could create better coherence to the system of governance and regulation. The focal point could be tasked with regular risk assessments, could be the facilitator for legislative review and could also be given the job of coordinating the administrative system for implementing regulations. The focal point can be the natural interlocutor for the representatives of the extractive industries.

A national system needs to be supported with the proper technical and human resources, and the system needs to be independent of those authorities tasked with promoting the development of extractive industry and marketing its output.

Internationally, the effectiveness of the national system will be greatly enhanced by different types of cooperation. Regular dialogue with the final customers for uranium can provide a uranium-supplier country with a better picture of the commercial transactions associated with the movement of national-origin uranium through the nuclear fuel cycle. This understanding could contribute to proliferation risk assessment and also help achieve equitable benefits from the

sale of national resources. For uranium suppliers, close cooperation with the providers of conversion and enrichment services would make a major contribution to proliferation risk assessment.

A common understanding of the proper conditions for safe and secure uranium supply among suppliers that participate in multilateral and regional arms control arrangements could make a valuable contribution to the global non-proliferation effort. This common understanding could be sought among uranium-supplier countries that are parties to the 1968 Non-Proliferation Treaty (NPT) and the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM) and the members of regional nuclear weapon-free zones.

There are a number of existing frameworks in which cooperation and harmonization and sharing of experiences and approaches to problem solving could be discussed. New institutions would not be needed. Examples include the opportunity for meetings at the margins of the International Atomic Energy Agency (IAEA) General Conference, discussions with the members of the Nuclear Suppliers Group, which has organized dialogue with non-participating states in the past, the network of African nuclear regulators that has already been created, consultations in the framework of the 1996 Treaty of Pelindaba and the arms control consultations that take place under the auspices of the African Union.

With a relatively modest investment, proliferation risks could be managed and reduced without compromising the opportunity to benefit from the development of the uranium-extraction industry in Africa.

Abbreviations

AU	African Union
CAD Fund	China–Africa Development Fund
CAR	Central African Republic
CNNC	China National Nuclear Corporation
CPPNM	Convention on the Physical Protection of Nuclear Material
DRC	Democratic Republic of the Congo
EITI	Extractive Industries Transparency Initiative
EU	European Union
GDP	Gross domestic product
CGNPC	China Guangdong Nuclear Power Company
IAEA	International Atomic Energy Agency
IMO	International Maritime Organization
ISO	International Standards Organization
NSG	Nuclear Suppliers Group
UN	United Nations
UOC	Uranium ore concentrate
WNTI	World Nuclear Transport Institute

1. Introduction

The actions of African countries will neither determine the number of nuclear weapons in the world, nor the identity of the countries that own them. But African countries have made a strong commitment to both preventing the spread of nuclear weapons and promoting steps to their ultimate elimination.

While the primary responsibility for nuclear arms control and disarmament lie elsewhere—and first and foremost with the states that possess nuclear weapons—there are limited, but not negligible, proliferation risks associated with uranium extraction in Africa. Nevertheless, with a relatively modest investment, countries in the region, in cooperation with external partners, could reduce those risks—although they can never be entirely eliminated.

The changing nature of the market for uranium

Uranium is a unique commodity. It differs from, for example, coal, copper or iron because it is the raw material from which nuclear weapons can be made (see box 1.1). For decades the international market for uranium was highly predictable and was largely managed through stable, long-term bilateral agreements between sellers and buyers with long experience of working together. For the most part, the market was managed by a small number of countries with a shared commitment to prevent the emergence of new nuclear-armed states.

At the start of the 21st century, the price of uranium oxide on commodities markets was roughly $10 per pound ($22 per kilogram). Between 2005 and 2007, the price increased sharply—from roughly $20 per pound ($44 per kg) to almost $140 per pound ($311 per kg)—and at this price, uranium extraction became a much more attractive business.[1] Decisions taken at that time may mean that new sources of supply are likely to join the market in the coming years. In particular, many African countries have commissioned surveys and exploration to identify new uranium deposits that could be commercially viable if exploited. Based on the results, a number of states are currently reviewing whether or not investment in uranium extraction is justified.[2] New African suppliers of uranium ore concentrate (UOC) may enter the global market in the coming decade.

The rapid increase in demand for uranium in the 1970s was mainly to fuel civil nuclear power reactors in the Euro-Atlantic community. However, since 2005 many of the main markets for uranium have been in Asia, and so not only new suppliers, but also new centres of demand are appearing. The way in which the

[1] For a historical time series of uranium oxide prices see InvestmentMine, 'Historical uranium prices and price chart', <http://www.infomine.com/investment/metal-prices/uranium-oxide/all>.

[2] As many as 15 African countries have uranium resources considered to be of commercial importance—i.e. they either make a significant contribution to the economy now or are likely to do so in the future. The countries are Algeria, Angola, Burundi, the Central African Republic, Chad, the Republic of the Congo, the Democratic Republic of the Congo, Gabon, Guinea, Malawi, Mali, Namibia, Niger, South Africa and Zambia. US Central Intelligence Agency (CIA), 'Natural resources', *The World Factbook* (CIA: Washington, DC, 2013), <https://www.cia.gov/library/publications/the-world-factbook/fields/2111.html>.

Box 1.1. Mining natural uranium and turning it into nuclear weapons

To constitute a nuclear proliferation threat, natural uranium needs to go through a challenging and time-consuming process of transformation as it moves through the nuclear fuel cycle.

Uranium extraction and milling

After natural uranium is extracted through mining it is usually processed into uranium ore concentrate (UOC), containing uranium oxide (most commonly U_3O_8, often called yellowcake, but also UO_4). The uranium rock from an open pit mine will be milled—that is, crushed and ground into small particles—before being chemically leached to produce a liquid slurry in which uranium ore is concentrated. The residue is dried and packaged for shipment to a convertor.

Conversion

Uranium conversion is the process by which unirradiated nuclear material, or irradiated nuclear material that has been separated from fission products, undergoes changes to its chemical or physical form so as to facilitate further use or processing. At conversion facilities, UOC is transformed, using chemical processes, into either uranium hexafluoride (UF_6) gas that can be the feedstock for centrifuges at a uranium-enrichment plant, or into an intermediate product that is then further transformed into UF_6. The conversion procedure will depend on the level of purity required in the UF_6, something that will in turn be dictated by the specific needs of the enrichment facility.

Enrichment and reprocessing

Making nuclear weapons or nuclear fuel requires access to an isotope or a mixture of isotopes capable of nuclear fission; such fissionable material does not exist in nature.

The isotope uranium-235 (^{235}U, or U-235) is fissionable. The natural uranium extracted from the earth through mining and then concentrated into UOC contains minute quantities of the isotope U-234, about 0.7 per cent of U-235, and 99.3 per cent of U-238. For use in nuclear reactors or nuclear weapons, the percentage of U-235 in the UF_6 has to be increased through enrichment. Low-enriched uranium (LEU) is uranium that has been enriched to less than 20 per cent U-235 (typically only 3–5 per cent). It is suitable for use in power reactors. Highly enriched uranium (HEU) has been enriched to contain at least 20 per cent U-235. While this is generally considered to be the lowest concentration that can be used in a nuclear weapon, weapon-grade uranium is usually enriched to over 90 per cent U-235.

Plutonium-239, which is produced through the atomic process that takes place inside the core of a nuclear reactor, is also fissionable. For use in weapons, the plutonium produced in a reactor must be separated from other reactor products and recovered by reprocessing the reactor fuel.

Sources: International Atomic Energy Agency (IAEA), *IAEA Safeguards Glossary: 2001 Edition*, International Nuclear Verification Series no. 3 (IAEA: Vienna, June 2002); and Glaser, A. and Mian, Z., 'Global stocks and production of fissile materials, 2012', *SIPRI Yearbook 2013: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2013), p. 326.

uranium market works has also been changing: it has become easier and more popular to sell uranium through the global commodities market.

Since 2007, the spot price for uranium has decreased again and is currently (as of November 2013) only $35 per pound ($78 per kg).[3] The volatile uranium market and low prices fit badly with the long-term operations and heavy investments required in the extractive industry. The market conditions have enhanced economic pressures on mining companies, which may translate into changes in

[3] Ux Consultancy Company, 'UxC nuclear fuel price indicators', <http://www.uxc.com/review/uxc_Prices.aspx>.

ownership or corporate takeovers and also increase pressure on national authorities to create a business climate that attracts investors.

The proliferation risks of uranium mining

States concerned about the potential implications of international transfers of proliferation-sensitive items have created mechanisms to help them regulate the spread of goods, materials and technologies that could contribute to the development of nuclear weapons. The best-known effort is probably the Nuclear Suppliers Group (NSG), in which participating states have coordinated national export controls on nuclear items since 1975 to reduce the risk that legitimate commercial trade will contribute to nuclear weapon programmes.

For a long time NSG participation was confined to a group of industrialized countries that accounted for almost all of the supply and demand for items especially designed and prepared for nuclear use. In the 1990s further consultation, among essentially the same group of states, led to agreement that international transfers of so-called dual-use items—not specially designed for nuclear use, but which could have nuclear applications—should also be screened against proliferation risk and approved for export by responsible authorities before leaving the jurisdiction of the exporting state.[4]

Over time, industrial development around the world has made both nuclear items and nuclear-related dual-use items more widely available. Even countries that are under close scrutiny because of international concerns over the way in which they are developing their nuclear programmes seem to be able to acquire sensitive items. Participation in arrangements like the NSG has expanded only gradually and still engages few developing countries.

A significant share—perhaps as much as one-third—of the UOC that is supplied to the global nuclear industry is provided by states that do not participate in the NSG.[5] South Africa is currently the only African country that participates in the NSG, and most of the significant UOC suppliers that are not members of the NSG are in Africa.

Although not all African countries participate in the NSG, they have all placed themselves under the global nuclear arms control legal *acquis*. However, there is convincing evidence that trade in controlled items also takes place between countries that are completely outside the international nuclear non-proliferation framework.[6] So far, the best efforts to create additional tools that could reduce or eliminate this trade—such as enhanced enforcement and interdiction efforts, the

[4] On the history and development of the NSG see Anthony, I, Ahlström, C. and Fedchenko, V., *Reforming Nuclear Export Controls: The Future of the Nuclear Suppliers Group*, SIPRI Research Report no. 22 (Oxford University Press: Oxford, 2007).

[5] See table 3.1 below.

[6] Squassoni, S. A., *Weapons of Mass Destruction: Trade Between North Korea and Pakistan*, Congressional Research Service (CRS) Report for Congress RL31900 (US Congress, CRS: Washington, DC, 11 Oct. 2006).

use of trade sanctions and other restrictive measures, or new forms of nuclear safeguards—do not seem to have had the desired impact.[7]

The main focus of efforts to reduce proliferation risk has been to further limit the spread of the industrial items and processes needed for the most sensitive stages of the fuel cycle—the enrichment or reprocessing that can turn uranium or plutonium into forms that could be used to make a nuclear weapon (see box 1.1).[8] However, despite the efforts by the countries that are most proficient in advanced nuclear industrial processes to construct 'higher walls' around the most proliferation-sensitive items, such items have become more widely available. This does not undermine the rationale for putting up barriers to proliferation. There is still a need for national export controls on nuclear items and nuclear-related dual-use items, and some have proved to be effective—for example, the acquisition of reprocessing technologies has been made difficult for proliferators. Efforts to further improve the effectiveness of export controls is justified, but experience suggests that a strategy based only on close monitoring of technology 'choke points' cannot, by itself, create a reliable barrier to the further proliferation of nuclear weapons.

If measures to control transfers of particularly sensitive items are no longer effective barriers to proliferation, perhaps a more comprehensive regulation of the nuclear fuel cycle 'from cradle to grave' is needed. As countries of proliferation concern achieve proficiency in the most sensitive industrial processes, restricting easy access to uranium could be one part of a comprehensive and integrated approach to non-proliferation across the fuel cycle.

Equitable benefits from uranium extraction

The management of risks associated with uranium extraction in Africa takes place in a specific domestic and regional political and economic context. For many African countries, extractive industries represent a significant economic activity. However, the sector also presents a paradox that was summarized in 2010 as follows: 'although the continent is strongly endowed with mineral resources, mining has not been the consistent engine of economic development that people in many countries have hoped for'.[9] There is a strong feeling in African countries that the benefits of extractive industry have not been shared in a fair way in the past, as well as a determination to bring about a more equitable

[7] E.g. despite the restrictive measures in place to reduce proliferation risks posed by the nuclear procurement activities of North Korea, it was able to acquire, install and operate centrifuges for uranium enrichment. Kile, S. N., 'Nuclear arms control and non-proliferation', *SIPRI Yearbook 2010: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2010), p. 392.

[8] The most important suppliers of nuclear technology have recently agreed guidelines to restrict access to the most sensitive industrial items, in the framework of the NSG. Bauer, S., 'Developments in the Nuclear Suppliers Group', *SIPRI Yearbook 2012: Armaments, Disarmament and International Security* (Oxford University Press: Oxford 2012).

[9] Bardouille, P., Hamblin, A. and Pley, H., 'Mining: unearthing Africa's potential', McKinsey & Company, June 2010, <http://www.mckinsey.com/insights/economic_studies/africas_path_to_growth_sector_by_sector>.

distribution in the future.[10] The concern over fairness has recently been reflected in the work of bodies such as the Group of Eight (G8) advanced industrial states. The 2013 G8 Summit focused on promoting global fairness through trade, taxation and transparency, and prominent issues on the agenda included facilitating trade in Africa while promoting greater transparency regarding the revenues from extractive industries and forestry.[11]

This strategy has three elements that are relevant to all mineral extraction, including uranium.

First, African countries are seeking new partnerships to complement and balance long-standing cooperation arrangements. For example, the rapid increase in Chinese investment in Africa has been the focus of a lot of attention.[12] The Chinese engagement in Africa has extended to the uranium-extraction industry.

Second, African countries are rebalancing long-standing cooperation arrangements in ways that maximize the economic benefits from extraction industries—from which uranium extraction is not excluded. For example, in September 2013 the Nigerien Government initiated an audit of uranium mines operated by the French company Areva in preparation for negotiation of a new long-term agreement to govern uranium extraction.[13]

Third, over time African countries are trying to increase the capacity for local companies to take responsibility for extraction, rather than depending on foreign mining companies. Recent reports suggest that African countries will increasingly use legislation to require foreign companies to educate, train and employ local staff in key positions in their African operations. Legislation will also compel significant local shareholding (although the share varies from country to country) in African operations.[14]

The main drivers of change in the extractive industries are not related to uranium extraction, which is a relatively minor economic activity in comparison to the mining of other minerals. These changes may have potential consequences for nuclear non-proliferation if new owners and operators that become active in the sector have an incomplete understanding of proliferation risk. However, the people whose decisions will ultimately shape the future of the uranium extraction industry are, first and foremost, motivated by local factors linked to economic development, not international security.

[10] E.g. Greve, G., 'Equal sharing of resource revenues essential for African stability', *Mining Weekly*, 13 July 2012.

[11] G8 Lough Erne Summit 2013, 'Lough Erne declaration', 18 June 2013, <http://www.international.gc.ca/g8/g8-declarations-declarations.aspx>.

[12] According to one recent report, Chinese official statistics record a growth in Chinese investment in Africa from $75 million to $1.5 billion between 2003 and 2007. Zadek, S. et al., *Responsible Business in Africa: Chinese Business Leaders' Perspectives on Performance and Enhancement Opportunities*, Corporate Social Responsibility Initiative Working Paper no. 54 (Harvard University, John F. Kennedy School of Government: Cambridge, MA, Nov. 2009), p. 8.

[13] Flynn, D. and Massalatchi, A., 'Niger audits Areva uranium mines, seeking better deal', Reuters, 20 Sep. 2013.

[14] KPMG Africa, *Mining in Africa: Towards 2020* (KPMG: Johannesburg, 2012).

The following chapters of this Policy Paper examine proliferation risks associated with the uranium-extraction industry more closely (chapter 2), provide an overview of uranium extraction in Africa (chapter 3), and describe and analyse the current legal framework for reducing proliferation risk in Africa (chapter 4). The final chapter draws conclusions about the adequacy of the current framework and suggests ways in which it could be improved.

2. Uranium extraction and proliferation risk

In conducting the field research for this Policy Paper in Africa, one question that was posed fairly frequently was why Africa should be in focus at all, given that the main nuclear proliferation risks are associated with parts of the nuclear fuel cycle that do not exist in Africa.

African countries have made a strong commitment to preventing the spread of nuclear weapons through their participation in key international agreements, both global and regional (see chapter 4). African countries have also lent their support to recent initiatives to reinvigorate the process of nuclear arms reductions, leading eventually to complete nuclear disarmament. For example, 11 of the 21 members of the Group of 21 non-aligned states in the Conference on Disarmament (the only permanent multilateral negotiating body focused on disarmament) are African states. Having strongly disassociated themselves from nuclear weapons, African countries have a clear interest not to take any action that could contribute to the acquisition of these weapons by countries that do not have them, or to increase the stockpiles of nuclear weapons in countries that do.

The proliferation risks that African countries are most likely to be exposed to can be briefly summarized as follows.

First, there is a risk that uranium will be supplied to a nuclear programme of proliferation concern with the knowledge and consent of the supplier state. This could happen if the state exporting the UOC does not carry out a satisfactory proliferation risk assessment, or if the state receiving the UOC does not have adequate safeguards in place or if its safeguards are implemented and interpreted in ways that facilitate proliferation. It could also happen if the legal provisions in agreements granting mining concessions are inadequate.

Second, there is a risk that uranium will be supplied to a programme of nuclear proliferation concern without the knowledge or consent of a supplier state. This could happen if, for example, uranium is supplied as a by-product from another type of mining activity. Uranium is one of the most ubiquitous elements in the earth and can be recovered from many different sources. The most common approach is to seek out rocks where the uranium content is high enough (and the extraction costs low enough) to make recovery profitable. However, uranium can be obtained as a by-product from mining other minerals, notably gold, or from industrial processes associated with, for example, the fertilizer industry, the ceramics industry and the manufacture of modern electronic devices (see chapter 3). If authorities are unaware that uranium is being exported, they will not have systems in place to regulate it.

A third risk is that uranium could be diverted from legitimate purposes to the illicit market. This could happen if the security arrangements at sites where uranium is extracted are inadequate. The theft of uranium in relatively small quantities but over an extended period could create a stockpile outside the knowledge and control of regulators. Another potential risk could be the loss of a shipment of uranium during transport, either on land or at sea.

After describing in the following section what happens to uranium once it leave the mine, the subsequent three sections focus on the three risks outlined above.

The flow of uranium during commercial transactions

The commercial relationships within the uranium sector have tended to work through stable long-term agreements between the companies that extract uranium and produce uranium ore concentrate on the one hand and the companies that own and operate nuclear power plants on the other.[15] While the specific terms of long-term uranium supply agreements are commercially confidential, it is believed that the price is normally based on the average market price for uranium over a given period, combined with an agreed price inflator applied over the duration of the contract. As a result, seen from the perspective of uranium suppliers, the customer base has not changed much over several decades.

For the most part, the companies engaged in generating electricity using nuclear reactors prefer to buy each of the different services that are needed along the supply chain—conversion, enrichment and fuel fabrication (see box 1.1)—separately in order to secure nuclear fuel. This approach allows the final customer to control costs and also maximizes security of fuel supply.

Customers have a strong interest in security of supply and want to be absolutely certain that they will get their fuel according to a firm schedule. In recent years the fluctuating price of uranium has awakened the interests of commodity traders and the spot market, which used to supply about 5 per cent of total global demand, has increased its share. However, it still only accounts for 10–20 per cent of uranium sales.[16] Because of the negative consequences of disruption in fuel supply, long-term contracts are likely to stay as the dominant model because of the stability they provide for the buyer and the seller.

With the full understanding of the supply chain that this approach ensures, a power company is able to tell the uranium-extracting companies how much UOC to deliver to which converter and when. Although the company operating a power plant is the customer, uranium-extraction companies have a close relationship with the converter, where the physical delivery of UOC takes place.

After a supplier delivers the agreed amount of UOC, the converter weighs the shipment and measures the concentration of uranium in it. Based on the results, the converter credits the account of the supplier with a given quantity of uranium.

The final customers of the uranium may have preferences for UOC from certain sources. For example, customers in Japan insist on uranium from Namibia

[15] Generic models of uranium purchase arrangements are described in Mulholland, J. P., Hering, J. and Martin, S., *An Analysis on Competitive Structure in the Uranium Supply Industry*, Staff Report (Federal Trade Commission, Bureau of Economics: Washington, DC, Aug. 1979). Current information illustrating commercial purchase arrangements can be found in US Energy Information Administration, *2012 Uranium Marketing Annual Report* (US Department of Energy: Washington, DC, May 2013).

[16] Information presented at 'Governing Uranium: Country Reports', Authors Workshop, Danish Institute for International Studies, Copenhagen, 23–24 Sep. 2013.

because the purchase agreement is considered to be part of Japan's development assistance to Africa. In contrast, the USA has put in place rules governing the origin of uranium in an attempt to protect US uranium mines from unfair competition.[17]

A uranium-supply contract is likely to commit a UOC supplier to make a good-faith effort to supply uranium from a specific source. However, this is probably not a rigid condition because of the risk that an unexpected event (e.g. a mining accident, flooding at a mine or a transportation failure) could disrupt the fuel supply. Moreover, uranium becomes completely fungible during conversion. The contract between a converter and the final customer will obligate the converter to deliver a specified amount of feedstock (uranium hexafluoride, UF_6) to the next point in the fuel cycle—an enrichment plant. In order to produce feedstock to the specifications required by the enrichment plant and to maximize the efficiency of the industrial process, the converter organizes the flow of material based on the chemical properties of the material that it has on site (possibly from a variety of sources mined by a variety of companies in a variety of countries). This makes it impossible for the uranium supplier to be confident that any commitment to supply the ultimate customer with uranium from a specific source is being implemented.

In addition, uranium suppliers also engage in various kinds of swap to meet their contractual obligations. Swapping uranium could be necessitated by a disruption in production that delays or prevents delivery from a specific source. In these cases a mining company may be forced to take material from inventory elsewhere in the company to make sure that it meets its contractual obligations. If necessary, the supplier might buy uranium, either on the open market or directly from another mining company, rather than miss a delivery to a converter. Swapping may also occur when it is convenient for suppliers to cooperate in order to reduce their costs. For example, if in a hypothetical case Converter A has a supply contract with Supplier X and Converter B has a contract with Supplier Y, it may be more convenient (due to e.g. location, transport costs, etc.) for Converter A to receive its uranium from Supplier Y and Supplier X to make a reciprocal shipment to Converter B.

Contractual guarantees on the origin of uranium are therefore met through a bookkeeping exercise based on material accountancy (tracking quantities and crediting or debiting uranium accounts accordingly), and not a physical exercise based on monitoring the movement of the actual material itself through the fuel cycle. Principles of equivalence and proportionality are applied so that equivalent quantities of material are designated to be of a particular origin for purposes of accountancy. These equivalent quantities, which would be of the same quality and concentration as the original material that entered the fuel cycle, would then be tracked through the different stages of processing. Thus, uranium designated

[17] Wilch, J. R., 'GATT and the half-life of uranium industry protection', *Northwestern Journal of International Law & Business*, vol. 10, no. 1 (spring 1989).

as being of African origin may in fact have been swapped or mixed with uranium from, for example, Australia or Kazakhstan.

Uranium supply to a programme of proliferation concern

The first category of proliferation risk is that uranium will be supplied to a nuclear programme of proliferation concern with the knowledge and consent of the supplier state. Not all the states that have developed a complex nuclear fuel cycle have naturally abundant uranium. This has created a global market for uranium that is relatively free compared with the market for sensitive technologies. For example, as noted in the introduction, the proliferation risks associated with uranium extraction attract relatively little attention compared to processes further along the nuclear fuel cycle, such as uranium conversion and enrichment.

Making sure that shipments are delivered safely and securely to the converter is one of the principal responsibilities of the state from which UOC is exported and the UOC-exporting company. Assessing the non-proliferation credentials of the converter will be a key task of the exporter to ensure that proliferation risk is minimized. One factor that will weigh heavily in that assessment is the country in which the conversion facility is based, in particular the standing of that country in relation to international arms control and non-proliferation norms and agreements. Another important factor will be the level of confidence that the converter has procedures in place to ensure that its products are only supplied to enrichment facilities that enrich uranium for peaceful uses.

There are relatively few companies or facilities in the world that offer uranium-conversion services, and most of these facilities are located in countries that have nuclear weapons.[18] A number of countries that do not have nuclear weapons also provide conversion services or have conversion plants located on their territory. However, those include countries, such as Brazil, that have explored the feasibility of producing nuclear weapons in the past and that still use enriched uranium for military uses, as fuel for a future generation of nuclear-powered submarines.

Given that converters are often located in countries that have a military dimension to their nuclear programme, there will always be some risk that nuclear material could be diverted from peaceful use. In a number of countries that possess nuclear weapons the risk of diversion is currently low because nuclear arms reductions have released significant amounts of weapon-usable fissile material. These countries currently have no need for additional weapon-usable fissile material, because existing stockpiles are more than adequate for any anticipated military requirement.[19] However, this is not true in all nuclear-weapon possessing states and cannot be guaranteed to be the case in the future in any of them.

[18] IAEA, *Country Nuclear Fuel Cycle Profiles*, Technical Reports Series no. 425, 2nd edn (IAEA: Vienna, May 2005), pp. 6–8.

[19] International Panel on Fissile Materials (IPFM), *Global Fissile Material Report 2013: Increasing Transparency of Nuclear Warhead and Fissile Material Stocks as a Step Toward Disarmament* (IPFM: Princeton, NJ, Oct. 2013), p. 11.

The way in which uranium moves through conversion means that it is a complicated exercise for an exporter to understand whether its uranium will be supplied to a country that possesses nuclear weapons. To the extent that the information needed to make that judgement exists, it is held further along the nuclear fuel cycle. Moreover, even if uranium were supplied to a country with nuclear weapons, it would be difficult for the original supplier to be certain that it went to a peaceful, as opposed to a military, purpose.

In interviews with SIPRI researchers, the governments of Malawi and Namibia reported that they have no means of tracking uranium once it is in the conversion facility.[20] Since the uranium is blended with uranium from other places in the conversion facility, the view is that following uranium beyond the conversion facility is not possible. However, one Namibian senior official said Namibia would welcome assistance on this issue.[21]

Supplies to India

At present, the outcome of ongoing deliberations in several countries over whether or not uranium can be sold to customers in India is the factor that could have the most important implications for traditional uranium suppliers. Given India's plans to increase the proportion of nuclear energy in its overall energy supply, most traditional uranium-extraction companies would want to be active in that market, provided that commercial activities do not compromise non-proliferation objectives.[22]

Several states have entered into bilateral civilian nuclear cooperation agreements with India, including Argentina, Canada, France, Kazakhstan, South Korea, Mongolia, Russia, the United Kingdom and the USA.[23] Negotiations are ongoing with Australia and Japan.[24] India's agreements with Canada, France, Kazakhstan, Mongolia and Russia reportedly include supply of uranium. The France–India agreement reportedly includes provisions for the supply of 300 tonnes of uranium to India, whereas the Russia–India agreement includes uninterrupted uranium supply.[25]

Given these agreements, it is difficult for the African countries that deliver UOC to converters in Canada, France and Russia to be certain that India will not be the ultimate destination of their uranium. The degree of confidence would be highest in uranium-supplier countries that have a full picture of how uranium

[20] Official, Malawian Department of Mines, Interview with author, Lilongwe, 18 Mar. 2013; Official, Malawian Ministry of Natural Resources, Energy and Environment, Interview with author, Lilongwe, 18 Mar. 2013; and Official, Namibian Ministry of Mines and Energy, Interview with author, Windhoek, 12 Mar. 2013.

[21] Official, Namibian Ministry of Mines and Energy (note 20).

[22] Institute for Defence Studies and Analyses (IDSA) Task Force, *Development of Nuclear Energy Sector in India* (IDSA: New Delhi, Nov. 2010).

[23] 'South Korea, India sign cooperation deal', World Nuclear News, 26 July 2011, <http://www.world-nuclear-news.org/np-south_korea_india_sign_cooperation_deal-2607114.html>; 'India-Kazakhstan nuclear cooperation agreement signed', World Nuclear News, 18 Apr. 2011, <http://www.world-nuclear-news.org/NP-India_Kazakhstan_nuclear_cooperation_agreement_signed-1804118.html>; and 'India, Mongolia sign civil nuclear deal', United Press International, 15 Sep. 2009.

[24] Yamamura, T., 'Status of nuclear cooperation with India', Japan Atomic Energy Agency Nuclear Non-proliferation Policy Letter no. 2, 28 Nov. 2012, <http://www.jaea.go.jp/04/np/nnp_pletter/0002_en.html>.

[25] Mishra, S., 'India's civil nuclear network: a reality check', *Air Power*, vol. 5, no. 4 (winter 2010), p. 117.

moves through the fuel cycle, rather than limiting the scope of their monitoring to delivery of UOC to the converter.

Three of the countries that have reached agreement on uranium supply to India—Argentina, Kazakhstan and Mongolia—are members of nuclear weapon-free zones.[26] The terms of the nuclear weapon-free zone treaties are rather consistent on the conditions of uranium supply. These three countries have decided that uranium supply to India is consistent with their nuclear weapon-free zone obligations. However, African countries have generally reached the opposite conclusion—that uranium supply to India would not be consistent with their obligations under the 1996 Treaty of Pelindaba (see chapter 4).

India and Namibia signed an Agreement on Cooperation in Peaceful Uses of Nuclear Energy in 2009, although Namibia has yet to ratify it.[27] While the agreement reportedly includes uranium supply from Namibia to India, in an interview with the authors in March 2013 Namibian authorities denied that the agreement granted India any automatic right to purchase uranium.[28] Exports from Namibia to India would require separate authorization.[29]

In South Africa, primary legislation—the 1999 Nuclear Energy Act—imposes conditions on supply of uranium.[30] Source material (including UOC) is only to be supplied to a nuclear weapon state on the condition that the material and equipment concerned is to be used only for peaceful purposes.[31] Source material can only be supplied to a non-nuclear weapon state on the condition that the material and equipment concerned will be subject to comprehensive international safeguards at all times. Under the current interpretation of the Nuclear Energy Act by the responsible authorities in South Africa, uranium supply to India is precluded.

The reputation of a country like Canada—with a long engagement in non-proliferation risk management—may be damaged by the nature of its agreement with India, which allows supply of uranium. If Australia, with a similar profile, also decides that sales to India can be managed at acceptable levels of risk, it could send a strong signal to other suppliers, including those in Africa, that supplying uranium to India is acceptable.[32]

[26] Argentina is a party to the 1967 Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco); Kazakhstan is a party to the 2006 Treaty on a Nuclear-Weapon-Free Zone in Central Asia (Treaty of Semipalatinsk); and Mongolia declared itself to be a single-state nuclear weapon-free zone in 1992, with effect from 2000.

[27] Indian Ministry of External Affairs (MEA), *Annual Report 2009–2010* (MEA: New Delhi, 2010), p. 61; and Indian High Commission to Namibia, 'Indo-Namibian bilateral relations', 1 Oct. 2013, <http://www.highcommissionofindia.web.na/Downloads/Bilateral Relations.pdf>, para. 17.

[28] 'Namibia gives India access to "world's best" uranium', *Economic Times* (New Delhi), 1 Sep. 2009.

[29] Kerr, P. K., *U.S. Nuclear Cooperation with India: Issues for Congress*, Congressional Research Service (CRS) Report for Congress RL33016 (US Congress, CRS: Washington, DC, 26 June 2012), p. 8.

[30] Nuclear Energy Act, Act no. 46 of 1999, assented to 20 Dec. 1999, commenced 24 Feb. 2000, *Republic of South Africa Government Gazette*, vol. 414, no. 20 759 (23 Dec. 1999), Article 35.

[31] According to the 1968 Non-Proliferation Treaty (NPT), only states that manufactured and exploded a nuclear device prior to 1 Jan. 1967 are legally recognized as nuclear weapon states. By this definition, China, France, Russia, the UK and the USA are the nuclear weapon states. See also chapter 4 in this volume.

[32] Thakur, R., 'Follow the yellowcake road: balancing Australia's national interests against international anti-nuclear interests', *International Affairs*, vol. 89, no. 4 (July 2013).

Supplies to Pakistan and China

Like India, Pakistan is both increasing the size of its nuclear weapons arsenal and making ambitious plans to increase the contribution that nuclear power makes to generating electricity. China is a third country that both has nuclear weapons and is expanding the role of nuclear energy in providing electricity. Approaches to uranium supply to Pakistan and China are sharply differentiated, and both cases contrast with the case of India described above.

It appears that no country is negotiating agreements for uranium supply to Pakistan. However, China—a long-standing partner in Pakistan's civil nuclear energy programmes—claims that its supply of uranium to Pakistan in the form of fuel for nuclear reactors is consistent with its non-proliferation commitments.[33]

China itself is an important customer for many uranium suppliers because of the scale of its plans for generating electricity using nuclear power. It is a nuclear weapon state as defined by the 1968 Non-Proliferation Treaty (NPT), and therefore different obligations pertain to uranium supply to China from the perspective of uranium suppliers.[34] However, given the general commitment of uranium suppliers not to take any action that assists or encourages research, development, manufacture, stockpiling, acquisition or possession of nuclear weapons, a supplier must consider how confident it can be that its uranium will not be used in China's military nuclear programmes.

Supplies to other countries

At different times, the level of proliferation concern raised by certain countries has changed.[35] As noted above, proliferation concerns around Brazil used to be much higher than they are today, and the same applies to Argentina and South Africa. In contrast, concern over nuclear weapon proliferation in Iran used to be relatively low, but today it is the centre of a great deal of attention largely because of the way in which it has developed its nuclear fuel cycle.[36]

As the situation can change over time, a uranium-exporting country needs to have the necessary legal powers to modify UOC export arrangements if necessary. This would not only apply to the legal powers of national authorities, but also the powers available to mining companies if, for example, proliferation concerns related to a foreign shareholder grow to the point at which the risk of continuing UOC supply is considered too high.

The need to ensure that adequate legal powers exist to exclude foreign shareholders from a uranium project is becoming a mandatory requirement on states. United Nations Security Council Resolution 1929 of 2010 imposed new restric-

[33] 'China says Pakistan nuclear deal "peaceful"', BBC News, 17 June 2010; and Bukhari, S. S. H. and Attiq-ur-Rehman, 'Pakistan–China nuclear deal & international fictions', *Berkeley Journal of Social Sciences*, vol. 1, no. 3 (Mar. 2011), p. 3.

[34] See note 31; and chapter 4 in this volume.

[35] See e.g. Hirdman, S., 'The near nuclear countries and the Non-Proliferation Treaty', *World Armaments and Disarmament: SIPRI Yearbook 1972* (Almqvist and Wiksell: Stockholm, 1972).

[36] See e.g. Kile, S. N., 'Iran and nuclear proliferation concerns', *SIPRI Yearbook 2013: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2013).

Table 2.1. Concentrations of uranium and thorium in unconventional resources

Figures are parts per million (ppm). All figures are approximate.

	Uranium concentration		Thorium concentration	
Mineral concentrate	Typical	Average	Typical	Average
Monazite	500–11 000	4 000	10 000–140 000	70 000
Tantalum concentrates	1 000–4 000	. .	100–500	. .
Typical uranium mine ore	500–5000	. .	. .	. .
Tin concentrates	100–500		100–500	
Zircon sands	50–700	250	50–450	150
Phosphate[a]	30–180	. .	. .	. .
Fly ash from thermal coal	10–40	. .	. .	. .
Thermal coal	0.1–9.0	1.3	. .	. .

[a] There are reports of unusual deposits of phosphates with uranium concentrations of 300–800 ppm.

Source: Everton, C., Australian Safeguards and Non-proliferation Office, Presentation at the SIPRI seminar 'The Global Market in Natural Uranium: Minimizing Proliferation Risks', Vienna, 17 Sep. 2013.

tive measures in response to the proliferation concerns arising from the Iranian nuclear programme.[37] One of the resolution's provisions is that 'Iran shall not acquire an interest in any commercial activity in another State involving uranium mining, production or use of nuclear materials and technology'.

At present a mining company may accept investment from any country other than Iran either into the parent company or, if it is operating internationally, into one or more affiliates in other countries. However, Resolution 1929 suggests that companies need to be aware of the current risk posed by investors and recognize that countries considered safe investors today may represent a proliferation risk in future. Therefore, mining companies need to develop internal rules, and mechanisms to enforce them, that minimize any proliferation risks that they identify. National laws need to protect companies from potential legal action by investors if the conditions of their investment change based on a new proliferation risk assessment.

In the final analysis, it will be for a uranium-exporting country to decide how much risk to accept. However, a systematic and sustained process for proliferation risk assessment is necessary.

Uranium supply outside the framework of current regulations

The second category of risk is that uranium supply may take place inadvertently, and outside the existing rules. Uranium extraction can be a side activity connected to, for example, gold mining or the extraction of phosphates (see chapter 3). Advances in technology are also making it commercially viable to recover residual quantities of uranium from what was previously regarded as waste

[37] UN Security Council Resolution 1929, 9 June 2010.

material. At the extreme, uranium can be extracted from seawater, and while the cost of doing this has been a barrier to commercial exploitation, future developments may reduce those costs.[38] The governance system for uranium should therefore be under continuous review to ensure that all activities that could lead to uranium extraction are covered, not only those where uranium extraction is the main stated objective.

There are a number of unconventional resources from which uranium is only recoverable as a minor by-product. The total amount of uranium in unconventional resources is estimated to be about 22 million tonnes—three times the volume of identified conventional resources (defined as reasonably assured resources and inferred resources).[39] Unconventional sources have different uranium concentration levels (see table 2.1). The sources with the highest uranium concentrates are monazite and tantalum concentrates, which have many applications in ordinary commercial products, such as electronic devices, ceramics and tiles.

Significant amounts of uranium have been recovered from phosphate rocks in the past, and the world's largest reserves of phosphate rocks are located in North Africa and the eastern Mediterranean (see chapter 3). Uranium has also been extracted from tantalum concentrates and mineral sands. Although unconventional resources are currently not a major source of uranium for civil nuclear purposes, they could be used increasingly in the future. Some projects are already in development to explore commercial uranium extraction from these sources.[40]

It is important that all actors involved in activities that could lead to the recovery of uranium from unconventional sources are aware of the potential proliferation risks. As a first step, national authorities need to undertake a comprehensive survey of all activities taking place in their territory that could lead to uranium recovery. Once these activities are identified, they—along with all of the actors involved—need to be incorporated into the national proliferation risk assessment. The authorities then need to put mechanisms in place to mitigate any identified risks.

Loss of custody and failures of physical protection

A third category of risk is that uranium ore concentrate could be diverted, either from the site where it was processed or during transport, so the legitimate owners no longer have control over it or how it is used. There is therefore a need for physical protection of the ore concentrate at both mining and milling sites and during transport to reduce the risk of diversion.

[38] Orcutt, M., 'Novel material shows promise for extracting uranium from seawater', *MIT Technology Review*, 16 May 2013.

[39] Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency and International Atomic Energy Agency (IAEA), *Uranium 2011: Resources, Production and Demand*, 'The Red Book' (OECD: Paris, 2012). The Red Book has been published biennially since the mid-1960s by the OECD Nuclear Energy Agency and the IAEA.

[40] Sole, K. C., Feather, A. M. and Cole, P. M., 'Solvent extraction in southern Africa: an update of some recent hydrometallurgical developments', *Hydrometallurgy*, vol. 78, nos 1–2 (July 2005).

UOC is usually produced at facilities close to mines—often at the mining site itself—to avoid the cost and inconvenience of transporting large quantities of heavy ore in raw form to a processing plant. The UOC is then usually packed into standard 205-litre steel drums, which, in turn, are put into standard 20-foot ISO freight containers (*c.* 6 metres long) for onward movement by road, rail or sea for further processing.[41]

The loss of custody of a full container during transport would be a serious proliferation risk in itself. There does not appear to be a fully standardized approach to the transport of drums of UOC.[42] The weight of each drum also appears to vary, from 372 to 400 kilograms.[43] The minimum proportion of uranium in the ore concentrate in the drum is 65 per cent, and in most cases will probably be much higher.[44]

In a scenario where one freight container carries 43 drums, each containing 400 kg of UOC with 85 per cent uranium content, the container will be carrying roughly 15 tonnes of natural uranium. Using these assumptions, which seem reasonable, each such freight container contains what the International Atomic Energy Agency (IAEA) considers to be enough uranium to produce, after conversion, enrichment and fabrication, one or possibly two nuclear explosive devices.[45] The IAEA considers a 25 kg quantity of 90 per cent highly enriched uranium (HEU) to represent the minimum amount of fissile material that, if diverted from peaceful purposes, could be used without further chemical separation or enrichment to manufacture a nuclear explosive device.[46]

From the brief discussion above, it can be concluded that the activities taking place in Africa do carry some proliferation risk, even though few African countries have an advanced nuclear fuel cycle as of today. The degree of risk should not be exaggerated. There is no evidence that African countries play any role in the programmes of countries that are armed with nuclear weapons. However, as more African countries become uranium suppliers, and if countries of nuclear proliferation concern diversify their sources of supply, there is a need for both vigilance and mitigation of proliferation risks.

[41] Rouse, T., Cameco Corp., 'Control of uranium ore concentrate', Presentation at IAEA Regional Seminar on Good Practices in the Processing and Control of Uranium Ore Concentrate, Windhoek, 23–27 Apr. 2012, <http://www.aebofnamibia.org/index.php?option=com_content&id=70>, p. 19.

[42] Cameco, a uranium-mining company, states that its usual packaging arrangement is 'approximately 43' barrels per container. Cameco Corp., 'Milling: from ore to yellowcake', Uranium 101, 2013, <http://www.cameco.com/uranium_101/mining-milling/milling/>. However, in theory more barrels can fit in a standard 20-foot container (probably ignoring packaging regulations): one source estimates 72–80 barrels. All Star Link Logistics Co. Ltd, 'ISO tank', <http://www.asl-tpe.com/asl/business-items/iso-tank?set_language=en>.

[43] Australian Uranium Council, *Guide to Safe Transport of Uranium Oxide Concentrate* (Department of Resources, Energy and Tourism: Canberra, 2012), p. 16.

[44] ASTM International, 'Standard specification for uranium ore concentrate', Active Standard ASTM C967-13, 2013, p. 1; and World Nuclear Association, 'The nuclear fuel cycle', Dec. 2012, <http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Introduction/Nuclear-Fuel-Cycle-Overview/>.

[45] According to the IAEA physical model, *c.* 7 tonnes of UOC are required to produce 1 significant quantity of HEU (assuming 90% enrichment and tails of 0.25%). International Atomic Energy Agency (IAEA), *Physical Model*, vol. 1, *Mining and Milling*, STR-314 (IAEA: Vienna, 1999), p. 2.

[46] Cochran, T. B. and Paine, C. E., *The Amount of Plutonium and Highly Enriched Uranium Needed for Pure Fission Nuclear Weapons* (National Resources Defense Council: Washington, DC, 13 Apr. 1995).

3. The uranium market

The demand for uranium: customers and quantities

The annual global demand for uranium in 2013 is estimated to be approximately 66 500 tonnes.[47] The main source of the demand is the need for nuclear reactor fuel. There are currently 435 nuclear reactors connected to national grids, a further 67 are under construction and another 484 are either planned or proposed for construction within 15 years.[48] States in the European Union (EU) and North America currently consume almost two-thirds of the global uranium output; however, this will change in the near future as nuclear power projects are expanding primarily in Asia and Eastern Europe, including in China, India, South Korea, Russia, Ukraine and the United Arab Emirates.[49]

China's demand for nuclear power generation grew by an annual average of 37 per cent in the period 1993–2004 (compared to a global annual growth rate of 2 per cent).[50] Between 2010 and 2030 China's demand for uranium is estimated to increase fivefold.[51] Currently, 15 reactors are operating in China, 26 are under construction and 51 are planned. India plans to increase its number of reactors by 25 and Russia plans 34 new reactors in the near future. South Korea is another growing uranium consumer, with 9 new reactors set to start production by 2030.[52]

Global demand for yellowcake is expected to increase to 103 000 tonnes by 2020 and to 127 000 tonnes by 2030.[53] The increase is strongly influenced by demand for fuel for initial reactor cores: when a new standard 1000-megawatts-electric light water reactor is commissioned it requires around 600 tonnes of uranium for its initial core; once the reactor has reached a steady state of operation, uranium requirements decline.[54]

The global annual output of mined uranium is approximately 55 000 tonnes (see table 3.1). The gap between demand and mined output is met by secondary sources of supply, of which the most important is the uranium released from weapon stockpiles. At the end of 2013, the 20-year programme to downblend 500 tonnes of HEU released from dismantled Russian nuclear weapons into

[47] Williams, L., 'Uranium: poised for another boom?', Mineweb, 1 May 2013, <http://www.mineweb.com/mineweb/content/en/mineweb-europe-and-middle-east?oid=188453&sn=Detail>; and Pistilli, M., 'Uranium outlook 2013: rebound on the horizon', 3 Jan. 2013, <http://uraniuminvestingnews.com/13407/uranium-outlook-2013-rebound-demand-supply-price-market.html>.

[48] Williams (note 47).

[49] Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency and International Atomic Energy Agency (IAEA), *Uranium 2009: Resources, Production and Demand*, 'The Red Book' (OECD: Paris, 2010).

[50] Mollard, W. S., Rumley, C., Penney, K. and Curtotti, R., '*Uranium Global Market Developments and Prospects for Australian Exports*, Australian Bureau of Agricultural and Resource Economics (ABARE) Research Report no. 06.21 (ABARE: Canberra, Nov. 2006), p. 8.

[51] Mollard et al. (note 50), p. 28.

[52] World Nuclear Association, 'World nuclear power reactors & uranium requirements', 1 Oct. 2013, <http://www.world-nuclear.org/info/reactors.html>.

[53] Pistilli (note 47).

[54] OECD Nuclear Energy Agency and IAEA (note 39); and Mollard et al. (note 50), pp. 27–28.

Table 3.1. Uranium production from mines, 2005–12

Figures are tonnes of uranium.

Country	2005	2006	2007	2008	2009	2010	2011	2012
Kazakhstan	4 357	5 279	6 637	8 521	14 020	17 803	19 451	21 317
Canada	11 628	9 862	9 476	9 000	10 173	9 783	9 145	8 999
Australia	9 516	7 593	8 611	8 430	7 982	5 900	5 983	6 991
Niger[a]	3 093	3 434	3 153	3 032	3 243	4 198	4 351	4 667
Namibia	3 147	3 067	2 879	4 366	4 626	4 496	3 258	4 495
Russia	3 431	3 262	3 413	3 521	3 564	3 562	2 993	2 872
Uzbekistan	2 300	2 260	2 320	2 338	2 429	2 400	2 500	2 400
United States	1 039	1 672	1 654	1 430	1 453	1 660	1 537	1 596
China[a]	750	750	712	769	750	827	885	1 500
Malawi	–	–	–	–	104	670	846	1 101
Ukraine[a]	800	800	846	800	840	850	890	960
South Africa	674	534	539	655	563	583	582	465
India[a]	230	177	270	271	290	400	400	385
Brazil	110	190	299	330	345	148	265	231
Czech Republic	408	359	306	263	258	254	229	228
Romania[a]	90	90	77	77	75	77	77	90
Germany	94	65	41	–	–	8	51	50
Pakistan[a]	45	45	45	45	50	45	45	45
France	7	5	4	5	8	7	6	3
World total	**41 719**	**39 444**	**41 282**	**43 764**	**50 772**	**53 671**	**53 493**	**58 394**
Tonnes U_3O_8	**49 199**	**46 516**	**48 683**	**51 611**	**59 875**	**63 295**	**63 084**	**68 864**
Share of world demand (%)	*65*	*63*	*64*	*68*	*78*	*78*	*85*	*86*

[a] Figures for these countries are estimates.

Source: World Nuclear Association, 'World uranium mining production', July 2013, <http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Mining-of-Uranium/World-Uranium-Mining-Production/>.

14 000 tonnes of low enriched uranium suitable for use in nuclear fuel fabrication will be complete.[55] The USA has relied on Russian downblending to provide half of the uranium fuelling its nuclear reactors, or 10 per cent of its electricity.[56] The USA has itself declared 209 tonnes of HEU released from dismantled nuclear weapons as surplus. Agreed projects will make use of 175 tonnes of this, of which 119 tonnes has already been downblended and released for commercial use. The remaining 34 tonnes is expected to be committed to projects by 2050.[57]

[55] On the project, which is implemented on behalf of the USA by the US company USEC, see USEC, 'Megatons to megawatts', May 2013, <http://www.usec.com/russian-contracts/megatons-megawatts>.

[56] Casey Research, 'Putin's power play to change the uranium mining sector', Market Oracle, 15 May 2013, <http://www.marketoracle.co.uk/Article40467.html>.

[57] On the programme to dispose of HEU declared surplus in the USA see US Department of Energy, National Nuclear Security Administration, 'U.S. HEU disposition program', <http://nnsa.energy.gov/aboutus/ourprograms/dnn/fmd/heu>.

As secondary supplies are reduced, reactor requirements will have to be increasingly met by mine production.[58] For this reason, investors in general believe that uranium prices are currently highly undervalued.[59]

While overall nuclear electricity production is projected to increase in the period up to 2030, the share of nuclear power in global electricity generation is projected to fall, from around 16 per cent in 2005 to 12 per cent in 2030.[60] This fall is mainly driven by slow growth in nuclear power generation in North America and the decommissioning of many existing plants in the EU. In these markets natural gas is increasingly seen as a preferred fuel for power generation.[61] Moreover, some additional reactors are likely to be withdrawn from operation for technical or political reasons. More effective use of uranium during fuel fabrication and energy production would also affect demand. Combined, these reasons increase the uncertainties that could influence the price of uranium and make it more volatile and less predictable.

The changing shares of the global market

In 2012, 19 states reported ongoing uranium production from mines, including 4 African states (see table 3.1).

The largest producer, Kazakhstan, has vastly increased its production in the past decade, and now supplies one-third of all uranium from mines. By 2017, it aims to increase annual production by a further 37 000 tonnes.[62] Although Russia was the sixth-largest uranium producer from mines in 2012, if production from downblending of nuclear weapons is included, it was the second-largest producer. While the USA doubled its domestic uranium production between 2004 and 2006 and China doubled its production between 2004 and 2012, Australia reduced production by 30 per cent between 2005 and 2011. This is despite the fact that Australia has much larger known uranium reserves than Kazakhstan.

The four African states that currently produce uranium—Malawi, Namibia, Niger and South Africa—together produced 10 700 tonnes of uranium in 2012, 18 per cent of world output (see table 3.1). Namibia accounted for 8.0 per cent of global production, Niger for 7.7 per cent, Malawi for 1.9 per cent and South Africa for 0.8 per cent. Unlike most other producing states, all uranium extracted in African states is exported, so their shares of the world market are higher than the production shares suggest. In particular, this gives the largest African producers—Namibia and Niger—higher statuses as uranium suppliers relative to their overall uranium output.[63]

[58] Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency and International Atomic Energy Agency (IAEA), *Uranium 2007: Resources, Production and Demand*, 'The Red Book' (OECD: Paris, 2008), pp. 11–12.

[59] Pistilli (note 47).

[60] Mollard et al. (note 50), pp. 26–27.

[61] Mollard et al. (note 50), pp. 26–27.

[62] Kazatomprom, 'Uranium mining', 2008, <http://www.kazatomprom.kz/en/pages/Uranium_Mining>; and OECD Nuclear Energy Agency and IAEA (note 39), pp. 70–71.

[63] Dasnois, N., *Uranium Mining in Africa: A Continent at the Centre of a Global Nuclear Renaissance*, South African Institute of International Affairs (SIIA) Occasional Paper no. 122 (SIIA: Sep. 2012), p. 5; and Inter-

Africa's share of the global uranium market remained relatively small for many decades, due to the low price of uranium, the high cost of establishing and running a uranium mine, political instability, an adequate supply of uranium from mines in Australia, Canada and the USA, and the ready availability of uranium from dismantled weapons in military nuclear stockpiles.[64] However, this is likely to change in the near future. In an Australian Government research report from 2006, Namibia, Niger and South Africa were listed among seven countries with 'the potential to significantly increase uranium mining capacity' in the medium-to-long term due to their large identified uranium resources.[65] There is generally strong government support to expand uranium mining: several projects are in the pipeline in the four African countries that currently mine uranium, and Russian companies have signed contracts to start mining in Nigeria and Tanzania.[66]

Four multinational corporations account for the vast majority of African uranium production: the French conglomerate Areva, the Anglo-Australian group Rio Tinto, the Australian company Paladin Energy and the South African gold-mining company AngloGold Ashanti.[67] All but Paladin Energy, which started investing in uranium-exploration projects in the late 1990s and is now a medium-sized company in the sector, have long experience in uranium mining.

Increasingly, African uranium is attracting interest from emerging economies, in particular China and India. China continues to make large-scale investments in resource-rich African states. Chinese investments in Africa are facilitated through the China–Africa Development Fund (CAD Fund), a large private equity fund. China Uranium Corporation—a subsidiary of the state-owned conglomerate China National Nuclear Corporation (CNNC)—has signed an agreement with the CAD Fund to jointly develop uranium resources in Africa.[68] In Niger, 37.2 per cent of Société des Mines d'Azelik (Somina), the operating company of Azelik mine, is owned by China Nuclear International Uranium Corporation (Sino-Uranium), another subsidiary of CNNC, and 24.8 per cent is owned by another Chinese company, ZXJOY Invest Corporation.[69] The Chinese state-owned company China Guangdong Nuclear Power Company (CGNPC) co-owns the Husab

national Atomic Energy Agency, 'Uranium mining in Africa: gathering momentum', 4 May 2012, <http://www.iaea.org/OurWork/ST/NE/NEFW/News/2012/repository/Uranium-mining-in-africa.html>.

[64] Dasnois (note 63), p. 5.

[65] Mollard et al. (note 50), pp. 2, 38.

[66] Sole, K. C., Coleb, P. M., Featherc, A. M. and Kotzed, M. H., 'Solvent extraction and ion exchange applications in Africa's resurging uranium industry: a review', *Solvent Extraction and Ion Exchange*, vol. 29, nos 5–6 (2009), p. 869; and Muchira, J., 'Russian group planning to start uranium mining in Tanzania after granting of licence', *Mining Weekly*, 19 Apr. 2013; and 'Russia and Nigeria agree to cooperation', World Nuclear News, 19 Mar. 2009, <http://www.world-nuclear-news.org/NP-Russia_and_Nigeria_agree_to_cooperation-1903094.html>.

[67] ten Kate, A. and Wilde-Ramsing, J., *Radioactive Revenues: Financial Flows between Uranium Mining Companies and African Governments* (Center for Research on Multilateral Corporations/World Information Service on Energy: Amsterdam, Mar. 2011), p. 1.

[68] 'CNNC, China–Africa Dev't Fund to develop uranium in Africa', China Knowledge, 2 Sep. 2010, <http://www.chinaknowledge.com/Newswires/News_Detail.aspx?NewsID=36606>.

[69] Dasnois (note 63), p. 8; and Societé du Patrimoine des Mines du Niger (Sopamin), 'Les chiffres de la Sopamin' [Sopamin's figures], <http://www.sopamin-sa.com/?q=node/48>.

uranium mine in Namibia (see below). China has also expressed an interested in cooperation with Russia on uranium production in Africa.[70]

The following subsections describe recent mining developments in Namibia, an established uranium producer, as well as in two emerging producers, Malawi and Tanzania.

Namibia

Between 2005 and 2012 Namibia's uranium production increased by nearly 50 per cent to almost 4500 tonnes per year (see table 3.1). The Namibian Government is considering new mines as well as expansions of the existing Rössing and Langer Heinrich mines.[71]

In 2011–12 a joint venture between Epangelo Mining, a Namibian Government company (see below), the CAD Fund and CGNPC bought the Husab mine from the Australian-listed company Extract Resources. Construction at the mine started in April 2013 and production is planned to start in late 2015, with a lifespan of almost 20 years.[72] Husab has been estimated to be the largest uranium-only deposit in the world and the richest deposit in Namibia. When production starts, it will be the second-largest uranium mine in the world (after Olympic Dam, Australia), producing 5800 tonnes of uranium annually—more than Namibia's current total production.[73]

Several other new mines are predicted to open for production in Namibia within the next few years. Trekkopje mine, developed by Areva's subsidiary UraMin, was expected to start production in 2013, but the project was suspended in October 2012 pending a rise in the uranium price.[74] Other future mining sites include Valencia (developed by Forsys Metals, Canada) and Etango (developed by Bannerman Resources, Australia), due to open in 2016.[75]

The amount of uranium that will be extracted from the new mines in Namibia is estimated to total 11 000–13 000 tonnes per year, equal to 20–25 per cent of the current global supply from mining.[76]

Malawi

Malawi started extracting uranium in 2009; by 2012 it was the world's 10th-largest uranium producer. After years of exploration and investigation into the prospect of developing uranium mining in Malawi, Paladin Energy was granted a licence in April 2007. Uranium production began in 2009 at the Kayelekera mine in northern Malawi.[77] As of 2012, 2700 tonnes had been mined and Malawi now

[70] Wise Uranium Project, 'New uranium mining projects: Africa', 26 Sep. 2013, <http://www.wise-uranium.org/upafr.html>.

[71] Menges, W., 'Uranium licence challenge fails', *The Namibian*, 15 Feb. 2011.

[72] 'Chinese-invested Husab uranium mine kicks off construction in Namibia', Xinhua, 19 Apr. 2013.

[73] Sole et al. (note 66), pp. 871–72.

[74] Els, F., 'Areva mothballs Namibia uranium mine', Mining.com, 12 Oct. 2012, <http://www.mining.com/areva-to-mothball-trekkopje-project-42349/>.

[75] OECD Nuclear Energy Agency and IAEA (note 39), p. 71, table 1.27.

[76] OECD Nuclear Energy Agency and IAEA (note 39), p. 71.

[77] Paladin (Africa) Ltd, 'Kayelekera mine, Malawi, Southern Africa: in production ramp-up', Sep. 2010, <http://media.corporate-ir.net/media_files/irol/17/176316/kayelekera.pdf>; and Brown, D., 'Uranium mining

produces more uranium than South Africa. In a full operating year, the Kayelekera mine will produce 1250 tonnes of uranium.[78] Malawi's limited reserves—estimates range from 8100 to 15 100 tonnes—mean that this level of production will not last long.[79]

Malawi has two other main uranium mines: Globe Metals and Mining's Kanyika Niobium Project and Resource Star's Livingstonia mine. Their uranium reserves are much smaller than those at Kayelekera, with the Kanyika Niobium Project having the possibility of producing uranium as a by-product sourced from a single open pit mine.[80]

Current estimates suggest that Malawi could have 12 uranium mines in the future. In 2011 Malawi had issued 30 exploration permits and 1 mining permit to explore and exploit the country's uranium reserves.[81] At the time of research, foreign companies actively involved in uranium exploration were from Australia (Paladin Africa, Globe Metals and Mining, and Balmain Resources), South Africa (Gondo Resources and Tanaka Resources), China (ZXJOY Invest Corporation) and the UK (African Consolidated Minerals and Retail Star).[82] The Australian company Resource Star has three pending applications in Malawi.[83] Resource Star describes Malawi as 'an under-explored country, strongly supporting mining & exploration', that is 'safe, historically stable, with reasonable infrastructure' and benefitting from 'English language & legal framework'.[84] However, the World Bank rates Malawi poorly in its 'easy of doing business' index, at 171 out of 183 countries.[85]

Tanzania

The Tanzanian Government issued its first uranium mining licence in April 2013, to Mantra Tanzania, a subsidiary of an Australian company, Mantra Resources, which was bought in 2010 by a Russia state-owned company, Atomredmetzoloto (ARMZ).[86] Mantra planned to start extracting uranium in the Mkuju River Project during 2013, but the project seems to have been delayed at least until 2014

in Malawi', Uranium Investing News, 14 June 2011, <http://uraniuminvestingnews.com/8029/uranium-mining-in-malawi.html>.

[78] Chikoko, R., 'Uranium mining: whose interest? Malawi case', Presentation at Investigating Extractive Industry Regional Conference, Lusaka, 13–15 Aug. 2012, <http://fairreporters.net/2012/08/12/conference-investigating-extractive-industries/>.

[79] Wise Uranium Project, 'Uranium mine ownership: Africa', 5 Nov. 2013, <http://www.wise-uranium.org/uoafr.html>.

[80] Wise Uranium Project, 'New uranium mining projects: Malawi', 14 Sep. 2013, <http://www.wise-uranium.org/upmw.html>.

[81] Citizens for Justice, Friends of the Earth Malawi, *Scramble for the Yellow Cake in Malawi* (Citizens for Justice, Friends of the Earth Malawi: Lilongwe, Mar. 2011).

[82] Citizens for Justice (note 81).

[83] Resource Star, Investor update presentation, Oct. 2011, <http://www.resourcestar.com.au/investor-centre/presentations>, p. 7.

[84] Resource Star (note 83), p. 10.

[85] World Bank, Ease of Doing Business Index, July 2013, <http://doingbusiness.org/rankings>.

[86] ARMZ Uranium Holding, 'ARMZ Uranliium Holding to acquire 100% of Australian public company Mantra Resources', Press release, 15 Dec. 2010, <http://www.armz.ru/eng/press/news/?id=257&p=1>.

due to the low price of uranium.[87] An agreement with Uranium One (a Canadian company that is 51 per cent owned by ARMZ) has given Uranium One operational control of the project.[88] The project is estimated to hold 139 600 tonnes of measured and indicated resources.[89]

Substantial uranium deposits have been discovered in southern and central Tanzania, including the Manyoni mine, the Mkuju River Project and at Mtonya, where exploration has intersected low- to medium-grade uranium at shallow depths (making it favourable for mining).[90] The Tanzanian Government estimates that it will receive substantial revenues from the exploitation of the reserves.[91] Uranium oxide below the Selous Game Reserve could potentially generate $200 million annually for 15 years for mining firms, and $5 million each year for the Tanzanian Government.[92] Tanzania's reserves of uranium oxide are believed to total at least 54 million pounds (120 million kg). Once operational, the Selous and Mkuju mines would make Tanzania the eighth-largest uranium producer globally and the third largest in Africa, after Namibia and Niger.[93]

Exploration and prospecting

A significant number of international companies are active in uranium exploration in the four African producing states as well as in Botswana, Cameroon, the Central Africa Republic (CAR), Chad, Gabon, Morocco, Mozambique, Nigeria, Tanzania, Zambia and Zimbabwe. Companies are no longer limiting exploration activities to areas with the potential to host high-grade, in situ leaching deposits (which facilitate safeguarding mines) in close proximity to known resources and existing production facilities but are also exploring lower-grade high-tonnage deposits.[94]

The Malawian Government encourages exploration by foreign companies as a way to assess the country's mineral wealth. Uranium exploration is perceived in Malawi as being expensive; one foreign company invested $15 million in uranium exploration. Foreign companies exploring for minerals in Malawi are, however, encouraged to team up with local companies.[95] There are currently 15–20 companies with exploration licences in Malawi.[96] Globe Metals and Mining, which is majority-owned by East China Mineral Exploration and Development Bureau, a

[87] Hall, K., 'Mantra Resources to start uranium mining at Mkuju River Project', Mining.com, 10 June 2013, <http://www.mining.com/mantra-resources-to-start-uranium-mining-at-mkuju-river-project-17947>.

[88] OECD Nuclear Energy Agency and IAEA (note 39), pp. 406–407.

[89] Hall (note 87).

[90] OECD Nuclear Energy Agency and IAEA (note 39), p. 405.

[91] Nzwili, F., 'Tanzania churches oppose uranium mining', Ecumenical News International, 18 June 2012, <http://allafrica.com/stories/201206191378.html>.

[92] 'Tanzania "will mine uranium on Selous Game Reserve"', 1 July 2011, <http://www.bbc.co.uk/news/world-africa-13989264>; and 'Mantra plans uranium mine in Tanzania', *Mining Review Africa*, 4 July 2011.

[93] Jackson, S., 'Tanzania will become the world's eight largest uranium producer', *African Business Review*, 12 July 2012.

[94] Sole et al. (note 66), p. 869; and OECD Nuclear Energy Agency and IAEA (note 39), p. 12.

[95] Official, Malawian Department of Mines (note 20).

[96] Malawian NGO representative, Interview with author, 20 Mar. 2013.

Chinese state-owned company, has been exploring for uranium in Malawi since 2009. It may partner with another Chinese company.[97]

In Tanzania there has not been a comprehensive national geological survey to determine the value of minerals. In recent years the Tanzanian Government has issued over 70 licences to foreign companies interested in uranium exploration. Tanzania has an 'open register' approach to issuing exploration licences—that is, it issues licences on a 'first come, first served' basis, and the only reason not to issue a licence is if the area is already taken. According to a representative from the national office of the Extractive Industries Transparency Initiative (EITI), the EITI does not consider private companies to be a reliable source for geological surveys as they tend to exaggerate findings to secure investments.[98]

Between 2007 and 2012 more than 30 companies were active in uranium exploration activities in Namibia, despite a moratorium on the issuing of new prospecting licences. Companies from Australia, Canada, China and Russia carried out the exploration.[99]

Intensified exploration for uranium is also taking place in Botswana. The Botswanan Government has issued 138 prospecting licences in recent years for the exploration of uranium throughout the country.[100] Uranium prospecting and exploration is being performed by a variety of companies. The most advanced is the Letlhakane Project, which is developed by A-Cap Resources of Australia. The company expected to produce 1350 tonnes of uranium per year starting in 2014.[101] However, the expected operating cost is currently higher than market price.[102] Another Australian-based company, Impact Minerals, operates a few exploration projects in Botswana.

Zambia has 45 070 tonnes of known and potential reserves of uranium.[103] Three major projects aim to start uranium production in the near future: the Mutanga Project is owned by Denison Mines of Canada; the Lumwana Copper Project, from which uranium would be recovered as a minor by-product, is being developed by Equinox Minerals of Australia; and Australian company African Energy Resources owns the Chirundu Project, which is expected to produce 500 tonnes of uranium per year.[104]

The Central African Republic's uranium resources have been explored in the past by French, Japanese and Swiss companies in collaboration with the Government of the CAR. UraMin has been exploring uranium in the CAR on a 25-year mining permit since 2005. In June 2007 (at the peak of uranium prices) Areva acquired UraMin and its 90-per cent share in the advanced Bakouma Project. Areva has now signed a contract for uranium mining in the CAR, with estimated

[97] Swanepoel, E., 'Globe's shareholder agrees to foot the bill', *Mining Weekly*, 7 May 2013.
[98] EITI Tanzania representative, Interview with author, Dar es Salaam, 25 Mar. 2013.
[99] Wise Uranium, 'New Uranium Mining Projects: Namibia', 15 Aug. 2013, <http://www.wise-uranium.org/upna.html>.
[100] Wise Uranium Project (note 70), 'Botswana'.
[101] World Nuclear Association, 'Uranium in Africa', July 2013, <http://www.world-nuclear.org/info/Country-Profiles/Others/Uranium-in-Africa/>.
[102] Wise Uranium Project (note 70), 'Botswana'.
[103] Wise Uranium Project (note 79).
[104] World Nuclear Association (note 101).

uranium reserves of 12 000 tonnes.[105] Areva has announced several times that it intends to start production soon, and still hopes to reach full production in Bakouma by 2014–15.[106]

Several companies have expressed an interest in uranium exploration in Nigeria and Russia has signed a nuclear cooperation agreement with Nigeria that includes uranium exploration and mining.[107] A small government-appointed committee drafted a new regulation on uranium exploration and mining in Nigeria. No prospecting company has applied for uranium exploration following the adoption of the new regulation.

Zimbabwe, which has measured and speculative resources of 26 400 tonnes of uranium, has created the Zimbabwe Mining Development Corporation to carry out uranium exploration activities in the country. The corporation is 100 per cent state owned but may conduct joint ventures together with other stakeholders. So far, the company has identified 10 areas containing uranium in the mid-Zambezi basin. Iran is alleged to have expressed interest in Zimbabwe's uranium and is believed to have offered to supply oil in exchange for uranium.[108] Somalia's estimated reserves of 7600 tonnes of uranium are also considered a possible source of interest for Iran.

Areva signed an exploration agreement with the Government of the Democratic Republic of the Congo (DRC) in 2009 for the country's estimated 2700 tonnes of uranium reserves.[109] The contract includes mining rights, but Areva has said that it will not proceed with uranium mining in the DRC until the political situation in the country stabilizes.[110] In Guinea, Forte Energy NL of Australia estimates 4700 tonnes of uranium to be available. In Mauritania, Forte estimates reserves at 25 500 tonnes. In Mali, Rockgate Capital Corporation of Canada estimates that 8533 tonnes of uranium is available for mining.

Revenues

Government interest in the profits of mining is growing throughout Africa, partly because mining contracts and revenue payments are under increasingly close scrutiny by the public.[111] So-called 'resource nationalism'—ensuring that the host state receives a fair share of the profit when its national wealth is extracted—is currently the key issue across the extractive sector and is increasingly receiving attention from the development cooperation sector. In the case of uranium, the issue of revenues is double-edged: unlike precious minerals (such as diamonds, which are of limited welfare value) or raw materials used in manufacturing (such as coltan, which returns to Africa from Asia in the form of cheap electronics),

[105] Wise Uranium Project (note 79).
[106] AREVA, 'Central African Republic, 2013, <http://www.areva.com/EN/group-1533/central-african-republic>.
[107] 'Russia and Nigeria agree to cooperation' (note 66).
[108] Laing, A., 'Zimbabwe to sell uranium to Iran', *Daily Telegraph*, 6 Mar. 2011.
[109] Wise Uranium Project (note 79).
[110] World Nuclear Association (note 101).
[111] 'Resource nationalism in Africa: wish you were mine', *The Economist*, 11 Feb. 2012.

uranium is used in health and energy services overseas while these are in high demand in Africa. States and non-state actors on the continent have started to develop tools for enhancing national and local revenues from uranium mining; however, there is no standard across countries and the success rates varies.

In Namibia, one of the most developed of sub-Saharan African states, mining accounts for half of exports but only about one-tenth of gross domestic product (GDP).[112] The Namibian Government owns only 3 per cent of Rössing uranium mine and is therefore dependent on high uranium prices to raise revenues. Host states that own shares in a mining company may receive dividends on the company's retained earnings. Mining royalties generally comprise a percentage of the export value of the uranium: if the mining company is not making taxable profits but still exports large quantities, royalties may still be a reliable source of government revenue.[113] To increase the benefits for Namibia, the state-owned company Epangelo Mining was formed in 2008, with a goal to become a leading mining company. However, so far it has limited itself to acquiring minority shares in a few projects (such as the Husab mine), without announcing any development activities of its own.[114]

Uranium contributes 5 per cent to the GDP of Niger, the largest uranium producer in Africa. Areva gained a monopoly over uranium extraction shortly before Niger's independence in 1960.[115] In 2007 Niger negotiated a right to directly sell a certain percentage of the uranium mined by Areva. The government has the right to sign long-term contracts, or the uranium can be sold on the spot market. In 2007 Societé du Patrimoine des Mines du Niger (Sopamin) sold 300 tonnes of uranium on the world market, and in 2008 it sold 830 tonnes.[116]

The mining agreement between the Malawian Government and Paladin Africa gave 15 per cent equity to Malawi in return for a tax reduction worth up to $120 million per year.[117] However, Paladin Africa has been making losses since production at the Kayelekera mine began in 2009, which has meant that no dividend has been paid to Malawi for 4 of the 10 years of the mine's estimated operating time. The tax reductions include reduced corporate tax; a royalty rate reduction from 5 per cent to 1.5 per cent in years 1–3 and 3 per cent thereafter; and removal of 17 per cent import tax during the first 10 years.[118] The mining agreement stipulates that Malawi will not change its taxes or regulations on other financial contributions with regard to the Kayelekera mine for 10 years. In general, the agreement leaves Malawi dependent on high uranium prices and

[112] Namibia was ranked 4th in mainland sub-Sahara Africa in the 2013 Human Development Index, below Botswana and South Africa. United Nations Development Programme (UNDP), *Human Development Report 2013: The Rise of the South—Human Progress in a Diverse World* (UNDP: New York, 2013), pp. 144–46.

[113] ten Kate, A. and Wilde-Ramsing (note 67), pp. 9–10.

[114] Epangelo Mining, 'History', <http://www.epangelomining.com/?page_id=2>.

[115] Powell, A., 'Niger government to renegotiate contracts with AREVA', Publish What You Pay, 15 Feb. 2013, <http://www.publishwhatyoupay.org/newsroom/blog/niger-government-renegotiate-contracts-areva>.

[116] ten Kate, A. and Wilde-Ramsing (note 67), pp. 9, 16.

[117] Chikoko (note 78).

[118] African Forum and Network on Debt and Development (AFRODAD), *The Revenue Costs and Benefits of Foreign Direct Investment in the Extractive Industry in Malawi: The Case of Kayelekera Uranium Mine* (AFRODAD: Harare, 2013), p. 4.

profits from the mine for significant revenues.[119] In 2012 mining in Malawi contributed 10 per cent to GDP and exports but only 0.76 per cent to government revenue and 1.2 per cent to domestic revenue.[120]

The Mkuju River Project in Tanzania is anticipated to generate $1 billion of foreign investment and about $630 million in direct and indirect cash flows during the life of the mine. Revenues were a key issue during the negotiation of the mining agreement between the Tanzanian Government and Mantra Resources. The agreement is not yet public.[121]

Other forms of extraction

Gold mining

In South Africa uranium has been produced as a by-product of gold mining since 1952, mainly in the Witwatersrand Basin, which also holds the world's largest gold reserves. South Africa was the 12th-largest uranium producer in 2012, but estimates suggest that it holds the seventh-largest uranium resources.

Only one company—AngloGold Ashanti—currently produces uranium in South Africa, as a by-product of its gold operations. According to AngloGold, large investments have resulted in improvements in extraction techniques (e.g. it now extracts uranium before gold), making it possible to extract both more gold and more uranium.

The recovery of uranium as a by-product poses special transparency problems. Gold, as a more valuable mineral, is the primary target of mining companies. This leads to a situation in which a company reports only gold production and it is not publicly known if it is producing uranium. For example, a major gold miner in South Africa, DRDGold, reported revenue of 2982 million rand ($356 million) from gold and 22 million rand ($2.6 million) from by-products in 2012.[122] The company does not define by-product but states in the same report that it is considering a feasibility study on potential uranium production in the future.[123]

Harmony Gold Mining Company has announced that it could start uranium production from material at its Masimong, Phakisa and Tshepong mines in 2014.[124] Chinese-owned Gold One International also has uranium-recovery capability in South Africa, following its acquisition of Ezulwini mine from First Uranium (which produced 39.5 tonnes of uranium in 2011) and takeover of Rand Uranium in 2012.[125] It is currently conducting a feasibility study on uranium recovering from tailings dams in cooperation with Gold Fields.

[119] ten Kate, A. and Wilde-Ramsing (note 67), p. 20.

[120] Yager, T. Y., 'The mineral industry of Malawi', United States Geological Survey, *2010 Minerals Yearbook*, vol. 3, *Area Reports, International, Africa and the Middle East* (Department of the Interior: Washington, DC, 2012); and African Forum and Network on Debt and Development (note 118).

[121] Hall (note 87).

[122] DRDGold Ltd, *Annual Financial Statements 2012* (DRDGold: Constantia Kloof, 17 Sep. 2012), p. 35.

[123] DRDGold Ltd (note 122), p. 31.

[124] Wise Uranium Project, 'New uranium mining projects: South Africa', 19 Sep. 2013, <http://www.wise-uranium.org/upza.html>.

[125] First Uranium, 'First Uranium announces the sale of its Ezulwini Mine to Gold One International Limited, changes to its management and Board of Directors and initial distributions to debentureholders

In recent years, many new junior uranium miners and explorers have entered the uranium market in South Africa. Most of them are domestically owned, but Australian, British, Chinese, French and Russian companies are also active there. Despite these developments, a representative of AngloGold does not predict any big change in uranium extraction in South Africa in the short-to-middle term.[126]

Other gold-producing states in Africa, such as Ghana and Tanzania, have not produced any uranium as a by-product, although deposits have been identified. It is reasonable to presume that this may change in the future, if the right technologies are made available and uranium prices increase.

Tailings and waste

While uranium can be directly mined as a by-product of mining operations for other minerals and metals, it can also be subsequently extracted from the tailings (i.e. the residue) of other mining operations.

Currently no company extracts uranium from tailings in South Africa. AngloGold Ashanti—which has a history of processing tailings to recover gold and uranium—has in the past few years invested in the necessary technology to mine uranium from tailings, which has made this form of uranium extraction more feasible. It is expected to boost its output of both gold and uranium as a result of its purchase in 2012 of a commissioned tailings-retreatment operation in the Vaal River region (close to AngloGold Ashanti's own tailings facilities) from First Uranium for $335 million.[127] AngloGold plans to start the re-extraction of uranium from tailings at the end of 2013. It is unlikely that any other company operating in South Africa currently has this capacity.[128]

Historically, gold mining in South Africa did not extract uranium, which enhances the potential for the recovery of uranium from former gold mining sites there. An estimated 477 mining dumps are scattered around South Africa, many of them containing uranium. Oversight of the dumps is lacking, and they are not properly managed. The dumps generate liquid waste, and there is no guidance from national or regional regulators on how to handle the waste or who is responsible for the sites. Moreover, the South African National Nuclear Regulator reports that it is too underfunded to take on full responsibility for the mining dumps.[129]

Uranium-containing phosphates

Another source of uranium is uranium-containing phosphates. As much as 22 million tonnes of uranium could be extracted from phosphate rocks, which is

and shareholders', News release, 2 Aug. 2012, <http://www.firsturanium.com/sjfu/action/media/downloadFile?media_fileid=1909>; and Gold One International Ltd, 'Quarterly activities report: quarter ended 30 September 2012', 31 Oct. 2012, <http://www.gold1.co.za/index.php?option=com_docman&Itemid=134>, p. 29.

[126] Representative of AngloGold Ashanti, Interview with author, Johannesburg, 11 Mar. 2013.

[127] AngloGold Ashanti, 'AngloGold Ashanti to acquire mine waste solutions from First Uranium Corporation', News release, 2 Mar. 2012, <http://www.anglogold.co.za/Additional/Press/2012/2012_03_02_+MWS.htm>; and Representative of AngloGold Ashanti (note 126).

[128] Representative of AngloGold Ashanti (note 126).

[129] South African civil society representative, Interview with author, Johannesburg, 9 Mar. 2013.

three times more than identified conventional sources. Phosphate rocks are the only unconventional source from which a significant amount of uranium has already been recovered; before production stopped in 1999, 686 tonnes was produced in Belgium from Moroccan phosphates.[130] Uranium production from unconventional sources will remain economically unfeasible unless the price of uranium increases significantly.

The largest phosphate deposits are found in the Mediterranean Tethyan Phosphogenic Province, which extends from Morocco and Western Sahara, through Algeria, Tunisia and Egypt, to Israel, Jordan and Syria. Morocco has reserves of 85 billion tonnes of phosphates, containing 6.53 million tonnes of uranium.[131] At a production rate of 4.8 million tonnes of phosphates per year, this would yield 960 tonnes of uranium per year as a by-product. There is some expectation of production of 1900 tonnes of uranium per year from 2013, and a more certain expectation from 2017. All Moroccan phosphate is produced by the state-owned Office Chérifien des Phosphates, which is responsible for managing and controlling all aspects of phosphate mining. The combined capacity of its main facilities is 27 million tonnes per year.[132]

Phosphate containing uranium is also found in Brazil and the USA.

Old and abandoned mines

Several African states closed down uranium production in the 1980s during a downturn in uranium prices.

South Africa

Several South African mines that previously extracted uranium as a by-product have closed their uranium-recovery projects but continue to mine gold or copper (as is the case in Palabora and Western Area mines). South Africa's Additional Safeguards Protocol with the IAEA does not require it to report on uranium ore deposits that are not being exploited (see chapter 4). Furthermore, supervision by the IAEA or national authorities may be hampered by a lack of infrastructure or otherwise difficult access to the abandoned mines.[133]

Southern Democratic Republic of the Congo

The Belgian Congo (now the DRC) supplied up to 60 per cent of the world's uranium from the 1940s to the 1960s. All mines were operated by a Belgium state-owned company, Union Minière du Haut Katanga (UMHK). The largest mine, Shinkolobwe, extracted approximately 40 000 tonnes of uranium during

[130] OECD Nuclear Energy Agency and IAEA (note 39), pp. 30, 32.

[131] Porter GeoConsultancy, 'Oulad Abdoun, Khouribga, Sidi Daoui, Ganntour, Youssoufia, Benguerir, Meskala, Bou Craa: Morocco', 2011, <http://www.portergeo.com.au/database/mineinfo.asp?mineid=mn1387>.

[132] 'Morocco: mining', Encyclopedia of the Nations, <http://www.nationsencyclopedia.com/Africa/Morocco-MINING.html>.

[133] Wise Uranium Project, 'Decommissioning data: Africa', 22 Oct. 2009, <http://www.wise-uranium.org/uddafr.html>; and Khripunov, I., 'Exploiting Africa: securing the continent's uranium resources', *Jane's Intelligence Review*, Sep. 2007, p. 52.

this time.[134] When the DRC gained independence in 1960, Belgium sealed the Shinkolobwe mine by filling its shafts with concrete. The mine has remained officially closed and commercial production ceased. In 1998 artisanal miners broke down the concrete lids in order to gain access to the cobalt, copper and uranium deposits.[135] Estimates suggest that there may be as many as 1 million artisanal miners in the DRC.[136]

In the 2000s there were several reported cases of uranium smuggling from the DRC, including a seizure by Tanzanian customs in October 2005 in the port of Dar es Salaam of a container containing yellowcake hidden in coltan.[137] The consignment, which was bound for Iran, had been transported from Shinkolobwe mine through southern DRC and Zambia before reaching Tanzania.[138]

Since 2010 freight from mining companies in the DRC's Katanga Province has been obligated to pass IAEA checkpoints at which searches of all mineral substances for radioactive content are conducted. The implementation of these measures by the IAEA was part of an agreement between the Congolese and US governments to fight trafficking of uranium and other radioactive substances.[139]

Regional transport in Southern Africa

In Southern Africa all uranium milling takes place at the mine. The UOC is then transported in trucks to either Walvis Bay in Namibia or Port Elizabeth in South Africa and shipped to a conversion facility in Asia, Europe or North America.

When transported overland, trucks containing UOC sometimes pass through several jurisdictions to reach a port. The longest transport route is currently that for uranium mined at Kayelekera in Malawi, which passes through Malawi, Zambia and Namibia on its ways to Walvis Bay. The national police in each state escorts the trucks in stages, based on bilateral agreements with the other states along the route.[140] Occasionally, the Malawian UOC is transported to a Namibian mining site rather than the port. In that case, Namibian officials inspect the site to verify the quantity of the material.[141] A bilateral contract for the transport of Malawi's uranium to Dar es Salaam, Tanzania, is foreseen.[142] National approaches to safety and security in transport and trans-shipment differ across the region; for example, Malawi has a 'light' approach, while Zambia 'overdoes it' (with 60

[134] Ecumenical Network Central Africa (OENZ), *Uranium Mining in the DR Congo: A Radiant Business for European Nuclear Companies?* (OENZ: Berlin, June 2011), p. 10.

[135] Ecumenical Network Central Africa (note 134), p. 13.

[136] Ecumenical Network Central Africa (note 134), p. 12. See also e.g. de Koning, R., *Conflict Minerals in the Democratic Republic of the Congo: Aligning Trade and Security Interventions*, SIPRI Policy Paper no. 27 (SIPRI: Stockholm, June 2011).

[137] United Nations, Security Council, Report of the Group of Experts on the Democratic Republic of the Congo, 15 June 2006, S/2006/525, 18 July 2006, paras 149–50.

[138] Ecumenical Network Central Africa (note 134), pp. 16–17; and Swain, J., Leppard, D. and Johnson-Thomas, B., 'Iran's plot to mine uranium in Africa', *Sunday Times*, 6 Aug. 2006.

[139] Ecumenical Network Central Africa (note 134), pp. 16–17.

[140] Official, Malawian Department of Mines (note 20).

[141] Official, Namibian Ministry of Mines and Energy (note 20).

[142] Official, Tanzania Atomic Energy Commission, Interview with author, Dar es Salaam, 25 Mar. 2013.

people escorting the transport). One senior Malawian official stated that there is a need for a harmonized approach to the transport issue at the regional level.[143]

All uranium mining operators in Southern Africa that the authors spoke to subcontract transport services. Rainbow Investment Ltd, a South African company based in Lusaka, Zambia, transports Malawian uranium to Walvis Bay, with the cargo staying overnight at the company's premises in Lusaka.[144] Rössing mine uses train transport, subcontracted to TransNamib, to move UOC from the mining site to the port. Rössing security personnel escort the train (since there is no mechanism for tracking the consignment). At the port a subcontracted shipping company checks drums, packing and so on.[145] AngloGold Ashanti subcontracts packing and transport to Nuclear Cargo + Service GmbH (DAHER-NCS), a subsidiary of the French DAHER group, which is a supplier of equipment to high-technology industries.

[143] Official, Malawian Ministry of Natural Resources, Energy and Environment (note 20).
[144] Official, Malawian Department of Mines (note 20).
[145] Representative of Rössing, Interview with author, Rössing Mine, Namibia, 14 Mar. 2013.

4. The legal framework

The international legal framework

For African countries, obligations in the field of non-proliferation build on commitments contained in the international conventions and treaties that each of them has, voluntarily and under its own responsibility, decided to join (see table 4.1 for lists of members). That international legal *acquis* rests on some shared principles and understandings that unite all of the parties to the treaties in a common endeavour to prevent the proliferation of nuclear weapons.

The Non-Proliferation Treaty and IAEA safeguards

Through participation in the 1968 Non-Proliferation Treaty, states have made it clear that they believe the proliferation of nuclear weapons would seriously increase the danger of nuclear war.[146] The NPT prohibits non-nuclear weapon states (as defined in the treaty) from using nuclear technology for weapons or explosive devices.[147] In order to reduce the danger that nuclear technology will be applied in weapons or explosives, the NPT requires non-nuclear weapon states parties to conclude a safeguards agreement with the IAEA.

Safeguards are described by the IAEA as activities that can 'verify that a State is living up to its international commitments not to use nuclear programmes for nuclear-weapons purposes'.[148] Article III of the NPT requires safeguards 'as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the [IAEA] Statute . . . and the Agency's safeguards system' to be applied to all source material and special fissionable material in all peaceful nuclear activities within the territory of non-nuclear weapon states parties.

Article III of the NPT also requires all states parties not to provide source or special fissionable material to any non-nuclear-weapon state for peaceful purposes, 'unless the source or special fissionable material shall be subject to the safeguards required by this Article'. The consultations that led to the formation of the Zangger Committee in 1971 recognized that interpretations regarding the requirement for safeguards in the NPT could differ among suppliers.

By the mid-1990s there was a shared understanding that 'New supply arrangements for the transfer of source or special fissionable material or equipment or material especially designed or prepared for the processing, use or production of special fissionable material to non-nuclear-weapon States should require, as a necessary precondition, acceptance of the Agency's full-scope safeguards and

[146] Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT), opened for signature 1 July 1968, entered into force 5 Mar. 1970, IAEA Information Circular INFCIRC/140, 22 Apr. 1970.

[147] On the definitions of nuclear weapon state and non-nuclear weapon state see note 31.

[148] IAEA, 'Safeguards overview: comprehensive safeguards agreements and additional protocols', <http://www.iaea.org/Publications/Factsheets/English/sg_overview.html>.

internationally legally binding commitments not to acquire nuclear weapons or other nuclear explosive devices'.[149]

The IAEA Statute defines source material in a way that includes natural uranium.[150] However, the Model Comprehensive Safeguards Agreement developed by the IAEA makes it clear that, for the purpose of comprehensive safeguards, 'The term source material shall not be interpreted as including ore or ore residue'.[151] Moreover, Article 33 of the Model Agreement states that safeguards shall not apply to material in mining or ore processing.

The accountancy and verification procedures applied in safeguards do not apply to mining, milling or ore processing or to the ore concentrate that these processes produce. However, safeguards do apply to the material at the next phase of the fuel cycle, the conversion process. Therefore, the quality of the reporting on the export and import of mining and milling products can provide the starting point for one part of the detailed nuclear material accountancy needed further along the fuel cycle.

IAEA safeguards have evolved to include a Model Additional Protocol, granting the IAEA expanded rights of access to information and sites to complement the inspection authority provided in the underlying safeguards agreements.[152] The specific elements of an additional protocol are agreed bilaterally by the IAEA and the state concerned. However, the main elements that could be included were agreed by IAEA member states in May 1997.

The Model Additional Protocol includes a number of references to uranium mines and concentration plants. According to Article 2, states shall provide the IAEA with information specifying the location, operational status and the estimated annual production capacity of uranium mines and concentration plants, as well as their current annual production. On request by the IAEA, the state concerned shall provide information on the current annual production of an individual uranium mine or concentration plant.

Under the terms of the Model Additional Protocol, the state concerned also agrees to permit IAEA inspectors access to all parts of the nuclear fuel cycle—including uranium mines and concentration plants. Inspectors should have access rights that allow them to answer questions or resolve inconsistencies in the information that the state has provided in reports sent to the IAEA. Inspections could include, for example, examination of records, environmental sampling, use of detection and measurement devices, and the application of seals and other identifying and tamper-indicating devices. It should usually be possible to grant this access at advance notice of 24 hours.

[149] NPT Review and Extension Conference, 'Principles and objectives for nuclear non-proliferation and disarmament', Decision 2, NPT/CONF.1995/32 (Part I), Annex, 17 Apr.–12 May 1995.

[150] Statute of the International Atomic Energy Agency, approved 23 Oct. 1956, entered into force 29 July 1957, <http://www.iaea.org/About/statute.html>, Article XX.

[151] IAEA, 'The structure and content of agreements between the agency and states required in connection with the Treaty on the Non-proliferation of Nuclear Weapons' (Model Comprehensive Safeguards Agreement), IAEA Information Circular INFCIRC/153 (Corrected), June 1972, Article 112.

[152] IAEA, 'Model protocol additional to the agreement(s) between state(s) and the International Atomic Energy Agency for the application of safeguards' (Model Additional Protocol), IAEA Information Circular INFCIRC/540 (Corrected), Sep. 1997.

Table 4.1. African states' membership in selected non-proliferation instruments

	NPT	Treaty of Pelindaba	IAEA safeguards agreement	IAEA additional protocol	CPPNM	Amended CPPNM
Algeria	Party	Party	In force	Approved	Party	Ratified
Angola	Party	Signatory	In force	In force	–	–
Benin	Party	Party	Signed	Signed	–	–
Botswana	Party	Party	In force	In force	Party	–
Burkina Faso	Party	Party	In force	In force	Party	–
Burundi	Party	Party	In force	In force	–	–
Cameroon	Party	Party	In force	Signed	Party	–
Cape Verde	Party	Signatory	Signed	Signed	Party	–
Central African Republic	Party	Signatory	In force	In force	Party	–
Chad	Party	Party	In force	In force	–	–
Comoros	Party	Party	In force	In force	Party	–
Congo, Republic of	Party	Signatory	In force	In force	–	–
Congo, Democratic Rep.	Party	Signatory	In force	In force	Party	–
Côte d'Ivoire	Party	Party	In force	Signed	Party	–
Djibouti	Party	Signatory	Signed	Signed	Party	–
Egypt	Party	Signatory	In force	–	–	–
Equatorial Guinea	Party	Party	Approved	–	Party	–
Eritrea	Party	Signatory	–	–	–	–
Ethiopia	Party	Party	In force	–	–	–
Gabon	Party	Party	In force	In force	Party	Accepted
Gambia	Party	Party	In force	In force	–	–
Ghana	Party	Party	In force	In force	Party	Ratified
Guinea	Party	Party	Signed	Signed	Party	–
Guinea-Bissau	Party	Party	Signed	Signed	Party	–
Kenya	Party	Party	In force	In force	Party	Accepted
Lesotho	Party	Party	In force	In force	Party	Accepted
Liberia	Party	Signatory	–	–	–	–
Libya	Party	Party	In force	In force	Party	Ratified
Madagascar	Party	Party	In force	In force	Party	–
Malawi	Party	Party	In force	In force	–	–
Mali	Party	Party	In force	In force	Party	Accepted
Mauritania	Party	Party	In force	In force	Party	Ratified
Mauritius	Party	Party	In force	In force	–	–
Morocco	Party	Signatory	In force	In force	Party	–
Mozambique	Party	Party	In force	In force	Party	–
Namibia	Party	Party	In force	In force	Party	–
Niger	Party	Signatory	In force	In force	Party	Ratified
Nigeria	Party	Party	In force	In force	Party	Ratified
Rwanda	Party	Party	In force	In force	Party	–
Sao Tome and Principe	Party	Signatory	–	–	–	–
Senegal	Party	Party	In force	Signed	Party	–
Seychelles	Party	Signatory	In force	In force	Party	Accepted
Sierra Leone	Party	Signatory	In force	–	–	–
Somalia	Party	Signatory	–	–	–	–
South Africa	Party	Party	In force	In force	Party	–
South Sudan	–	–	–	–	–	–
Sudan	Party	Signatory	In force	–	Party	–
Swaziland	Party	Party	In force	In force	Party	–
Tanzania	Party	Party	In force	In force	Party	–
Togo	Party	Party	In force	In force	Party	–

	NPT	Treaty of Pelindaba	IAEA safeguards agreement	IAEA additional protocol	CPPNM	Amended CPPNM
Tunisia	Party	Party	In force	Signed	Party	Accepted
Uganda	Party	Signatory	In force	In force	Party	–
Western Sahara	–	Signatory	–	–	–	–
Zambia	Party	Party	In force	Signed	–	–
Zimbabwe	Party	Party	In force	–	–	–
Total in force	**53**	**36**	**43**	**32**	**36**	–
Total pending	–	**18**	**6**	**11**	–	**12**

CPPNM = Convention on the Physical Protection of Nuclear Material; IAEA = International Atomic Energy Agency; NPT = Non-Proliferation Treaty.

Sources: United Nations, Office for Disarmament Affairs, 'Treaty on the Non-Proliferation of Nuclear Weapons: status of the treaty', <http://disarmament.un.org/treaties/t/npt/>; African Union, 'List of countries which have signed, ratified/acceded to the African Nuclear-Weapon-Free Zone Treaty (the Treaty of Pelindaba)', 28 Mar. 2013, <http://au.int/en/treaties/>; IAEA, 'Status list: conclusion of safeguards agreements, additional protocols and small quantities protocols', 24 Sep. 2013, <http://www.iaea.org/safeguards/documents/sir_table.pdf>; IAEA, 'Convention on the Physical Protection of Nuclear Material', 17 Oct. 2012, <http://www.iaea.org/Publications/Documents/Conventions/cppnm_status.pdf>; and IAEA, 'Amendment to the Convention on the Physical Protection of Nuclear Material', 16 Sep. 2013, <http://www.iaea.org/Publications/Documents/Conventions/cppnm_amend_status.pdf>.

The NPT has 53 African states parties; 43 of these states have comprehensive safeguards agreements in force, including 32 that have agreed an additional protocol with the IAEA (see table 4.1).

The Convention on the Physical Protection of Nuclear Material

The 1980 Convention on the Physical Protection of Nuclear Material (CPPNM) is the only international, legally binding instrument that establishes measures for the physical protection of nuclear material.[153] For the purposes of the CPPNM, nuclear material includes natural uranium, except when it is in the form of ore or ore residue. Uranium ore concentrate is therefore subject to the provisions of the convention and parties to the CPPNM should have provisions in place to ensure physical protection of UOC.

The provisions of the original CPPNM of 1980 applied to nuclear material used for peaceful purposes while in international transport. In July 2005 the convention was amended and its provisions were strengthened.[154] The process of amendment was undertaken to avert potential dangers posed by trafficking, the unlawful taking and use of nuclear material, and the sabotage of nuclear material and nuclear facilities. The states that participated noted in the preamble to the amendment that physical protection of nuclear material 'has become a matter of increased national and international concern'.

[153] Convention on the Physical Protection of Nuclear Material, opened for signature 3 Mar. 1980, entered into force 8 Feb. 1987, amended in 2005, IAEA Information Circular INFCIRC/274/Rev.1, May 1980.

[154] The text of the amendment is reproduced in IAEA, Board of Governors, GOV/INF/2005/10–GC(49)/INF/6, 6 Sep. 2005.

The amended convention—which will be renamed the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities when it enters into force—makes it legally binding for states parties to protect nuclear facilities and material in peaceful domestic use, storage and transport. The definition of a nuclear facility includes any facility in which nuclear material is produced, processed, handled or stored.

The convention requires each state party to establish, implement and maintain an appropriate physical protection regime applicable to nuclear material and nuclear facilities under its jurisdiction, to protect against the theft or other unlawful taking of nuclear material in use, storage and transport, and to ensure the implementation of 'rapid and comprehensive measures' to locate and, where appropriate, recover missing or stolen nuclear material. The convention also provides for expanded cooperation between and among states to locate and recover stolen or smuggled nuclear material as quickly as possible.

The convention does not prescribe in detail the measures that would be needed to comply with these provisions. However, the amended convention does list 12 agreed Fundamental Principles of Physical Protection of Nuclear Material and Nuclear Facilities. These principles include ensuring that nuclear material is adequately protected during international transport until responsibility is properly transferred to another state. The legislative and regulatory framework to govern physical protection should include a system of evaluation and licensing or other procedures to grant authorization to the actors that own and control nuclear material.

In order to make these responsibilities operational, each state party should establish or designate a competent authority, and this authority should be equipped with the necessary powers, technical competence, and financial and human resources needed to fulfil its responsibilities. The competent authority should be independent of the bodies that are in charge of promoting or exploiting nuclear material for commercial reasons.

Many of the measures needed for proper physical protection have to be taken by the actors that hold the relevant licences or permits—including mining companies and shippers. The CPPNM includes the principle that a regulatory framework should include a system for inspection of facilities and transport to verify compliance with applicable requirements and conditions of the licence or other authorizing document, and a means to enforce applicable requirements and conditions, including effective sanctions.

The task of physical protection entails a partnership between the regulators and the market actors, and the CPPNM includes the principle that all organizations involved in implementing physical protection should give due priority to developing and maintaining a 'security culture' that will ensure the effective implementation of measures across the entire organization.

The CPPNM calls for actions that are appropriate to manage the risk posed by the activities in a country. States are not required or expected to invest more in physical protection than is necessary, and the system for assuring compliance with the CPPNM should not impose excessive burdens on the country concerned. To that end, the agreed principles for national implementation measures include a requirement for a graded approach that takes into account the current evaluation of threat, as well as the relative attractiveness and the nature of the nuclear material in question and the potential consequences should it be lost from custody. From this perspective, the measures needed to protect UOC would be different from those needed to protect fissionable material.

The level of African participation in the CPPNM is uneven: while 36 African states are party to the original CPPMN, only 12 have ratified or accepted the amended convention (see table 4.1). A significant number of countries that either export uranium or are considering doing so in the future have not joined the original convention, and relatively few African states have taken steps to join the amended convention. However, as noted below, the great majority of African states have made a legal commitment to implement physical protection measures laid down by the CPPNM by creating a regional nuclear weapon-free zone.

Regulations on safe and secure transport

Since the 1960s the IAEA has published guidelines for the safe transport of radioactive materials, including the transport of uranium ore concentrate from the site where it is milled to the facility where it is converted into the feedstock for use in an enrichment plant. The first IAEA advisory regulations for the safe transport of radioactive material were published in 1961. The Committee of Experts on the Transport of Dangerous Goods within the UN Economic and Social Council (ECOSOC) has also developed recommendations on safe transport of radioactive material, including model regulations. After the terrorist attacks of 11 September 2001 on the USA, experts began to consider transport security provisions, and the most recent editions of the UN model regulations now include general security requirements for dangerous goods, including radioactive material.

The IAEA Regulations for the Safe Transport of Radioactive Material were most recently revised in 2012.[155] Their requirements are widely adhered to.[156] For example, the International Maritime Organization (IMO) has developed its own code based on the IAEA regulations. The International Maritime Dangerous Goods Code (IMDG Code), dating back to 1965, was developed as an international code for the transport of dangerous goods by sea. The code was made mandatory for IMO members in 2002; however, its provisions on transport of radioactive material (Class 7) remain at the level of recommendations.[157]

The IAEA, UN and IMO guidance documents, which are closely aligned, are tailored to risk, with more demanding requirements included for high-consequence dangerous goods—goods that have the potential to cause mass casualties or mass destruction if used in the physical form in which they are

[155] IAEA, *Regulations for the Safe Transport of Radioactive Material*, 2012 edn, IAEA Safety Standards Series no. SSR-6 (IAEA: Vienna, 2012).

[156] World Nuclear Association, 'Transport of radioactive materials', July 2011, <http://world-nuclear.org/info/Nuclear-Fuel-Cycle/Transport/Transport-of-Radioactive-Materials/>.

[157] International Maritime Organization, 'International Maritime Dangerous Goods (IMDG) Code', <http://www.imo.org/blast/mainframe.asp?topic_id=158>.

being transported. National authorities are free to classify goods depending on their own threat determination, but the model regulations include an indicative classification.

When shipped, UOC is classified as a Class 7 dangerous good, which covers all radioactive materials under the UN model regulations.[158] The classification requires strict packaging, proper procedures and precautions during handling and transport. Risks are perceived as limited because UOC has a low level of radioactivity per unit mass, remains stable under all conditions of storage, handling and transport, and does not pose a fire or explosion hazard.[159]

The main purpose of the IAEA guidelines and UN recommendations is to assure safety for both people and the environment by containing the effects of radiation during transport—first and foremost by using appropriate packaging and containers. The safety aspects of the model regulations include guidance on several issues that can have relevance to security. For example, guidance is offered on appropriate labelling of drums and containers, record keeping related to shipments (including storage and retention of records), reporting procedures for accidents and incidents during transport, and how to manage shipments that cannot be delivered to the customer.

The World Nuclear Transport Institute (WNTI) and the World Institute for Nuclear Security (WINS) have jointly developed a good-practice guide on electronic tracking in the transport of radioactive materials.[160] The WNTI represents the entities that transport radioactive materials or those that benefit from the transport of radioactive materials. Its founder members—Areva, International Nuclear Services Ltd and the Federation of Electric Power Companies of Japan (FEPC)—decided not to become involved in issues relating to non-proliferation, disarmament or transport for these purposes. However, their activities are relevant to reducing proliferation risk because they contribute to strengthening physical protection. Three uranium mining corporations with subsidies in Southern Africa—ARMZ, Paladin Energy and Rio Tinto Uranium—are members of WNTI. AngloGold Ashanti follows the good-practice guidelines on a voluntary basis through the use of individual satellite tracking system on all containers, physical escorts and elaborated emergency measures.[161]

The Nuclear Suppliers Group

The Nuclear Suppliers Group has developed Guidelines for Nuclear Transfers that should be applied to the international transfer of an agreed set of items.[162]

[158] United Nations, *Recommendations on the Transport of Dangerous Goods: Model Regulations*, 18th edn (United Nations: New York, 2013).

[159] World Nuclear Association (note 156); and Australian Uranium Council (note 43), p. 8.

[160] World Nuclear Transport Institute (WNTI) and World Institute for Nuclear Security (WINS), *Electronic Tracking for the Transport of Nuclear and other Radioactive Materials*, revision 1.0 (WNTI: London, Feb. 2012)

[161] Representative of AngloGold Ashanti (note 126).

[162] The most recent version of the Guidelines for Nuclear Transfers is published in IAEA, Communication received from the Permanent Mission of the United States of America to the International Atomic Energy Agency regarding certain member states' guidelines for the export of nuclear material, equipment and technology, Information Circular INFCIRC 254/Rev.11/Part I, 12 Nov. 2012.

The items to which the guidelines apply (which are listed in Annex A of the guidelines) include nuclear source material—the definition of which includes ‘uranium containing the mixture of isotopes occurring in nature’.

The NSG has agreed certain quantity thresholds for transfers to a given recipient country during a 12-month period. These thresholds determine whether or not the guidelines need to be applied to given shipments. For source material, the threshold is 500 kg. Therefore, a state participating in the NSG should apply the guidelines when licensing the transfer of UOC to any country where shipments exceed 500 kg over a 12-month period. However, if the exporting government is confident that the source material is for use in a non-nuclear industrial process, such as the production of metal alloys or ceramics, there is no requirement to apply the NSG guidelines.

Annex C of the NSG guidelines includes some guidelines for the physical protection of nuclear material. These are calibrated according to proliferation risk. For UOC the guidance is that the material should be stored in an area to which access is controlled, and that it should be transported under special precautions—including prior arrangements among sender, recipient and carrier specifying the time, place and procedures for transferring transport responsibility.

Only one African country—South Africa—currently participates in the NSG. Therefore, whether or not other uranium-exporting states choose to apply the Guidelines for Nuclear Transfers is at their own individual discretion.

In the past, countries that participate in arrangements such as the NSG absorbed almost all of the output of UOC of non-participating states, which was another factor that minimized proliferation risk. However, this may be changing as countries that are outside the core group of nuclear suppliers buy more UOC to feed expanding domestic nuclear industries. The future demand from countries such as India, Iran and Pakistan is still likely to represent a small share of the total value of UOC sales. However, the proliferation risk attached to this trade may be greater than its commercial significance.

Several countries that do not participate in the NSG have decided to apply the Guidelines for Nuclear Transfers, and the NSG has carried out many outreach activities with non-participating states to help inform the efficient implementation of the guidelines. Further outreach efforts, with a specific focus on the early phases of the nuclear fuel cycle, would be justified.

UN Security Council Resolution 1540

On 28 April 2004 the UN Security Council unanimously adopted Resolution 1540 acting under Chapter VII of the UN Charter—which therefore makes compliance with the terms of the resolution mandatory for all UN members.[163]

Resolution 1540 requires all states to put in place effective measures to prevent the proliferation of nuclear weapons, including by ‘establishing appropriate controls over related materials’. The system of appropriate controls referred to in the

[163] UN Security Council Resolution 1540, 28 Apr. 2004; and Charter of the United Nations, signed 26 June 1945, entered into force 24 Oct. 1945, <http://www.un.org/en/documents/charter>.

resolution includes physical protection, effective border controls, law enforcement efforts 'to detect, deter, prevent and combat, including through international cooperation when necessary, [trafficking and brokering]', and 'appropriate laws and regulations to control export, transit, trans-shipment and re-export and controls on providing funds and services related to such export and trans-shipment'. However, as 'related materials' in the context of nuclear weapons are not defined in the resolution, it is unclear whether any of these provisions would apply to natural uranium or UOC.

Analyses of African responses to Resolution 1540 have emphasized the relatively low numbers of reports detailing implementation submitted by African countries.[164] Moreover, African responses generally seem to emphasize the need to avoid creating multiple and overlapping obligations that stretch already limited resources for implementation and enforcement.[165] By fulfilling the requirements of arms control and disarmament treaties and conventions, African countries are also demonstrating their support for the resolution.

The African Nuclear-Weapon-Free Zone Treaty (Treaty of Pelindaba)

In addition to international treaties and conventions and the international frameworks for non-proliferation cooperation, Africa has developed its own regional measures. First and foremost, is the 1996 African Nuclear-Weapon-Free Zone Treaty (Treaty of Pelindaba).[166]

The treaty, which entered into force in 2009, prohibits the research, development, manufacture and acquisition of nuclear explosive devices and the testing or stationing of any nuclear explosive device on the continent of Africa, on island states that are members of the African Union (AU) and all islands considered by the AU to be part of Africa. In Article 3 the parties agree 'Not to take any action to assist or encourage the research on, development, manufacture, stockpiling or acquisition, or possession of any nuclear explosive device'. In Article 9 each party undertakes not to provide source material to any non-nuclear weapon state 'unless subject to a comprehensive safeguards agreement concluded with IAEA'.

The Treaty of Pelindaba builds on the NPT. The NPT uses a form of words that can be seen as a functional equivalent to a requirement for comprehensive safeguards as a condition of supply to non-nuclear weapon states, and, as noted above, subsequent decisions by states parties have confirmed this interpretation. However, the Treaty of Pelindaba makes that requirement explicit and legally binding.

The parties to the Treaty of Pelindaba apply the definition of source material contained in the IAEA Statute—which includes uranium containing the mixture

[164] Dye, D., 'African perspectives on countering weapons of mass destruction', Institute for Security Studies (ISS) Paper no. 167, Sep. 2008, <http://www.issafrica.org/publications/papers/>.

[165] Rousseau, G., 'Relevant lessons: South Africa', *United Nations Seminar on Implementing UN Security Council Resolution 1540 in Africa, 9–10 November 2006, Accra, Ghana*, Office for Disarmament Affairs (ODA) Occasional Papers no. 12 (United, Nations, ODA: New York, May 2007).

[166] African Nuclear-Weapon-Free Zone Treaty (Treaty of Pelindaba), signed 11 Apr. 1996, entered into force 15 July 2009, <http://au.int/en/treaties>.

of isotopes occurring in nature, including ‘in the form of metal, alloy, chemical compound, *or concentrate*’.[167]

In Article 10 the parties undertake to maintain the highest standards of security and effective physical protection of nuclear materials in order to prevent theft or unauthorized use and handling. Each party 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’.

The Treaty of Pelindaba has 36 parties and has been signed but not yet ratified by a further 18 states (see table 4.1).

Bilateral agreements

Apart from multilateral agreements, uranium-exporting states have sometimes used bilateral nuclear agreements to reassure themselves that exports take place at minimum risk. In some cases the exporting state has used these bilateral agreements to obtain treaty-level assurances from the government of the importing state that nuclear material will be used exclusively for peaceful purposes, and that uranium of national origin will be covered by safeguards agreed with the IAEA.

Bilateral agreements perhaps play a particularly important role in assuring suppliers that nuclear-armed states will not divert uranium to weapon programmes. While nuclear weapon states have no legal obligation to sign a safeguards agreement with the IAEA, all five have concluded voluntary-offer agreements. These agreements, which apply safeguards to civil nuclear fuel cycle activities other than those with direct significance for nuclear weapon programmes, provide the IAEA with limited oversight in comparison to the comprehensive safeguards agreements signed with non-nuclear weapon states.

African uranium suppliers are not only committed to preventing the emergence of new nuclear-armed states but are also interested in ensuring that their uranium is not used in any existing nuclear weapon programme. Bilateral agreements with nuclear weapon states have provided uranium exporters with some assurances that nuclear material will be covered by a safeguards agreement with the IAEA, and that the material must be used only for peaceful purposes. Typically, bilateral agreements also stipulate that prior consent is required for sale of the nuclear material to a third party, enrichment of the material beyond 20 per cent in uranium-235 or reprocessing of the material.

On occasion, the required assurances have gone further. For example, Australia insists that uranium of Australian origin should not be diverted to any military use or explosive purposes—including, for example, the use of nuclear material for naval reactor fuel or depleted uranium munitions.[168] The agreements also require

[167] Statute of the International Atomic Energy Agency (note 150), Article XX (emphasis added). See also IAEA, *IAEA Safeguards Glossary: 2001 Edition*, International Nuclear Verification Series no. 3 (IAEA: Vienna, June 2002), p. 30.

[168] Australian Safeguards and Non-proliferation Office (ASNO), *Annual Report 2011–2012* (ASNO: Canberra, Sep. 2012), p. 35.

the physical protection of Australian-origin material using internationally agreed standards, such as those laid down in relevant IAEA Information Circulars.

To implement bilateral nuclear agreements, administrative arrangements will have to be applied linking the responsible national authorities. These arrangements may well include regular consultations and reporting requirements for agreed procedures related to, for example, shipping and transfer documentation; calculations of process losses, consumption and production; knowledge of the nuclear fuel cycle in the country concerned; regular liaison with industry; and consultation on implementation of IAEA safeguards.

It is more rare for bilateral agreements to be required with all of the countries via which material is trans-shipped. However, when deciding on the transport route for UOC it may be a requirement that certain arrangements are in place all along the supply route—such as the requirement that the state concerned is a party to the CPPNM and has agreed an additional protocol with the IAEA, and that national implementation measures are in place for both instruments.

The success of legal agreements depends on the quality of national implementation. Finding a balance between effectiveness and affordability requires states to think carefully about which legal and technical competences are required and how to organize administrative efforts for success.

The national legal frameworks

As described above, current international agreements, regulations and advisory documents provide a lot of guidance to states when it comes to minimizing proliferation risk. However, it is an agreed principle that the responsibility for defining in detail and then implementing the measures needed to comply with the international legal *acquis* rests entirely with states. Without effective implementation by states, the effort to combat nuclear non-proliferation and nuclear security risks will be seriously undermined.

In many African states the national legal framework that governs uranium mining and milling has been substantially amended in the past few years. Some states have sought and received external assistance in drafting new regulations or updating existing ones. In some cases, it has been argued that new mining agreements should be placed on hold while legislative amendments are being made. Another argument put forward in national debates is that the process of legislative review requires the proper level of resources if investors and the public are to be properly informed about legislative changes and what new rights and responsibilities they entail.

This section provides a general overview of national legal frameworks for uranium mining in four African states: Namibia, Malawi, South Africa and Tanzania. It also attempts to identify shortcomings in the legislation and its implementation. In general, the four states do not have specific legislation for uranium mining and milling. Instead, uranium extraction falls under general mining legislation and legislation on atomic energy and radioactive sources. These are addressed in turn below.

Legislation on mining

The general mining legislation of Namibia, Malawi, South Africa and Tanzania (see table 4.2) normally covers exploration and mining licensing, reporting requirements, and health and safety issues. In general, the legislation contains the following elements.[169]

1. Prospecting and exploration of uranium require a permit. These permits are generously handed out, on a 'first come, first served' basis. Fees for obtaining permits are low.
2. Mining of uranium requires a mining contract between the company and the government of the host state, which includes the right to mine. In some of the countries, mining permits are only issued to companies that are registered domestically, causing international corporations to set up subsidiary companies in host states. The mining permits are time limited (e.g. 10 years). Once obtained, the mining rights can be sold to another company. This has been common practice in the region.
3. Risk-reduction measures are the obligation of mine operators. A mining plan must be submitted to and approved by the responsible ministry before mining starts.
4. The responsible ministry makes unannounced inspections of the mining sites, sometimes jointly with another relevant ministry (e.g. environmental affairs). However, the system is based on companies operating in good faith.
5. To export uranium, the company must obtain the government's approval. The government issues a general licence for export of uranium during a limited time (e.g. 2–3 years). During this period, the company must notify the authorities of the quantity and destination of each export.
6. The government (i.e. the minister of mines) must approve all general sales contracts for uranium before they are signed. In the assessment of the sales contract the government makes sure that it follows existing legislation but does not make a proliferation risk assessment of the sales contract.
7. Mining companies may choose to subcontract parts of their contracted activities to others, from on-site maintenance work (as is done at Rössing), to transport and even the mining and milling itself (as Paladin does in Malawi). The government only has a contract with the original operator and will hold it accountable in the event of problems.

In Malawi the government makes an inspection prior to each individual export (approximately fortnightly).[170] In Tanzania the national export controls team is drawn from different ministries, as no autonomous dedicated authority exists. No

[169] Official, Namibian Ministry of Mines and Energy (note 20); Official, Malawian Department of Mines (note 20); and Official, Malawian Ministry of Natural Resources, Energy and Environment (note 20).

[170] Official, Malawian Department of Mines (note 20).

Table 4.2. Mining legislation of Malawi, Namibia, South Africa and Tanzania

Country	Act	Responsible authority	Status
Malawi	1981 Mines and Minerals Act	Ministry of Natural Resources, Energy and Environment, Department of Mines	Under review
Namibia	1992 Minerals (Prospecting and Mining) Act	Minister of Mines and Energy	Under review
South Africa	2002 Minerals and Petroleum Resources Development Act	Ministry of Mines	. .
Tanzania	2010 Mining Act	Ministry of State, Vice-President's Office (Environment)	. .

Sources: Mines and Minerals Act, Laws of Malawi Chapter 61:01, 1 June 1981, <http://www.malawilii.org/mw/legislation/consolidated-act/6101>; Minerals (Prospecting and Mining) Act, Act no. 33 of 1992, signed 16 Dec. 1992, *Government Gazette of the Republic of Namibia*, no. 564 (31 Dec. 1992); Minerals and Petroleum Resources Development Act, Act 28 of 2002, assented to 3 Oct. 2002, commenced 1 May 2004, *Republic of South Africa Government Gazette*, vol. 448, no. 23 922 (10 Oct. 2002); and Mining Act, Tanzanian Act no. 14 of 2010, assented to 20 May 2010, <http://www.mem.go.tz/Resources/eLibrary/tabid/93/>.

decision has yet been made on who will be responsible for scrutinizing the uranium sales contracts.[171]

Legislation on atomic energy and radioactive sources

In addition to mining legislation, Namibia, Malawi, South Africa and Tanzania have legislation governing the use, production, import and export of nuclear materials (see table 4.3). In general, the legislation contains the following elements.[172]

1. The legislation establishes a separate, independent authority with the capacity to monitor the implementation of the legislation and to verify company reports.
2. It requires safeguards and the protection of people and the environment from radiation, including in uranium exploration, mining authorization and inspections.
3. It specifies the rules governing transport of nuclear materials.
4. It requires all mining sites to have a radiation-management plan, including on waste quantities, transport and shipment. The plan follows a format proposed by the responsible authority and must be approved by the authority prior to the start of mining. The plan is used as the basis for inspections (which take place regularly). The inspections do not include safeguards, but could be expanded to do so.

[171] Official, Tanzania Atomic Energy Commission (note 142).
[172] Official, Namibian Atomic Energy Board and National Radiation Protection Authority, Interview with author, Windhoek, 12 Mar. 2013.

Table 4.3. Legislation on atomic energy and radioactive sources of Malawi, Namibia, South Africa and Tanzania

Country	Act	Responsible authority	Status
Malawi	2011 Atomic Energy Act,	To be established	In force since Aug. 2012
	2010 Uranium Regulations		
Namibia	2005 Atomic Energy and Radiation Protection Act	National Radiation Protection Authority	. .
South Africa	1999 Nuclear Energy Act and 1999 National Nuclear Regulator Act	National Nuclear Regulator	. .
Tanzania	2003 Atomic Energy Act	Tanzania Atomic Energy Commission	Under review
	2010 Uranium Regulations under the Radioactive Minerals Act	Radiation Authority	

Sources: Official, Malawian Department of Mines, Interview with author, Lilongwe, 18 Mar. 2013; Atomic Energy and Radiation Protection Act, Act no. 5 of 2005, signed 24 Apr. 2005, *Government Gazette of the Republic of Namibia*, no. 3429 (16 May 2005); Nuclear Energy Act, Act no. 46 of 1999, assented to 20 Dec. 1999, commenced 24 Feb. 2000, *Republic of South Africa Government Gazette*, vol. 414, no. 20 759 (23 Dec. 1999); National Nuclear Regulator Act, Act no. 47 of 1999, assented to 20 Dec. 1999, commenced 24 Feb. 2000, *Republic of South Africa Government Gazette*, vol. 414, no. 20 760 (23 Dec. 1999); and Atomic Energy Act, Tanzanian Act no. 7 of 2003, assented to 23 May 2003, <http://taec.or.tz/Downloads/atomic_energy_act_2003.pdf>; Official, Tanzania Atomic Energy Commission, Interview with author, Dar es Salaam, 25 Mar. 2013.

5. It sets out obligations regarding measuring radiation in proximity to the mining operations. The companies are responsible for measuring radiation and for complying with the standards; the monitoring is checked during inspections.[173]

In South Africa the production, use, storage and transport of nuclear materials are controlled through the 1999 Nuclear Energy Act and the 1980 National Key Points Act, while physical protection is codified under the Non-Proliferation Act and Notice no. 22 of 2010 under this act.[174] Border control is covered by the various customs and excise acts implemented by the South African Revenue Service, with enforcement in conjunction with the South African Police Service and Border Police.[175]

[173] Representative of Rössing (note 145).

[174] United Nations, Security Council, Committee established pursuant to Resolution 1540 (2004), 'South Africa', Matrix document according to para. 1 of Resolution 1540, 14 Dec. 2007, <http://www.un.org/en/sc/1540/national-implementation/1540-matrix/committee-approved-matrices.shtml>, pp. 14–15; Nuclear Energy Act (note 30); National Key Points Act, Act no. 102 of 1980, assented to 1 July 1980, commenced 25 July 1980, <http://www.saps.gov.za/docs_publs/legislation/juta/a102of1980.pdf>; and Non-Proliferation of Weapons of Mass Destruction Act, Act no. 87 of 1993, assented to 23 June 1993, commenced 16 Aug. 1993, *Republic of South Africa Government Gazette*, vol. 337, no. 14 919 (2 July 1993).

[175] United Nations (note 174), p. 24.

In Namibia a draft Nuclear Cycle Policy was being finalized in March 2013. It will be a guiding document covering exploration, mining, enrichment and nuclear power. It is estimated to be completed during 2014. The policy is being drafted in cooperation with the Finnish Radiation and Nuclear Safety Authority.[176] The 2005 Atomic Energy and Radiation Protection Act's task is to 'regulate the use of nuclear and radioactive material as well as administer the requirement of international treaties and conventions' governing the mining and transport of nuclear materials within the country.[177]

Malawi's new legislation was prompted by the country joining the IAEA in 2006. Although provisions for establishing an independent monitoring and verification authority are a key feature of the legislation, the government lacks the capacity to carry out such activities. The Ministry of Natural Resources, Energy and Environment is looking into building that capacity with assistance from South Africa. Recruitment of officers and establishment of a governing board for the new authority took place in March 2013. In the meantime there is a national technical team, whose members are drawn from different institutions.[178]

[176] Official, Namibian Ministry of Mines and Energy (note 20).

[177] United Nations, Security Council, Committee established pursuant to Resolution 1540 (2004), Letter dated 27 April 2006 from the Permanent Mission of Namibia to the United Nations addressed to the Chairman of the Committee, S/AC.44/2004/(02)/36/Add.1, 28 Apr. 2006; and United Nations, Security Council, Committee established pursuant to Resolution 1540 (2004), 'Namibia', Matrix document according to para. 1 of Resolution 1540, 27 Apr. 2006, <http://www.un.org/en/sc/1540/national-implementation/1540-matrix/committee-approved-matrices.shtml>.

[178] Official, Malawian Ministry of Natural Resources, Energy and Environment (note 20).

5. Conclusions and recommendations

The past decade has seen renewed interest in expanding uranium mining, not least in Africa. Africa is already producing one-fifth of the world's uranium, and it has large untapped resources. In the coming decade it may be that there are changes to the uranium market, with new suppliers and new centres of demand emerging. A number of the new centres of demand, in particular in Asia but perhaps also in the Middle East, will be countries that either have nuclear weapons now or are considered to be potential countries of nuclear proliferation concern.

African countries have made a strong political commitment to ensuring that national-origin uranium is only used for peaceful purposes, and the current uranium-supplier states seem to be working hard to ensure that they do not contribute to nuclear weapon programmes—either existing or potential. However, these countries (some of which have limited resources to devote to the effort) still face significant challenges. Other states that are entering, or considering entering, the market as uranium suppliers are at an earlier stage of establishing national systems to minimize proliferation risks.

Several mining projects are on hold until the spot price of uranium increases. There is now an opportunity to review and strengthen national measures to reduce proliferation risks in existing uranium suppliers, to improve and harmonize current practices and legislation, and to plan for effective measures to be put in place before production takes off in countries such as Nigeria, Tanzania and Zambia.

Another conclusion that can be drawn from the analysis in previous chapters is that countries would benefit from discussing potential proliferation risks with others, rather than seeking national solutions. Key partners in such discussions would be specialized organizations, first and foremost the IAEA; other countries that have experience of mitigating proliferation risks in uranium supply; other countries that have made similar non-proliferation commitments (in particular in the framework of nuclear weapon-free zones); and other countries in Africa that face similar issues and problems.

International cooperation can play an important role in understanding proliferation risk and assessing approaches to mitigating identified risks. In the final analysis, however, uranium-supplier countries carry the responsibility for ensuring that they follow responsible policies and meet the obligations they have freely entered into.

An exporting state's understanding of risk will be facilitated by a good understanding of how national-origin uranium moves through the civilian fuel cycle. This understanding should include the movement of uranium through the phases of conversion and enrichment to fuel fabrication. Information about how converters and enrichment service providers ensure that national-origin uranium is only used for peaceful purposes is unlikely to be shared with exporting states by, for example, the IAEA because of issues related to safeguards confidentiality. The exporting state should therefore seek this information directly from the converters and enrichment service providers, supplemented by collection and analysis of information in the public domain.

Understanding the movement of national-origin uranium is likely to be based on material accountancy, rather than the monitoring of physical inventory. This understanding would be complemented and supplemented by a good understanding of the commercial relationships between converters and the providers of enrichment services, and between the enrichment service providers and fuel fabricators. Some of this information may be held by the private sector uranium-extracting companies and may not be available to the state authorities. Information about commercial arrangements along the fuel cycle, who is involved and the nature of their involvement could be sought in cooperation with the final customer of national-origin uranium. A dialogue with the final customer and uranium-extraction companies would be the first step in building understanding of commercial relationships.

At the national level, the measures that are needed as part of an integrated and comprehensive system include legal, administrative and technical capacities.

The national capacities should be tailored to risk, and should respect the legitimate objective of engaging in peaceful commerce. Non-proliferation policies should be pursued in a way that is cost efficient and that does not handicap the important development needs of uranium-supplier countries.

Uranium extraction can play an important role in national economic life. If a uranium-supplier country applies standards that go beyond the current international understanding of normal practice, the reasons for deviation may have to be explained to a domestic audience.

Recommendations for uranium-supplier states at the national level

Establish a focal point for non-proliferation issues related to uranium extraction

This focal point would liaise regularly with all stakeholders inside the country, in key external partner countries and in key external organizations. In a short space of time this focal point would become the main resource for understanding proliferation risks, understanding non-proliferation obligations and the practical challenges of risk mitigation. The focal point would become a natural point of reference for stakeholders seeking information.

Perform regular proliferation risk assessment

This might be a task allocated to the focal point, in which case the focal point should have the necessary authority and resources. The risk assessment should take account of the three categories of risk identified in the previous chapters: (*a*) risks associated with regular uranium supply; (*b*) risks associated with supply of uranium from irregular sources; and (*c*) risks associated with the loss of control over material and diversion of uranium into illicit networks.

While the risk assessment is a national responsibility, the methodologies for risk assessment could be discussed in regional or international forums.

Review legislation

It is important that national legislation provides all the necessary powers and resources needed both to meet national policy needs and to comply with international obligations. Primary legislation should be seen as an integrated set of measures that, together, provide the necessary powers and resources. This does not necessarily need to mean that every convention has its own implementing legislation, since the obligations in different treaties and agreements may overlap.

It would be particularly important for African countries to ensure that national legislation provides the powers and resources necessary to meet obligations under bilateral agreements with the IAEA (including bringing into force an additional protocol), and with the Treaty of Pelindaba. The necessary powers to ensure effective export control constitute an important part of the national legislation. Obligations contained in, for example, the NPT and the CPPNM are also embedded in safeguards agreements and the legislation establishing the African nuclear weapon-free zone.

It is important that the legislative review takes account of secondary legislation as well as primary legislation. The implementation of legislation will probably be through instruments such as permits and licences. The obligations placed on permit holders, the conditions under which licences will be granted, the administrative arrangements to manage the system of permits and licences, and the penalties for violations are all examples of key elements of an effective system of risk management that will be laid down in secondary legislation and regulations. If these are missing or incomplete, then the effectiveness of primary legislation will quickly be undermined.

Create an integrated administrative system

A range of tasks—such as collection and analysis of safeguards-relevant information, monitoring to ensure respect for conditions contained in permits and licences, facilitation, on request, of IAEA inspections or requests for supplementary information, and provision of physical security measures at facilities and for material in transport—needs to be performed efficiently. These tasks are unlikely to be allocated to a single existing authority, and the scale of the work probably does not justify the creation of a dedicated, permanent agency. However, if tasks are fragmented across government agencies or are placed in parts of government where proliferation risk management is not a key activity or priority, then sustaining the necessary capacities and resources could be difficult.

The national focal point mentioned above could be a key resource ensuring that the different actors maintain a sense that they are performing an important national function and operating as part of a coherent and integrated national team.

Ensure the independence of regulators

The various tasks of regulating uranium extraction and supply are unlikely to be concentrated in one place, and may be distributed across several authorities. This not only raises the issue of coherence noted above, but also the issue of independence.

Promoting the development of extractive industries, attracting investment and marketing uranium supply to foreign customers on the one hand, and the task of regulation to ensure the implementation of proper standards for safety, security and non-proliferation on the other are mutually supporting and complementary. However, these functions should be separated.

Ensure relevant technical capacities are available

Implementation of the various tasks noted above requires a degree of technical knowledge that needs to be built and sustained. This does not require large numbers of people, but a small, motivated and well-trained cadre of technical experts with skills in areas such as material accountancy, material analysis and assay, so that the information provided by the extractive industry can be analysed and not simply collected and sent onwards to the IAEA. The development of these skills may be accomplished through partnership with non-governmental actors, such as technical universities, either inside or outside the country.

Technical competence is required to implement effective facility and transport security measures. There are likely to be specialists with relevant skills in other sensitive sectors, as well as in the military, who can be drawn on to recruit individuals that contribute to proliferation risk management.

Training and maintaining groups of specialists is an area where support from external donors could be both accessed and coordinated to reduce the resource costs.

Engage with industry

The extractive industries carry a significant responsibility for important parts of proliferation risk mitigation. In particular, industry will supply the information that is relevant for safeguards compliance when an additional protocol is in place with the IAEA and will have a key role to play in the physical security of facilities and material transport. Industry should be required to explain the measures that support proliferation risk mitigation and to demonstrate their effectiveness as a condition of doing business.

Recommendations for international cooperation

Initiate dialogue with converters and suppliers of enrichment services

Uranium-supplier countries, perhaps working in cooperation with each other, should initiate a dialogue with converters and suppliers of enrichment services to better understand how those actors meet their legal obligations and manage proliferation risk.

A potential framework would be to invite converters and enrichment service providers to participate in special sessions of regional or subregional meetings that are already being organized by African nuclear regulators. Another potential framework would be to make contact with, for example, the Nuclear Suppliers Group to explore the opportunities for dialogue on specific subjects relevant to proliferation risk management.

Those discussions could take up the questions: What are the legal obligations of converters and enrichment service providers? How do they understand those obligations? What procedures are in place to make them effective? What procedures exist in countries that have nuclear weapons to ensure separation of civil and military activities?

Initiate dialogue with uranium suppliers located in nuclear weapon-free zones

As countries increasingly explore commercial uranium supply arrangements with countries in Asia and the Middle East, it will be important to develop a common understanding among uranium-supplier countries about how they interpret their obligations under current nuclear weapon-free zone treaties.

Although the language related to conditions for supply in the nuclear weapon-free zone treaties is similar or, in some cases, identical, their parties nevertheless seem to reach different conclusions about whether or not commercial agreements with, for example, India can be implemented with acceptable levels of risk.

An international conference could bring together uranium suppliers (current and anticipated) to discuss their interpretations of treaty obligations, with the final objective of a harmonized approach to conditions for supply.

Discuss at the regional level current practices for key proliferation risk management policies and practices

African countries engaged in uranium supply could benefit themselves and each other through regular discussion on the subject of how they manage proliferation risk. This can also be a valuable opportunity for information sharing and the development of standards tailored to specific conditions found in Africa. Special sessions of the regular meetings already taking place in the context of, for example, the Treaty of Pelindaba, the network of African nuclear regulators and on arms control under the umbrella of the African Union could offer opportunities to convene such discussions.

A topic that could be taken up at an early stage of such meetings is the need for a comprehensive understanding of uranium supply from Africa, taking into account the unconventional sources. A joint analysis and a comprehensive picture of unconventional sources of uranium in Africa would be a valuable outcome from discussions.

A second topic that could be taken up at an early stage is assessing proliferation risks that may arise out of uranium supplied for non-nuclear purposes.

Convene the group of uranium suppliers and prospective uranium suppliers at periodic meetings to discuss proliferation risks and risk mitigation

At present, there is no forum where uranium suppliers meet to discuss proliferation risk management. Most African uranium-supplier countries participate in the IAEA Annual Conference. This could be a good opportunity to convene as many uranium-supplier countries as possible for an annual discussion of current tendencies and developments of mutual interest.

Examples of issues that could usefully be included on the agenda of such meetings include exchange of information on current practices in, for example, administration of safeguards, national implementation of physical protection obligations and effective export controls.

Meetings of this kind would be an opportunity to inform uranium-supplier states of the latest developments in guidance and principles of best practice on, for example, conditions to attach to permits, conditions for granting licences, physical protection, and safe and secure transport.

RECENT SIPRI POLICY PAPERS

No. 29 *China's Energy and Security Relations with Russia: Hopes, Frustrations and Uncertainties* by Linda Jakobson, Paul Holtom, Dean Knox and Jingchao Peng (Oct. 2011)

No. 30 *Arms Flows to Sub-Saharan Africa*, by Pieter D. Wezeman, Siemon T. Wezeman and Lucie Béraud-Sudreau (Dec. 2011)

No. 31 *Transparency in Military Spending and Arms Acquisitions in Latin America and the Caribbean*, by Mark Bromley and Carina Solmirano (Jan. 2012)

No. 32 *Maritime Transport and Destabilizing Commodity Flows*, by Hugh Griffiths and Michael Jenks (Jan. 2012)

No. 33 *Verifying a Fissile Material Cut-off Treaty: Technical and Organizational Considerations*, by Shannon N. Kile and Robert E. Kelley (Aug. 2012)

No. 34 *China's Arctic Aspirations*, by Linda Jakobson and Jingchao Peng (Nov. 2012)

No. 35 *The Future of the Chemical Weapons Convention: Policy and Planning Aspects*, by Mohamed Daoudi, John Hart, Ajey Lele and Ralf Trapp (Apr. 2013)

No. 36 *The Proliferation Security Initiative: Legal Considerations and Operational Realities*, by Aaron Dunne (May 2013)

No. 37 *Strengthening the European Union's Future Approach to WMD Non-proliferation*, by Ian Anthony and Lina Grip (June 2013)

No. 38 *China's Exports of Small Arms and Light Weapons*, by Mark Bromley, Mathieu Duchâtel and Paul Holtom (October 2013)

All SIPRI Policy Papers are available to download or buy at <http://www.sipri.org/publications/>.

sipri

STOCKHOLM INTERNATIONAL
PEACE RESEARCH INSTITUTE

Africa and the Global Market in Natural Uranium: From Proliferation Risk to Non-proliferation Opportunity

Little attention has been paid to the limited, but not negligible, nuclear proliferation risks associated with the mining of uranium. As the global market for uranium changes and as more African countries become uranium suppliers, there is a need for them to be vigilant of those risks.

This is the first study to look at the proliferation risks associated with uranium extraction in Africa and to suggest practical ways in which African states can act to mitigate them. The authors argue that, as countries of proliferation concern achieve proficiency in uranium conversion and enrichment, restricting easy access to uranium could be one part of a comprehensive and integrated approach to non-proliferation across the nuclear fuel cycle.

Dr Ian Anthony (United Kingdom) is Director of the SIPRI Arms Control and Non-proliferation Programme and Head of the SIPRI European Security Project. Among his numerous other publications on issues related to arms control, disarmament and export control are *Reforming Nuclear Export Controls: The Future of the Nuclear Suppliers Group*, SIPRI Research Report no. 22 (2007, co-author), and 'Measures to combat nuclear terrorism', *SIPRI Yearbook 2013*.

Lina Grip (Sweden) is a Researcher with the SIPRI Arms Control and Non-proliferation Programme and is SIPRI's coordinator for the EU Non-proliferation Consortium. She is also a doctoral candidate in political science at Helsinki University. Her research interests include regional and multilateral non-proliferation and arms control policies and processes, with a focus on the EU and East and Southern Africa. Her recent publications include 'Small arms control in Africa', *SIPRI Yearbook 2013*.

ISBN 978-91-85114-81-8

9 789185 114818