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REPORT

Nuclear Infrastructure and Proliferation Risks of the United Arab Emirates, Turkey, and Egypt

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Introduction

Apart from Saudi Arabia, which our Institute views as currently the largest proliferation risk in the Middle East, three key neighbors of Iran also warrant intensive study as to their nuclear capabilities and plans, safeguards and obstacles to proliferation, and future proliferation risks. After Saudi Arabia, the United Arab Emirates (UAE), Turkey, and Egypt are seen by the Institute as states in the Middle East most poised to seek advanced nuclear capabilities in response to a resurgent nuclear Iran, or as the limitations under the Joint Comprehensive Plan of Action (JCPOA) conclude or otherwise end. Egypt has the most experience of the three in working with nuclear materials and facilities under efforts dating back decades. Turkey may pose the greatest risk as far as surprise proliferation given the state of political affairs in that country and growing impulse of President Erdogan to consolidate power. The UAE, which was the first Middle Eastern country to adopt a so-called "gold standard" of renouncing enrichment and reprocessing, will be a country to watch for reversing course on its pledge. Each of these countries has varying security concerns with regard to Iran, and each has nuanced domestic goals that could propel proliferation attempts. A common recommendation for all three countries is that the United States and its allies should seek strong defensive relationships with those countries potentially affected by the end of JCPOA limits; others include the United States should work to prevent the spread of enrichment and reprocessing capabilities in the region and use national intelligence and diplomatic capabilities to detect and work to reverse proliferation if it emerges. A summary of findings on each country follows, with a technical look at their emerging nuclear capabilities and plans, the security context with regard to Iran, status of their safeguards and obstacles to proliferation, and recommendations for preventing the spread of advanced nuclear capabilities in the region.

United Arab Emirates

Summary

The United Arab Emirates is often touted as a model country in a region of proliferation concern that has gone to great lengths to assure neighbors about its peaceful nuclear intentions. In 2009, the UAE institutionalized legislative prohibitions to enrichment or reprocessing, reaching a so-called "gold standard" in its nonproliferation commitments.[1] *This same legislation criminalized and assigned harsh penalties to "the unauthorized use, theft, transport or trade in nuclear materials."*[2] *In light of the Iran deal, however, complications have emerged. The UAE has had to face that under the JCPOA, Iran's enrichment infrastructure is left in place despite the program first being developed as part of a covert nuclear weapons effort. Worse, the nuclear deal allows Iran to grow its enrichment program to industrial levels following the end of the JCPOA's restrictions, although the Trump administration is increasingly taking the position that this enrichment buildup will not be allowed. Nonetheless, the UAE has suggested that it must reevaluate its commitments. Edward Royce, Chairman of the House Foreign Affairs Committee, reported that the UAE Ambassador to Washington, Yousef al-Otaiba, told him that the UAE no longer felt bound by its bilateral agreement with the United States, its "123 Agreement" which forgoes enrichment and reprocessing of any U.S.-origin fuel.*[3] *While subsequent statements from the UAE embassy in Washington, D.C. have indicated that the "government has not formally changed its views or perspective on the 123 Agreement or commitments," the ambiguity is unsettling for the future of nonproliferation in the region.*[4] *The UAE is a country to watch to see if it changes its approach on not acquiring or developing advanced nuclear capabilities. Its decisions will likely continue to be influenced by its rivalry with Iran. In any case, any UAE effort to develop enrichment or reprocessing capabilities should be opposed.*

Security Context

The UAE consists of a federation of seven emirates that act with substantial autonomy and maintain separate interests. Two of the emirates, Abu Dhabi and Dubai, have differing relations with Iran, with Dubai holding closer ties and Abu Dhabi remaining more suspicious of Iranian influence. This dynamic may play out with one emirate winning out and largely determining whether the UAE ultimately decides to renege on its nonproliferation commitments and pursue advanced nuclear capabilities. However, Abu Dhabi is the UAE's largest, most powerful state and seat of UAE leadership and it harbors deep distrust of the Iranian government that stems from fundamental differences in religious ideology. It believes Iran incites unrest among its

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[1] "UAE Adopts Nuclear Law," *World Nuclear News*, October 6, 2015, http://www.world-nuclear-news.org/NP-UAE_adopts_nuclear_energy_law-0510095.html.
[2] "UAE Adopts Nuclear Law," *World Nuclear News*.
[3] Deb Riechmann, "UAE Tells US Lawmaker it Has Right to Enrich Uranium, Too," The Associated Press. October 16, 2015, http://bigstory.ap.org/article/1c56cae59325422086997619d347d17b/uae-us-lawmaker-we-have-right-enrich-uranium-too.
[4] "UAE Might Seek Right to Enrich Uranium," *Al-Jazeera,* October 16, 2015, http://www.aljazeera.com/news/2015/10/report-uae-seek-enrich-uranium-151016052723467.html.

own and other Arab countries' Shi'ite populations. Iranian influence in the UAE languished under international economic sanctions, and some Abu Dhabi leaders feared that the lifting of sanctions under the JCPOA would lead to a reconstitution of that influence. If economic relations are reestablished and grow, an increase in Iranian immigration may also occur as Iran seeks to capitalize on economic opportunities in the UAE, which is of concern for leaders.

Dubai, by contrast, has strong economic and cultural ties with Iran, which also played a role in Dubai becoming one of the world's most notorious illicit transshipment hubs that was instrumental to Iran's and Pakistan's secret nuclear weapons efforts. Over 8,000 Iranian traders and businesses are anchored in Dubai, and nearly 10 percent of Dubai's population is ethnic Iranian.[5] This strong economic relationship is largely credited with creating Dubai's booming economy. A state that had been until the 1960s bereft of electricity, roads, running water, or telephones was bolstered by Iranian economic ties and immigrants.[6] This mutually beneficial relationship, however created a serious threat. Dubai became a major conduit through which Iran secretly or illegally imported controlled or sanctioned nuclear and military technologies.[7] Dubai free trade zone companies freely aided Iran's illicit nuclear, missile, and military trade networks until international pressure led the country to create export controls and stronger enforcement.[8]

Although the illicit trade problem remains, it is reduced. The UAE leadership in Abu Dhabi may not have approved of Dubai's close relationship with Iran, but it was swayed by the economic aspect. Many UAE officials see further promise in the prospect of increased economic growth and diversification because of the lifting of sanctions.[9]

The relationship between the UAE and the United States is a complicating factor. The UAE has enjoyed significant military and security benefits from the United States over the past 20 years.[10] Pursuit of advanced nuclear capabilities could damage its economic and military

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[5] Humeyra Pamuk, "Mideast Money-Sanctions Sap Dubai's Role as Iran Trade Hub," Reuters. February 15, 2012, http://www.reuters.com/article/2012/02/15/iran-business-dubai-idUSL5E8DC0CE20120215.

[6] Kambiz Foroohar, "Dubai Helps Iran Evade Sanctions as Smugglers Ignore U.S. Laws," *Bloomberg*, January 25, 2010, http://www.bloomberg.com/apps/news?pid=newsarchive&sid=av5smtYe_DDA.

[7] Colum Lunch, "Shutting Down Iran's Nuclear Smugglers," *Foreign Policy*, July 1, 2015, http://foreignpolicy.com/2015/07/01/shutting-down-irans-tehran-nuclear-smugglers-security-council-united-nations/.

[8] See for example: Andrea Stricker," Case Study: Two Arrested in Iranian Aircraft Parts Trafficking Scheme, Result of U.S. Sting Operation," Institute for Science and International Security Report, December 7, 2016, http://isis-online.org/isis-reports/detail/case-study-two-arrested-in-iranian-aircraft-parts-trafficking-scheme/; David Albright and Andrea Stricker, "If You Give a Mouse a Cookie," Institute Report, September 28, 2015, http://isis-online.org/uploads/isis-reports/documents/Iran_Prisoner_Swap_28Sept2015-Final.pdf; David Albright, Paul Brannan and Andrea Scheel, "A Smuggler's Procurement of Nuclear Dual-Use Pressure Transducers for Iran," Institute Report, July 14, 2009, http://www.isisnucleariran.org/assets/pdf/Yadegari_Iran_illicit_trade_14July2009.pdf

[9] Andrew Torchia, "Billions Up for Grabs if Nuclear Deal Opens Iran Economy," Reuters. April 3, 2015, http://www.reuters.com/article/us-iran-nuclear-economy-idUSKBN0MU0QP20150403#tHM0JLraO2YljzhY.97.

[10] "UAE-US Security Relationship," *Embassy of the United Arab Emirates*, http://www.uae-embassy.org/uae-us-relations/security_2012.

relationships with the United States. It is possible, however, that the UAE would decide to pursue advanced fuel cycle capabilities as a policy of independence and safeguarding against a future, re-energized Iranian nuclear weapons program, citing the precedent of the JCPOA as international approval of its right to enrich. Such a move would put the United States in a difficult position.

Regarding a broader push toward nuclear weapons capabilities, the UAE's economy is reliant on oil and natural gas exports which account for roughly 40 percent of its GDP.[11] As such, the UAE would be highly vulnerable to energy sanctions from the international community. Pursuit of advanced fuel cycle capabilities or nuclear weapons could carry with it substantial security and economic costs. This prospect will likely play a role in the UAE's calculus when deciding how far to go in matching Iran's nuclear capabilities, as will the perception level of a U.S. security commitment to the UAE.

Current Plans and Capabilities

By the year 2020, domestic energy demands of the UAE are projected to more than double.[12] As a result, the UAE has begun to expand and diversify its energy sources, and set a goal to have nuclear energy supply 6 percent of its energy demand by 2050.[13] Its first nuclear power reactor is nearing completion.[14] Its nuclear program has steadily progressed compared to other programs, having started discussing a nuclear power program in 2008 to accommodate projected increases in electrical demand and for desalination purposes.

Through extensive cooperation with the International Atomic Energy Agency (IAEA) and international partners, the UAE progressed relatively quickly in its endeavor to lay its nuclear infrastructure. It first created institutions to oversee and regulate nuclear development, starting with the Federal Authority of Nuclear Regulation (FANR) in 2009, followed by the Nuclear Energy Program Implementation Organization, which established the Emirates Nuclear Energy Corporation (ENEC) the same year to "evaluate and implement nuclear power plans."[15] The ENEC accepted a $20 billion dollar bid from the Korean Electric Power Corporation (KEPCO) to design and build four APR[16] 1400 megawatt-electric (MWe) pressurized water reactors.[17] The construction of the four reactors called Barakah 1-4 in the coastal town Ruwais in Abu Dhabi is going well, with construction progress at 94%, 82%, 68%, and 41%, respectively,

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[11] "UAE Facts and Figures," *OPEC,* http://www.opec.org/opec_web/en/about_us/170.htm.
[12] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*, updated May 2017, http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/United-Arab-Emirates/
[13] "UAE to invest $163bn in renewable-energy projects," *Al-Jazeera*, January 10, 2017, http://www.aljazeera.com/news/2017/01/uae-invest-163b-renewable-energy-projects-170110160613154.html
[14] "Barakah-1," *IAEA, Power Reactor Information System,* updated March 26, 2017, https://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=AE
[15] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*.
[16] APR-1400 is the name of the model, where APR stands for Advanced Power Reactor and 1400 indicates the electricity output.
[17] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*.

according to a statement by the Emirates Nuclear Energy Corporation.[18] Barakah 1 is projected to be operational by 2018;[19] the other three are projected to be operational by 2020.[20] Early concerns of delays were based on the fact that construction of two APR-1400s in South Korea experienced delays (Shin Kori 3 and 4).[21] However, Shin Kori 3 eventually began operation in December 2016, and Shin Kori 4 is expected to follow.[22] In October 2016, KEPCO agreed to invest $90 million in a company that will operate the UAE's first nuclear power plant.[23]

The four Barakah reactors will be jointly operated by the UAE and KEPCO personnel for 60 years, which is the expected lifespan of the reactors.[24] To fulfill its front end nuclear fuel cycle requirements, the UAE established a vast network of international partners to ensure smooth operation of the reactors. It will purchase natural uranium externally, deliver this uranium to contracted partners for conversion and subsequent enrichment, and finally send the enriched product to KEPCO for fuel fabrication.[25] In 2012, FANR and six companies signed agreements to supply uranium for 15 years: Conver Dyn, Uranium One, Urenco, Rio Tinto, Tenex, and Areva.[26] The APR-1400 uses low-enriched uranium dioxide fuel, with an average enrichment of 2.6 % U-235.[27] Each reactor has a net capacity of 1345 MWe and a thermal capacity of 3983 megawatts-thermal (MWt).[28] The high burn-up of the spent fuel adds to the proliferation resistance of the reactors, as high burn-up decreases the amount of plutonium 239, which is the most desirable plutonium isotope for nuclear weapons, and increases the amount of undesired plutonium 240 to more than 25 percent.[29] Moreover, given that the reactors will be jointly operated with South Korea and inspected by the IAEA, the UAE would face difficulties in

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[18] "Construction Program," Emirates Nuclear Energy Corporation, accessed March 27, 2017, https://www.enec.gov.ae/barakah-npp/construction-program/

[19] Caline Malek, "Construction of UAE's First Nuclear Reactor Complete but Operation Delayed to 2018," *The National,* May 5, 2017, https://www.thenational.ae/uae/government/construction-of-uae-s-first-nuclear-reactor-complete-but-operation-delayed-to-2018-1.42360?mkt_tok=eyJpIjoiTURFd09EVXdaV1kyTWpVMyIsInQiOiJPSXgyYVFpVHBsbSt6ZFZZWVpWXC82WVlhYzJ6UTZMWkZkbTNDZkMzaWxsYzArcktSZ0pqQ1dNXC9VeXQrRDh4M3dyTVlVaHduNmtvMkRIaFFLdWFmcHpYSlIxMGhJNVMwZ0U3KzhOdW4zXC9IaHZoNTlpVjZiYVhqVllYelpHSEtLdCJ9 ; Adam Vaughan, "Foreign companies flock to build nuclear plants in the UK," *The Guardian*, March 25, 2017, https://www.theguardian.com/business/2017/mar/25/foreign-firms-flock-to-build-nuclear-plants-in-uk

[20] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*.

[21] Anthony McAuley, "UAE Nuclear Project Enters Critical Phase," *The National*, July 7, 2015 http://www.thenational.ae/business/energy/uae-nuclear-project-enters-critical-phase.

[22] "First Korean APR-1400 enters commercial operation," *World Nuclear News*, December 20, 2016, http://www.world-nuclear-news.org/NN-First-Korean-APR-1400-enters-commercial-operation-2012164.html

[23] "S.Korea Signs on to Venture to Operate UAE's 1st Nuclear Power Plant," Reuters Africa. October 20, 2016, http://af.reuters.com/article/energyOilNews/idAFL3N1C32ZG

[24] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*.

[25] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*.

[26] "UAE Signs Six Deals for Uranium Supply in 2012," *UAE Interact*, December 19, 2012, http://www.uaeinteract.com/docs/UAE_signs_six_deals_for_uranium_supply_in_2012/52462.htm

[27] Han-Gon Kim, "The Design Characteristics of Advanced Power Reactor 1400," IAEA-CN-164-3S09.

[28] IAEA, "Barakah-1*," IAEA Power Reactor Information System,* updated March 26, 2017, https://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=AE

[29] IAEA, "Status report 83 - Advanced Power Reactor 1400 MWe (APR1400)," April 11, 2011, https://aris.iaea.org/PDF/APR1400.pdf

secretly diverting spent fuel in a hypothetical attempt to collect and recover plutonium in a reprocessing plant, regardless of plutonium quality.[30] The UAE plans to store all spent fuel in a national repository designed with the assistance of the Swedish Nuclear Waste Management Corporation or delivered to France for reprocessing.[31] The latter, if implemented, is bound to be seen by many U.S. experts and officials as inconsistent with the Gold Standard. One issue will be the fate of the separated plutonium, and whether overseas reprocessing will encourage the UAE to start using plutonium-based fuels in its power reactors, as is common in France. These fresh plutonium-bearing fuels, called mixed oxide (MOX) fuels, pose a much more serious proliferation risk than spent fuel or low enriched uranium fuels.

The IAEA has taken measures with the UAE to develop the necessary human capital for a sustainable nuclear program by providing many scholarships and opportunities for on-the-job training, as well as introducing nuclear science courses at universities at the Bachelors, Masters, and doctorate levels.[32] An emphasis on English proficiency will also be important as the workplace language will be English.[33] Since KEPCO will help operate the plant for 60 years, the UAE has sufficient time to create a domestic infrastructure through its international partnerships.

The nonproliferation gold standard pledged by the UAE on forgoing enrichment and reprocessing faces a challenge particularly if the enrichment restrictions on Iran under the JCPOA start to end. In 2017, at the Carnegie Nuclear Policy Conference, UAE Ambassador to the United States Yousef al-Otaiba publicly raised the UAE's situation, expressing that Iran got a "better" deal than the UAE, as it was able to keep its enrichment capacity.[34] He stated: "…If you're sitting where we're sitting, the country that is largely unfriendly to the United States and the West seems to have gotten a better deal… I offer this as just a perspective of how the deal looks, not on the technical merits but as friends and adversaries go." This regional dynamic requires monitoring particularly in light of worsening UAE/Iran relations and any signs that the UAE could move to abandon its pledge not to reprocess or enrich.

It is worth noting too that the UAE has purchased arms and missiles from North Korea, despite its condemnations of North Korea's nuclear tests and missile launches. This could indicate or further facilitate the emergence of a problematic back channel for the UAE to obtain advanced

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[30] Although a high fraction of plutonium 239 is desirable to those making nuclear weapons, any plutonium, even low quality power reactor plutonium, can be used to make nuclear weapons, with tradeoffs in explosive yield, heat management, and the risk of premature detonation.
[31] "Nuclear Power in the United Arab Emirates," *World Nuclear Association*.
[32] Elisabeth Dyck and Ayhan Evrensel, "From Consideration to Construction: The United Arab Emirates' Journey to Nuclear Power: A Country Case Study," IAEA, February 3, 2015, https://www.iaea.org/newscenter/news/consideration-construction-united-arab-emirates-journey-nuclear-power.
[33] McAuley, "UAE Nuclear Project."
[34] "Plenary – The Iran Deal: International Perspectives," *2017 Carnegie Nuclear Policy Conference*, transcript, http://carnegieendowment.org/2017/03/20/plenary-iran-deal-international-perspectives-pub-67681?mkt_tok=eyJpIjoiTlRrNVl6SmtNREEzTmpsailsInQiOiJheSt4ZE5JcnhcL3MyZmJwOFAzVkhUb09oakwrR1V4dnU1aXBBY1R6c3QrWFwvbUxMZk1SOHhEK2Mya3dGbU9uaktQaUhIb3IzVFJiMEpUbFZuZDZPZ1Nza2taNnhjZHB6YUlzOWt5bTZ6RE5CU1JXSGJMcXlZZnV4NGZqTWZPRzZPIn0%3D

nuclear technologies if it decided to proliferate.[35] This information also demonstrates that the UAE is willing to pursue illicit trade if it suits the government's interests.

Research and Training

As of March 2017, *Web of Science*, a database of published scientific research, had collected only 16 publications affiliated with Emirati research institutions addressing "uranium" within the past 15 years. Iran, in comparison, had produced 412 publications. Of the 16 publications, not one was written independently, or without collaboration of other nations' institutions. Most cooperation appears to be with China and the United States.

International cooperation is necessary in part because the UAE does not have any major nuclear research centers. The UAE's main nuclear body is the above-mentioned FANR, which is responsible for "safety, security, radiation protection and safeguards" of the UAE's nuclear power reactors. FANR is also the main overseer of the implementation of international agreements, which include the U.S. 123 agreement.[36] The FANR website shows a high degree of intended transparency for its future nuclear program. Under a web site tab titled "Open Data," inspection reports of the Barakh Nuclear Power Plant are available.[37] As an example, one can identify that the inspection team from the December 2016 Barakah report consisted of 24 individuals. Based on evaluating their names and affiliations, roughly one third of the people appear to come from organizations outside the UAE.[38] In fact, 40 percent of FANR employees are not Emirati.[39,40]

It is unlikely, but unclear from this open source evaluation, whether FANR hosts any laboratories. A section for "Research and Studies" exists on its website but is lacking any publications as of April 2017.[41] As indicated by publications found in scientific databases, the UAE's concrete, experimental research seems primarily conducted within general science departments of universities or other academic institutions. Examples are the Departments of Geology, Physics, and Chemistry at United Arab Emirates University (UAEU) and the

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[35] Samuel Ramani, "Why Did the UAE Purchase Weapons from North Korea?" *The Diplomat,* August 8, 2017, http://thediplomat.com/2017/08/why-did-the-uae-purchase-weapons-from-north-korea/

[36] "About FANR," Federal Authority for Nuclear Regulation, Web page, Accessed April 2017, https://fanr.gov.ae/en/about-us/about-fanr

[37] See: "Open Data," Federal Authority for Nuclear Regulation, Web page, Accessed April 2017, https://fanr.gov.ae/en/open-data

[38] FANR, *Nuclear Facility Inspection Report*, December 2016, https://fanr.gov.ae/en/Lists/InspectionReports/Attachments/88/00062-2017%20December%20report%20EN.pdf

[39] According to Reuters, the ratio of non-citizens to Emiratis is more than five to one, implying that less than 20 percent of the population is Emirati. Mahmoud Habboush, "Call to naturalise some expats stirs anxiety in the UAE," Reuters. October 10, 2013, http://uk.reuters.com/article/uk-emirates-citizenship-feature-idUKBRE99904J20131010

[40] "FANR in Numbers," Federal Authority for Nuclear Regulation, Web page, Accessed April 2017, https://fanr.gov.ae/en

[41] See: "Research and Studies," Federal Authority for Nuclear Regulation, Web page, Accessed April 2017, https://fanr.gov.ae/en/open-data/researches-studies

Department of Geology at Al Ain University of Science and Technology. Additionally, research is conducted at the Dubai Central Laboratory, which integrates seven major research departments into one, ranging from Food and Environment to Electromechanics Departments.[42]

As of September 2016, UAEU is approved to use radioactive material for "nuclear research, nuclear physics, and other types of research involving radioactive material."[43] This makes it possible that new equipment like hot cells could eventually be installed at the UAEU.

Khalifa University for Science, Technology and Research (KUSTR) in Abu Dhabi, which is merging with the Petroleum Institute and the Masdar Institute, has a nuclear engineering department.[44,45] These two other institutions have participated in nuclear-related research.[46]

Safeguards and Proliferation Obstacles

Due to extensive international involvement in the UAE's nuclear program by the IAEA, KEPCO, and uranium providers, it would be difficult for the UAE, without declaring a reversal of its gold standard commitments and voiding its legislation, to shift efforts to build front or back-end fuel cycle capabilities. The UAE would likely also face Nuclear Suppliers Group (NSG) opposition to any efforts to acquire enrichment or reprocessing facilities. It is, however, not certain that the NSG would block such purchases. Proposed NSG guidelines asking suppliers to consider "[g]eneral conditions of stability and security" within the recipient's state and the state's region before agreeing to the transfer of any material, for example, are blocked by certain members, including Turkey.[47]

Any secret effort by the UAE to develop advanced fuel cycle capabilities would likely be detected, resulting in international pressure. Moreover, the safeguards in the UAE are extensive and would complicate any secret nuclear effort. The IAEA has established comprehensive verification measures to which the UAE has voluntarily complied, including the Additional Protocol. The four Barakah nuclear reactors will be jointly owned and operated by KEPCO personnel for 60 years, further impeding any secret diversion from them. Finally, the

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[42] "About Us – Dubai Central Laboratory Introduction," Government of Dubai, Web page, Accessed August 2017, http://bit.ly/2vgn8SK

[43] "UAEU students train in nuclear research," United Arab Emirates University, News Archive, September 2016, http://www.uaeu.ac.ae/en/news/2016/september/nuclear_research.shtml

[44] "Abu Dhabi approves merger of universities and billions in projects," *The National*, October 13, 2016, https://www.thenational.ae/uae/government/abu-dhabi-approves-merger-of-universities-and-billions-in-projects-1.192240

[45] "College of Engineering," Khalifa University, Web page, Accessed August 2017, http://www.kustar.ac.ae/pages/college-of-engineering

[46] "Abu Dhabi approves merger of universities and billions in projects."

[47] Daniel Horner, "NSG Revises Rules on Sensitive Exports," *Arms Control Today*, August 2011, http://search.proquest.com.ezproxy.vccs.edu:2048/docview/884218279/2ADC40EC266E4043PQ/1?accountid=12902

UAE has no significant domestic uranium resources and would require imported uranium in order to undertake a parallel covert fuel cycle effort.[48]

If an enrichment or reprocessing program is sought by the UAE during the next two decades, it would need to change its domestic regulations forbidding uranium enrichment or reprocessing and the 123 agreement with the United States. However, the UAE is far from establishing mastery or independent control of either the front or back-end of the nuclear fuel cycle. If it pursued them alone, the UAE would require many years to acquire the technical equipment and expertise required to engage in successful enrichment, and may have to engage in secret, illicit procurements to acquire all the necessary goods and know-how. North Korea could even emerge as a supplier for such goods. Alternatively, the UAE could decide, particularly if Iran succeeds in scaling up its enrichment program, to seek to modify the Gold Standard commitments and buy enrichment or reprocessing capabilities from an overseas supplier and subject these facilities to IAEA safeguards. This situation, if allowed to develop, would enable the UAE to develop a nuclear weapons capability and open the door for breaking out to nuclear weapons at a time of its choosing, perhaps faster than the international community could react to stop it.

Conclusion

Because of the risk of advanced nuclear capabilities proliferating in the Middle East, all nuclear suppliers should commit not to supply the UAE enrichment or reprocessing capabilities, including reprocessing UAE spent fuel abroad unless the plutonium is not returned. The United States should make clear its defensive commitment to the UAE but underscore that any pursuit of uranium enrichment or reprocessing would threaten the U.S. defense commitment. National intelligence capabilities should monitor any UAE efforts to renege on its commitment to not acquire advanced fuel cycle capabilities and look for signs that it is carrying out research on weaponization. In addition, any increase in Iran's enrichment or reprocessing capabilities beyond current levels should be opposed as stimulating nuclear proliferation and posing an unacceptable risk to the region. The United States should work to strengthen the JCPOA by better enforcing the deal and extending the duration of the major nuclear limitations in order to address the security concerns of allies such as the UAE. The United States should also continue pressuring the UAE on its commitment to strong enforcement of its export controls and prevention of illicit trade to Iran. Middle East security concerns should be addressed and threat reduction efforts should be pursued more broadly.

[48] IAEA, Analysis of Uranium Supply to 2050, STI/PUB/1104, May 2001.

Turkey

Summary

The risk is substantial that Turkey will seek advanced nuclear capabilities in order to have comparable power to Iran under ambitious nuclear energy plans laid by President Recep Tayyip Erdogan. Erdogan's increasingly dictatorial actions increase the risk that Turkey will seek nuclear weapons capabilities – tools that Erdogan may find useful for consolidating power and augmenting Turkey's regional power status. Turkey is also adamant about making its nuclear infrastructure as independent from foreign aid as possible, as soon as it has acquired the needed workforce and technology. Turkey's interpretation of the Nuclear Non-Proliferation Treaty (NPT) as granting a "right to enrich" and its resistance to tightened Nuclear Suppliers Group (NSG) restrictions on transfers of enrichment and reprocessing technology are strong indicators of a desire to keep open the possibility of advanced fuel cycle development. Therefore, although official statements deny Turkish plans to acquire enrichment capabilities, NSG member states should block any attempts by Turkey to import technology that would support enrichment facilities and further destabilize the Middle East. National intelligence agencies should watch for any signs of illicit efforts by Turkey to procure these or weaponization knowledge and capabilities.

If Iran develops nuclear weapons, Turkey has said in the past that it would "follow suit - immediately," according to remarks by a high-level Turkish foreign ministry official. [49] More recently, in March 2017, an imam and confidant of Erdogan expressed the need for Turkish nuclear weapons and insisted on "inventing these weapons, not buying them."[50] A Turkish journalist also recently claimed that officials in Erdogan's inner circle informed him of secret plans and discussions to acquire nuclear weapons for deterrence purposes, and in reaction to worsening relations with the West.[51] Turkey would be able to acquire nuclear weapons more quickly if it is able to develop sensitive fuel cycle capabilities while the Iran nuclear deal, or Joint Comprehensive Plan of Action (JCPOA), is in place. But Turkey appears to lack as strong of a drive to match Iran's current nuclear capabilities as Saudi Arabia possesses. Part of the reason is that Turkey reportedly still hosts an estimated 50 U.S. nuclear weapons under its NATO arrangement and is by most accounts satisfied with the protection provided by the extended deterrent.[52] Despite the attempted military coup in July 2016, during which Incirlik Air Base hosting the weapons played a critical role, the weapons seemed to remain secure based on

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[49] Alexandra Bell, "Turkey's Nuclear Crossroads," *Good Magazine*, August 26, 2009, http://magazine.good.is/articles/turkeys-nuclear-crossroads

[50] Zoie O'Brien, "Nuclear Turkey? Imam close to Erdogan calls for weapons now amid tensions with EU," *Express,* March 16, 2017, http://www.express.co.uk/news/world/780240/TURKEY-Imam-Erdogan-nuclear-weapons-NOW-EU-tension-Germany-Netherlands

[51] Rebecca Flood, "Turkey is Trying to Get an Atomic Bomb in Secret Weapons Plan, Warns Expert," *Express*, August 8, 2017, https://www.express.co.uk/news/world/838694/Turkey-atomic-bomb-Recep-Tayyip-Erdo-an-nuclear-weapon-fears/amp

[52] Robert S. Norris and Hans M. Kristensen, "U.S. Tactical Nuclear Weapons in Europe, 2011," *Bulletin of the Atomic Scientists*, Vol. 67, Issue 1, p. 69, January/February 2011,

publicly available accounts. Media reports that the nuclear weapons were transferred to Romania were denied by the Romanian government.[53] Moreover, Turkey has important trade relations with Iran, and despite contentious foreign policies issues, the two have not engaged in combat for hundreds of years.[54] Turkey has tried to maintain a good economic and diplomatic relationship with Iran, speaking against economic sanctions and promoting a nuclear fuel swap agreement with Iran in 2010.[55] President Erdogan and Turkey's finance minister also spoke positively about the JCPOA, respectively calling it "an important development for peace in the region"[56] and "'great news' for the Turkish economy."[57] Nonetheless, Turkey could develop nuclear weapons capabilities simply to be a competitive power in the region, as a means of Erdogan coalescing his power, and to remain comparable to Iran.

Turkey can be expected to pursue its nuclear energy independence and its perceived "right to enrich" while balancing its increasingly troubled ties with the West. It would be subject to additional Western pressure to maintain a peaceful nuclear program if it does manage to acquire advanced fuel cycle capabilities. After the attempted military coup in July 2016, Erdogan removed all identified "adversaries" from military and political ranks and is therefore unlikely to face any substantial challenges in future decision making, even if it would turn the international community against Turkey. Erdogan would need to decide whether Western sanctions and pressure would be worth a push toward developing nuclear weapons capabilities and eventually nuclear weapons. The attempted coup revealed Turkey's political instability, which makes it a risky place for sensitive nuclear programs (and potentially NATO stationed nuclear weapons), even if a program is strictly civilian in nature.

Current Plans and Capabilities

Turkey's energy demand is increasing rapidly, and due to its lack of natural resources, its two main options are to keep importing fossil fuels or to invest in alternative energy sources, including nuclear energy. Erdogan is opting for a smooth but steady transition from the former to the latter; the government is planning to have nuclear power provide five percent of the

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[53] Georgi Gotev and Joel Schalit, "US moves nuclear weapons from Turkey to Romania," *Euractive*, August 18, 2016, https://www.euractiv.com/section/global-europe/news/us-moves-nuclear-weapons-from-turkey-to-romania/

[54] This is despite supporting differing military and political objectives in neighboring Syria. See Ali Omidi, "If it ain't broke, don't fix it: Why Turkey and Iran's 376 years of peace will continue," *Al-Monitor*, December 22, 2015, http://www.al-monitor.com/pulse/originals/2015/12/iran-turkey-tension-syria-yemen-iraq.html#ixzz3wI0PMzMS ; Nader Habibi, "Turkey and Iran: Growing Economic Relations Despite Western Sanctions," *Middle East Brief,* Brandeis University, May 2012, No. 62, http://www.brandeis.edu/crown/publications/meb/MEB62.pdf

[55] Parisa Hafezi, "Turkey, Brazil seal deal on Iran nuclear fuel swap," Reuters. May 16, 2010, http://www.reuters.com/article/2010/05/16/us-iran-nuclear-deal-idUSTRE64F29P20100516

[56] "Erdoğan speaks with Iran's Rouhani, welcomes nuclear deal," *Today's Zaman,* July 17, 2015, http://www.todayszaman.com/anasayfa_erdogan-speaks-with-irans-rouhani-welcomes-nuclear-deal_393928.html

[57] Daren Butler and Tulay Karadeniz, "Turkey welcomes Iran deal, urges Tehran to rethink regional policies," Reuters. July 14, 2015, http://www.reuters.com/article/iran-nuclear-turkey-idUSL5N0ZU3XE20150714

nation's energy demand by 2023, and 15 percent by 2030.[58] The International Energy Agency's (IEA's) recommendation is five percent by 2020.[59]

Turkey currently has two operable research reactors and plans to build multiple nuclear power plants.[60,61] Although the first power plant at Akkuyu will be foreign built – and operated by Russia – Turkey is planning to decrease the involvement of foreign companies such as Rosatom over a series of three to four power plants and eventually build reactors that are "100 percent national."[62] Four VVER units of 1200 megawatts electric (MWe) each will be Russian-built at Akkuyu with construction slated to begin in 2018.[63] A second nuclear power plant at the Sinop site, located at the Black Sea, was contracted to Mitsubishi Heavy Industries and AREVA in 2013.[64] The plant will be jointly owned and operated by Mitsubishi, Itochu, GDF SUEZ, AREVA, and EÜAŞ — the largest electric power company in Turkey, and will have a total capacity of 4400 MWe.[65,66] The construction of the ATMEA1 reactor, a French (AREVA) designed generation III+ pressurized water reactor, is to start in 2017, and the reactor is planned to start operating in 2023.[67] Another project at Igneada is in the planning stages with China. It will be constructed by China's State Nuclear Nuclear Power and Technology Corporation (SNPTC) and Westinghouse, but operated by Turkey's Elektrik Uretim. The planned reactors are two 1250

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[58] Salih Sari, Nuclear Engineer, MSc., The Ministry of Energy & Natural Resources, "Current Status of Nuclear Power Program in Turkey," *PowerPoint Presentation at "Technical Meeting on Country Nuclear Power Profile,"* Vienna, May 10-13, 2016, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2016/2016-05-10-05-13-NPES/Country_pres/Turkey_CNPP_Meeting_Turkey_Presentation_10-13_May_2016.pdf

[59] International Energy Agency, "Turkey," *Energy Policies of IEA Countries,* 2009, https://www.iea.org/publications/freepublications/publication/turkey2009.pdf

[60] IAEA Research Reactor Database, accessed July 2017, https://nucleus.iaea.org/RRDB/RR/HeaderInfo.aspx?RId=342

[61] David O'Byrne, "Turkey Aiming for Five Nuclear Power Plants by 2030: Ministry," *Platts*, February 2, 2011, http://www.platts.com/latest-news/electric-power/istanbul/turkey-aiming-for-five-nuclear-power-plants-by-8488525

[62] "Davutoğlu says third nuclear plant will be '100 percent national'," *Today's Zaman,* October 21, 2014, http://www.todayszaman.com/anasayfa_davutoglu-says-third-nuclear-plant-will-be-100-percent-national_362284.html. The article has been removed by Turkish authorities since, but the event was also covered by Nuclear Street News Team, "Turkey Plans on a 100 Percent Domestic Nuclear Plant," *Nuclear Street,* October 23, 2014.

[63] Akkuyu NGS AS, "Akkuyu Nuclear Power Plant – Progress To-date and the Way Forward," *PowerPoint Presentation at IAEA meeting*, IAEA, 2013, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2013/2013-02-11-02-14-TM-INIG/20.smirnov.pdf

[64] Huseyin Erdogan, "Sinop nuke project's site review to be ready by end '17," *Anadolu Agency*, March 24, 2017. http://aa.com.tr/en/economy/sinop-nuke-projects-site-review-to-be-ready-by-end-17-/778770

[65] "Turkish utility eyes large stake in Sinop project," World Nuclear News, May 12, 2015, http://www.world-nuclear-news.org/C-Turkish-utility-eyes-large-stake-in-Sinop-project-12051501.html

[66] Karel Beckman, "Interview Taner Yildiz, Energy Minister Turkey: 'We will ensure security of supply through the market'," *Energy Post,* August 24, 2015, http://www.energypost.eu/taner-yildiz-energy-minister-turkey-competitive-market-can-ensure-security-supply/

[67] Yasuro Kawai, "A business analysis of Japan's NPP export to Turkey" (Tokyo: Citizens' Nuclear Information Center, July 30, 2014), http://www.cnic.jp/english/newsletter/nit161/nit161articles/01_export.html

MWe AP1000s and two 1400MWe CAO1400s reactors.[68] Often, nuclear newcomers seek agreements with China or Russia to benefit from transfer of technology and knowledge going beyond the construction of a nuclear reactor. In this case too, the agreement "promises capacity improvement throughout the entire cycle of nuclear energy generation," including "development of innovative reactor- and fuel-related technologies."[69] According to an announcement made by Prime Minister Davutoğlu in October 2014, this third plant is the one that will be "100 percent national."[70]

Turkey has one operating research reactor, one research reactor that is temporarily shut down, and one that is permanently shut down.[71] The operating research reactor, the Istanbul Technical University TRIGA Research Reactor (ITU-TRR) is a 250-kilowatt Triga Mark II reactor which started operating in March 1979.[72] Its main purposes are neutron radiography, neutron activation analysis, and teaching and training, and it only runs 12 weeks per year and two days per week.[73] Its fuel rods are composed of near 20 percent uranium 235.[74] The enriched uranium in the fuel, in the form of uranium-zirconium hydride, is enriched in the United States.[75] The second research reactor is at Cekmece Nuclear Research Training Center (CNRTC). The five-megawatt reactor, Turkish Reactor 2 or TR-2, started operating in December 1981 and was shut down in 1995.[76,77] Its main purpose was the production of medical and industrial isotopes including Tc-99[78] and Ir-192.[79] Originally operating on highly enriched uranium, it was gradually converted to operate on less than 20 percent enriched uranium.[80] All spent fuel of U.S. origin was removed from the country, with the last shipment of 5.4 kilograms (kg) highly

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[68] "Nuclear Power in Turkey," *World Nuclear Association*, updated June 21, 2017, http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/turkey.aspx

[69] Altay Atli, "China, Turkey seal nuclear partnership," *Asia Times,* August 31, 2016, http://www.atimes.com/article/china-turkey-seal-nuclear-partnership/

[70] "Davutoğlu says third nuclear plant will be '100 percent national.'"

[71] *IAEA Research Reactor Database.*

[72] N. Aybers et al, "Planning and Implementation of Istanbul Technical University TRIGA Research Reactor Program," IAEA Collection, 1982, http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/40/026/40026092.pdf

[73] "ITU-TRR," *IAEA Research Reactor Database,* https://nucleus.iaea.org/RRDB/RR/ExpmtlFacility.aspx?RId=343

[74] T. Bueke and H. Yavuz, "Fuel Element Burn-Up Calculation in ITU TRIGA Mark-II Reactor," IAEA Collection, September 1992, http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/40/010/40010582.pdf

[75] Ebinger et al, "Models for Aspirant Civil Nuclear Energy Nations in the Middle East" (Washington, DC: Brookings Institution, September 2011), http://www.brookings.edu/~/media/research/files/papers/2011/9/27-middle-east-nuclear-ebinger-banks/0927_middle_east_nuclear_ebinger_banks.pdf

[76] Turkish Atomic Energy Authority, "Turkey's Regulatory Plans for High Enriched to Low Enriched Conversion of TR-2 Reactor Core," IAEA Collection, http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/35/066/35066237.pdf

[77] "TR-2," IAEA Research Reactor Database, https://nucleus.iaea.org/RRDB/RR/HeaderInfo.aspx?RId=342

[78] Technetium-99, a decay product of Mo-99, which is a fission product of U-235. For more information see: http://hyperphysics.phy-astr.gsu.edu/hbase/nuclear/technetium.html

[79] Turkish Atomic Energy Authority, "Research and Development, CNAEM," updated October 4, 2010, http://www.taek.gov.tr/en/research-development.html

[80] "TR-2."

enriched uranium (HEU) sent out in January 2010.[81] To restart the reactor, Turkey heavily invested in upgrading and overhauling it, and it is currently waiting for licensing.[82]

Another Turkish research and training center, Sarayköy Nuclear Research and Training Center (SANAEM), focuses on archaeological and geological use of nuclear material and techniques. The laboratory of the center's fission unit has three Am-Be neutron irradiation cells for research on nuclear properties of several elements, including uranium and thorium.[83] Additionally, a 30 mega-electron volt (MeV) cyclotron was constructed at the center in 2010 to produce radioisotopes and for research activities.[84] While any neutron source can in theory be used to irradiate uranium-238 to produce plutonium-239, non-reactor technologies are highly inefficient. According to an American Association for the Advancement of Science estimate, a 30 MeV neutron source would need 1,500-3,000 years to produce 5-10 kg Pu-239, the critical mass for a nuclear weapon.[85]

As of 2017, Turkey is far away from having the workforce or the technology needed to follow a nuclear Iran "immediately." In an interview with the IAEA, Necati Yamac, head of the Nuclear Energy Project and Implementing Department of the Turkish Ministry of Energy and Natural Resources, explained the benefits of the Build-Own-Operate (BOO) model intended for Turkey's first foreign-operated nuclear power plants: it saves time and resources.[86] A nuclear newcomer country like Turkey does not have the time or money to develop on its own the workforce and the experience needed for the "design, construction and operation of NPPs [nuclear power plants]."[87] In order to include Turkish citizens in the Akkuyu project, around 600 students are, or will be, studying science and engineering at the MePhi University in Russia.[88] For comparison, the *Turkish Nuclear Engineers Society, a non-profit organization for nuclear engineers, had 180 members in 2015, while their French partner, the French Nuclear Society had 3500.*[89] The workforce needed to operate a power plant would have to come from "a nuclear

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[81] "Final HEU return from Turkey," World Nuclear News, January 14, 2010, http://www.world-nuclear-news.org/RS-Final_HEU_return_from_Turkey-1401108.html
[82] "TR-2."
[83] Turkish Atomic Energy Authority, "Fission Unit," October 04, 2010, http://www.taek.gov.tr/en/institutional/affiliates/saraykoy-nuclear-research-and-training-center/291-research-a-development-division/907-fission-unit.html
[84] Organisation for Economic Co-operation and Development (OECD), "Nuclear Legislation in OECD and NEA Countries," 2008, https://www.oecd-nea.org/law/legislation/turkey.pdf
[85] Seth A. Hoedl and Derek Updegraff, "Medical Isotopes without Reactors or Uranium Enrichment," American Association for the Advancement of Science, *PONI Summer Conference*, 2013
[86] Marta Ferrari, "How They Do It: Turkey," IAEA, February 11, 2014, https://www.iaea.org/newscenter/news/how-they-do-it-turkey
[87] Ferrari, "How They Do It: Turkey."
[88] Salih Sari, "Current Status of Nuclear Power Program in Turkey," *PowerPoint Presentation at 'Technical Meeting on Country Nuclear Power Profile'*, IAEA, Vienna, May 10-13, 2016, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2016/2016-05-10-05-13-NPES/Country_pres/Turkey_CNPP_Meeting_Turkey_Presentation_10-13_May_2016.pdf
[89] "The French Nuclear Society signs a cooperation agreement with the Turkish Nuclear Engineers Society," French Nuclear Society Press Release, January 19, 2015, https://www.euronuclear.org/e-news/e-news-47/sfen.htm

research group, which has to quickly learn the challenges of implementing a large industrial project."[90] The same time, expertise, and material constraints are true for nuclear weapon capabilities: laboratory scale enrichment of uranium will enhance the knowledge of a country's experts, but it does not result in industrial scale capability.

From a proliferation viewpoint, nuclear power plants that are operated by domestically-owned companies are more concerning than foreign-operated plants. Therefore, there are different proliferation concerns for Turkey's different plans with Rosatom and Mitsubishi. Under its agreement with Russia, Turkey will not have access to fuel or spent fuel from the power plant. Fuel will be imported from Russia and spent fuel exported right away.[91] This reduces the risk of Turkey further enriching the fuel or separating plutonium from spent fuel. The cooperation with Japan for the second nuclear power plant was accompanied by a Nuclear Energy Agreement between the two governments.[92] After a draft of the $22 billion agreement was signed in May 2013 by Erdogan and his Japanese counterpart Prime Minister Shinzo Abe,[93] and revised to accelerate the project in January 2014, it caused controversy among Japanese and U.S. proliferation analysts. Some argued that it "contain[ed] a provision that would enable Turkey to eventually enrich uranium and extract plutonium by reprocessing spent nuclear fuel."[94] The agreement was seen by many as a "respon[se] to Iran's enrichment program."[95] The agreement was subsequently modified and endorsed by the Diet, the Japanese legislative assembly, and entered into effect in June 2014.[96] The current agreement does not allow for a transfer of technologies for uranium enrichment or reprocessing of spent nuclear fuel to Turkey. However, Article VIII of the agreement states that this provision can be altered in the future if both governments agree. Details on the treatment of spent fuel are unknown. Japan has an excess of spent nuclear fuel and is unlikely to agree to the return of spent fuel.[97]

The nuclear power plant agreement with Japan and impending plans for a third, wholly national project with China signal that Turkey is planning to gradually reduce foreign guidance and control of its nuclear fuel cycle.

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[90] Ferrari, "How They Do It: Turkey."
[91] Sinan Uelgen, "Turkey and the Bomb" (Washington, D.C.: Carnegie Endowment for International Peace, February 2012), http://carnegieendowment.org/files/turkey_bomb.pdf
[92] Ministry of Foreign Affairs of Japan, "Agreement between the Government of Japan and the Government of the Republic of Turkey for Co-operation in the use of Nuclear Energy for peaceful purposes," Approved by Japanese Diet on April 18, 2014, http://www.mofa.go.jp/mofaj/files/000018111.pdf
[93] Selcan Hacaoglu and Tara Patel, "Mitsubishi, Areva Sign $22b Turkish Nuclear Plant Deal," *Bloomberg,* May 03, 2013, http://www.bloomberg.com/news/articles/2013-05-03/mitsubishi-areva-set-to-sign-turkish-nuclear-plant-deal-today
[94] EDITORIAL: Urgent rethink needed on Japan-Turkey nuclear energy pact," *The Asahi Shimbun*, January 8, 2014, http://ajw.asahi.com/article/views/editorial/AJ201401080039
[95] Jessica C. Varnum, "Closing the Nuclear Trapdoor in the U.S.-Turkey 'Model' Partnership" (Washington, D.C.: The Brookings Institution, Turkey Project Policy Paper, No. 1, June 2013), http://www.brookings.edu/~/media/research/files/papers/2013/06/17-us-turkey-nuclear-partnership-cooperation-varnum/17-us-turkey-nuclear-partnership-cooperation-varnum.pdf
[96] Kawai, "A business analysis of Japan's NPP export to Turkey."
[97] Kawai, "A business analysis of Japan's NPP export to Turkey."

Turkey has no official plans to construct an enrichment or reprocessing facility but it has assiduously defended its right to acquire such facilities in the future: Turkey interprets Article IV of the NPT as granting the "right to enrich," and has actively opposed further NSG restrictions on the transfer of enrichment and reprocessing technology. Turkey became member of the NSG in 2000, shortly after joining the Zangger Committee in 1999.[98] Acquiring these steps would be attractive from the point of nuclear energy independence, or 'closing' the domestic nuclear fuel cycle, but it would also bring Turkey significantly closer to nuclear weapons.

Enrichment ambitions were dismissed publicly by Energy Minister Taney Yildiz.[99] Yildiz stated in October 2013 that enriched uranium will remain imported, and in 2014, he reconfirmed: "Turkey does not have an aim of building an atom bomb, nor nuclear enrichment."[100] At both the 2009 and 2010 meetings of the NSG, however, Turkey objected to "further restrictions on access to nuclear material, equipment, and technology beyond restrictions expressed in the NPT."[101] More specifically, Turkey was concerned that its own nuclear infrastructure would be disadvantaged because the proposed guidelines asked suppliers to consider "'[g]eneral conditions of stability and security'" within the recipient's state and the state's region before agreeing to the transfer of any material.[102] Turkey also opposed the "black-box" approach, proposed by the United States, which asks suppliers to ensure that the transfer "take[s] place under conditions that will not permit or enable the replication of the technology."[103] In 2012, the NSG reached an agreement on the revision of the guidelines, and the 2013 version of the NSG guidelines contained both ideas Turkey had opposed, but in looser language.

Turkey has invested in a fuel rod production facility and uranium mining, crucial steps toward making domestically produced nuclear fuel. A 2015 research center report cites Turkish newspapers reporting Turkey's hopes to construct a fuel rod production facility.[104] The report mentions a $300 million investment planned for the production facility.[105] According to Yildiz,

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[98] Organisation for Economic Co-operation and Development (OECD), "Nuclear Legislation in OECD and NEA Countries," 2008, https://www.oecd-nea.org/law/legislation/turkey.pdf

[99] "Energy in 2011," Anadolu Agency, *AA Energy News Terminal.*

[100] Ersan Temizel, "Nuclear power plant fuel rods to be produced in Turkey," Enerji Enstitusu, October 28, 2013. Translated by Google Translate, original title: "Nükleer santralin yakıt çubukları Türkiye'de üretilecek," http://enerjienstitusu.com/2013/10/28/nukleer-santralin-yakit-cubuklari-turkiyede-uretilecek/ ; "Turkey's nuclear plant for peaceful purposes: Yildiz," *Anadolu Agency*, October 10, 2014, http://aa.com.tr/en/economy/turkeys-nuclear-plant-for-peaceful-purposes-yildiz/112298

[101] Mark Hibbs, "Nuclear Suppliers Group and the IAEA Additional Protocol" (Washington, D.C.: Carnegie Endowment for International Peace, August 18, 2010), http://carnegieendowment.org/2010/08/18/nuclear-suppliers-group-and-iaea-additional-protocol

[102] Daniel Horner, "NSG Revises Rules on Sensitive Exports," *Arms Control Today*, August 2011, http://search.proquest.com.ezproxy.vccs.edu:2048/docview/884218279/2ADC40EC266E4043PQ/1?accountid=12902

[103] Fred McGoldrick, "Limiting Transfers of Enrichment and Reprocessing Technology: Issues, Constraints, Options" (Cambridge: Harvard University Belfer Center, Project on Managing the Atom, May 2011), http://belfercenter.ksg.harvard.edu/files/MTA-NSG-report-color.pdf

[104] Ahmet K. Han et al., "Nuclear Security: A Turkish Perspective," *EDAM Center for Economics and Foreign Policy Studies,* Istanbul, 2015, http://edam.org.tr/document/NuclearBook3/edam_nucphysec2015_full.pdf

[105] Ersan Temizel, "Nuclear power plant fuel rods to be produced in Turkey."

Turkey plans on producing the "outer shell"[106] of nuclear fuel pellets; enriched uranium will be imported. Yildiz does not name a potential supplier, but refers to the "seven countries that enrich uranium" as possible suppliers. The plan to import raw enriched uranium, not in the form of fuel pellets, is in accord with Turkey's refusal to agree to the 2008 version of the NSG's proposed stricter guidelines on enrichment (and reprocessing).

Turkey does not have an enrichment facility; all enriched fuel has been imported. However, in 2009, the Mineral Research & Exploration General Directorate (MTA) laboratory began to produce small quantities of uranium hexafluoride, the uranium compound used for enrichment in gas centrifuges.[107] Laboratory reports and publications indicate small scale usage of uranium hexafluoride and other uranium fluoride compounds at the Technical University in Istanbul[108] and other institutions. Also in small quantities, the MTA converts natural uranium to uranium oxide, and since 1986 it has been producing UO_2 pellets that can be used for a nuclear reactor.[109] An active IAEA project, approved in 2012, is titled "Supporting Uranium Exploration, Resource Augmentation and Production Using Advanced Techniques."[110]

Turkey has abundant natural uranium and thorium deposits. After decades of researching and evaluating different sites, Turkey started its first mining and purification project, the Temrezli project, in 2011.[111] An annual 385 tonnes of uranium are planned to be produced, however, a drop in uranium market prices has stalled the effort temporarily[112]

There are units within CNRTC's Nuclear Technology Division of interest from a proliferation standpoint: within nuclear physics, radioisotope, reactor technology, and material technology units, studies are conducted on power plant and research reactor design and technology, fuel and material, fuel production techniques, and safety. Specific activities include purifying small quantities of uranium,[113] analyzing "every type of nuclear material" and neutron activation, and manufacturing UO_2, ThO_2 and $ThUO_2$ powder and pellets.[114]

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[106] Ersan Temizel, "Nuclear power plant fuel rods to be produced in Turkey."
[107] Uelgen, "Turkey and the Bomb."
[108] Ziya Engin Erkmen, "A study on the reaction of yttria (Y2O3) in flowing uranium hexafluoride (UF6) gas at 900°C," *Journal of Nuclear Materials,* October 1998, https://www.researchgate.net/publication/232370696_A_study_on_the_reaction_of_yttria_%28Y2O3%29_in_flowing_uranium_hexafluoride_%28UF6%29_gas_at_900C
[109] Uelgen, "Turkey and the Bomb."
[110] Nuclear Energy Agency and the International Atomic Energy Agency, "Uranium 2016: Resources, Production and Demand," OECD, 2016, https://www.iaea.org/technicalcooperation/documents/Projects/TCEU/Turkey.pdf
[111] Philipp M. Mobbs, "The Mineral Industry of Turkey," in U.S. Department of the Interior and U.S. Geological Survey, *2011 Minerals Yearbook*, 2011, http://minerals.usgs.gov/minerals/pubs/country/2011/myb3-2011-tu.pdf
[112] IAEA Report by the General Director, "Nuclear Technology Review 2014," July 17, 2014, https://www.iaea.org/About/Policy/GC/GC58/GC58InfDocuments/English/gc58inf-4_en.pdf
IAEA Report by the General Director, "Nuclear Technology Review 2015," July 2, 2015, https://www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[113] Uelgen, "Turkey and the Bomb."
[114] Can S., "Activities and Cooperation Opportunities at CEKMECE Nuclear Research and Training Center," published in *The Third Eurasian Conference 'Nuclear Science and its Application',* IAEA, October 2004 http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/36/108/36108804.pdf

While developing its nuclear infrastructure, Turkey is also investing in a domestic ballistic missile system, which adds weight to the international community's task to ensure Turkey's nuclear program remains strictly civilian.[115] Turkey already has nuclear-capable aircraft, such as Turkish McDonnell-Douglas F-4 aircraft, which are capable of delivering tactical B61 nuclear weapons (B61-3 and B61-4).[116,117]

Research and Training

In addition to its physical infrastructure, Turkey must also invest in its academic sector in order to have a burgeoning nuclear power program; currently there are only a few nuclear engineering and related programs. Ankara University has a "subcritical assembly" where students learn about reactor mechanisms using light water and natural uranium.[118] The core consists of 2,500 kilograms of natural uranium that was supplied by the United States.[119] Extensive exchange programs with Russia and Japan are taking place to increase the number of engineering students. Additionally, the second nuclear power plant at Sinop will incorporate a nuclear training center for simulators, laboratories, and workshops.[120] Although Turkey's nuclear energy workforce currently lacks the quantity of personnel needed, it has been developing good quality personnel in other scientific and engineering fields. In May 2014, Turkey's European Council for Nuclear Research (CERN) membership was upgraded from observer status to associate member, which means that Turkish physicists can actively participate in "high energy" physics experiments, although it should be noted that these activities have nothing to do with sensitive nuclear facilities or nuclear weapons.[121] However, they show that if Turkey invests the resources, it will develop a more sophisticated scientific and technical workforce.

A review of both older and recent scientific journals, reports, and dissertations, indicates that sophisticated research is being done in the field of nuclear engineering. Noticeable from a

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[115] "Turkey test-fires first domestically-manufactured ballistic missile," *PressTV*, May 12, 2017, http://www.presstv.ir/Detail/2017/05/12/521559/Turkey-ballistic-missile-NATO-Russia

[116] "The B61 Life Extension Program" (Washington, D.C.: Union of Concerned Scientists, accessed July 26, 2017), http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/B61-life-extension-program-FS.pdf

[117] Peter Davies, "USAF McDonnell Douglas F-4 Phantom II," (Bloomsbury Publishing, 2013), p. 28.

[118] F. Domanic, "Atomic Energy Projects Turkey," published in M.L. Smith, *The Role of Science in the Development of Natural Resources with Particular Reference to Pakistan, Iran and Turkey* (Great Britain: Pergamon Press, January 1962), https://books.google.com/books?id=g-xsBQAAQBAJ&pg=PA138&lpg=PA138&dq=ankara+university+subcritical+assembly&source=bl&ots=D2P3ewKNfE&sig=o7erShU3DHmm_2OhR-w8q4SM0G4&hl=en&sa=X&ved=0ahUKEwif_tO-xPLJAhUKSyYKHeq1AmQQ6AEIKzAC#v=onepage&q=ankara%20university%20subcritical%20assembly&f=false

[119] *Nuclear Engineering International, Volume 6* (California: Heywood-Temple Industrial Publications, 2011) https://books.google.com/books?id=Eh5KAQAAIAAJ&q=uranium-zirconium+hydride+turkey&dq=uranium-zirconium+hydride+turkey&hl=en&sa=X&ved=0ahUKEwj8vtK5wfLJAhVMeT4KHZ8rBZUQ6AEISjAG

[120] Sari, "Current Status of Nuclear Power Program in Turkey."

[121] Dan Noyes, "Turkey to become Associate Member State of CERN," CERN, May 12, 2014, http://home.cern/about/updates/2014/05/turkey-become-associate-member-state-cern

proliferation standpoint are topics such as: uranium-fluoride compounds, both liquid and gaseous;[122] heavy water reactor nuclear fuel pellets consisting of UO_2 and ThO_2;[123] pressurized light-water-reactors (LWR) fueled with plutonium, urania-gadolinia, and low enriched uranium (LEU)-thorium;[124] accelerator-driven systems (ADS) fueled with thorium;[125] light water reactor (LWR) spent fuel;[126] and fusion and hybrid reactors.[127]

Research on different reactor types and fuels is common. It serves as a way for scientists and engineers to become more familiar with nuclear properties, reactions and processes, independent of whether this knowledge will be used for peaceful or military purposes. Knowing how to store and handle uranium-fluoride compounds, especially in gaseous state, is one example. Uranium-fluoride compounds are important for the enrichment of uranium, which is needed for light-water reactor fuel, but can also be used to make highly enriched uranium for a nuclear explosive.

Export Controls, Safeguards, and Proliferation Obstacles

Although Turkey is a member of the NSG, it poorly enforces its own export control laws. There have been numerous cases of controlled or otherwise sensitive nuclear-related goods passing through Turkey to Iran. On the Institute's Peddling Peril Index, which evaluates the effectiveness of countries' export control system, Turkey is in the bottom ranking. For many countries with poor export control records, they also are more willing to pursue illegal imports for their own purposes. As such, concerns remain that if Turkey pursues sensitive nuclear capabilities, it may seek to procure goods illicitly if suppliers deny imports.

Because Turkey has ratified the Additional Protocol, the IAEA is familiar with Turkey's current nuclear capacity and plans: it also works closely with the Turkish Atomic Energy Authority

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122 Z. E. Erkmen, S. Anghaie, "Performance of molybdenum with UF4 at high temperatures as a wall material for space reactors," 1997, http://link.springer.com/article/10.1007/s11661-997-0169-4; Z.E. Erkmen, "A study on the corrosion behavior of yttria (Y2O3) in flowing uranium hexafluoride (Uf6) gas at 1173 K," *Korozyon*, 1993.

123 S. Can, "Recent activities of the nuclear fuel technology department of Cekmece Nuclear Research and Training Center," Accessed January 2016, http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/31/006/31006085.pdf

124 H. Disbudak, "Perspective of thorium research and boron carbide coating of urania-gadolinia fuel in Turkey," in IAEA-TECDOC-1319, 2002.

125 M. Arik et al, "A provisional study of ADS within Turkic Accelerator Complex Project," in *Thorium Energy for the World* (Switzerland: Springer, Cham, 2016), pp. 423-424.

126 S. Sahin, H. Yapici, "Rejuvenation of light water reactor spent fuel in fusion blankets," *Annals of Nuclear Energy*, November 1998, Vol. 25, Issue 16, pp. 1317-1330, http://www.sciencedirect.com/science/article/pii/S0306454998000188; S. Sahin, B. Sarer, Y. Celik, "Utilization of nuclear waste plutonium and thorium mixed fuel in candu reactors," *International Journal of Energy Research*, November 2016, Vol. 40, Issue 14, pp. 1901-1907, http://onlinelibrary.wiley.com/doi/10.1002/er.3464/abstract

127 Kadir Yildiz and Adem Acir, "Investigation of Effectiveness of different Tritium breeding materials in a fusion-fission hybrid reactor fueled with $ThSi_2$ – moderated with natural Li," *Journal of the Faculty of Engineering and Architecture of Gazi University*, 2005, Vol. 20, Issue 4, p. 463.

(Türkiye Atom Enerjisi Kurumu) or TAEK to ensure that all safety and security measures are applied. Since 2012, the IAEA has awarded Turkey annually with the "broader conclusion" under the Additional Protocol and Comprehensive Safeguards Agreement.[128] This safeguards conclusion, still absent in the case of Iran, by contrast, means that "all of the nuclear material in the State had been placed under safeguards and remained in peaceful nuclear activities […]", and, more relevant for Turkey, concludes "the absence of undeclared nuclear material and activities."[129]

Turkey has been participating in numerous IAEA Technical Cooperation (TC) Programmes[130] and has signed a Country Programme Framework for 2013-2017.[131] In November 2013, the IAEA conducted an Integrated Nuclear Infrastructure Review (INIR) mission in Turkey. The mission goes over the '19 Milestones in the Development of a National Infrastructure for Nuclear Power' and evaluates a possible nuclear infrastructure through site visits, interviews and reviewing of documents.[132,133] Unfortunately, unlike the UAE and Jordan, Turkey has not agreed to make its INIR report publicly available. The IAEA's detailed understanding of Turkey's nuclear situation may make any steps taken by Turkey towards nuclear weapons capabilities more evident, suspicious, and detectable.

These extensive cooperation programs, especially on the technical side, indicate that if Turkey should decide to "close" the domestic fuel cycle and start an enrichment or reprocessing program, it would likely initially try to acquire the needed technology under safeguards. However, given the actions of Erdogan, the country's political turmoil, and on-going tensions in the region, suppliers in the NSG would likely block the sale of enrichment or reprocessing plants to Turkey, even under safeguards. However, Turkey could pursue a slower path of domestically building sensitive nuclear facilities via the illicit procurement of technology, equipment, and materials abroad. The plant would be expected to be placed under safeguards, but today illicit procurements for safeguarded plants are not prohibited by existing treaties and safeguards agreements and cannot be excluded in the case of Turkey. If Turkey builds enrichment or reprocessing plants under safeguards, it could decide to use them later to break out to nuclear weapons or as a basis to build covert, parallel, sensitive facilities, although the latter approach risks detection and a negative international response, long before Turkey could finish any facilities. In the former case, the facilities would be available in case Turkey decides to promptly and openly pursue nuclear weapons after withdrawing from the Nuclear Non-

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[128] IAEA, "IAEA SAFEGUARDS GLOSSARY Edition 2001," INTERNATIONAL NUCLEAR VERIFICATION SERIES No. 3, Vienna, 2002, http://www-pub.iaea.org/MTCD/publications/PDF/nvs-3-cd/PDF/NVS3_scr.pdf
[129] Ibid.
[130] Varnum, "Closing the Nuclear Trapdoor in the U.S.-Turkey 'Model' Partnership."
[131] IAEA Department of Technical Cooperation, "Turkey signs a Country Programme Framework (CPF) for 2013-2017," September 17, 2013, https://www.iaea.org/technicalcooperation/Regions/Europe/News/Archive/09172013_CPF_Turkey.html
[132] Starz and Dyck, "IAEA Reviews Turkey's Progress in Nuclear Power Development," IAEA, November 14, 2013, https://www.iaea.org/newscenter/news/iaea-reviews-turkeys-progress-nuclear-power-development
[133] IAEA, "Integrated Nuclear Infrastructure Review Missions," Updated November 11, 2015, https://www.iaea.org/NuclearPower/Infrastructure/INIR.html

Proliferation Treaty. Although this step would be momentous, it will become more likely if Iran pursues nuclear weapons.

If Turkey were to pursue developing the means to build nuclear weapons themselves, separate from making nuclear explosive materials, it would need to circumvent safeguards and international attention. In that case, it would need to pursue this capability via illicit trade networks and covert domestic activities.

While Turkey is not actively pursuing enrichment or reprocessing capabilities as of 2017, it is actively pushing to keep the door to acquiring sensitive nuclear capabilities, as the international community is trying to close it further. Turkey's main reasoning for defending Iran's "right to enrich" is that it does not want to rule out the option to go as far as Iran.

Conclusion

A U.S. priority should be discouraging and blocking Turkey developing sensitive fuel cycle capabilities. This policy should be carried out at the NSG and in bilateral discussions with potential suppliers, and with Turkey directly.

Turkey should be encouraged to improve the effectiveness of its export control systems, particularly as they affect exports or retransfers to Iran. Toward this end, the United States should produce an evaluation of how Iran and other pariah states exploit Turkey's weak export control system. An unclassified version of this study should be presented to Turkey, and in egregious cases, prosecutions sought. If Turkey is uncooperative, the United States should impose sanctions on the companies and entities committing illicit exports.

Western national intelligence capabilities should focus on the detection of proliferation-relevant Turkish research and development, as well as procurements which could signify covert, or even overt, nuclear fuel cycle development or interest in nuclear weaponization.

To reduce further Turkey's incentives to seek nuclear weapons capabilities, the United States should continue to seek a strong defense relationship with Turkey, including maintaining Turkey as a productive member of NATO. However, the United States should make clear to Turkey in private conversations that its pursuit of uranium enrichment or reprocessing would threaten the U.S. defense commitment to it and destroy it if Turkey seeks nuclear weapons. This U.S. policy should happen in parallel with efforts to strengthen and extend, or make permanent, the nuclear limitations of the JCPOA.

Egypt

Summary

Egypt may develop an indigenous nuclear weapons capability in response to Iran's nuclear accomplishments. It has the one of the largest nuclear infrastructures in the Middle East, has sought nuclear weapons in the past, and views Iran as a regional rival. Its main regional rival in the nuclear realm is Israel, and Egypt considered developing nuclear weapons in the 1960s and early 1970s to counter it, but abandoned those efforts long ago. However, if Iran's nuclear program appears threatening or advanced nuclear capabilities begin to proliferate beyond Iran in the Middle East, Egypt may seek parity. Much like Turkey, it seeks to maintain an option to develop enrichment or reprocessing capabilities. Egypt is also a vocal nuclear disarmament advocate and supports a Middle East Zone Free of Nuclear Weapons, while eschewing stronger nonproliferation commitments. It is an NPT signatory but not a signatory to the Additional Protocol, and is adamant that the Nuclear Non-Proliferation Treaty (NPT) preserves a country's rights to all nuclear energy related technologies, including sensitive technologies such as uranium enrichment and reprocessing capabilities. The country had issues with the implementation of its IAEA safeguards agreement in 2004 and 2006 due to the revelation of undeclared nuclear material, activities, and facilities that spanned many years. A minor issue arose again in 2007 and 2008 relating to the discovery of uranium particles.

Egypt currently possesses one operating research reactor and limited nuclear infrastructure but has ambitious nuclear energy plans. The success of the latter may depend on improved political and economic stability of the country, which remains in tumult following a revolution in 2011 leading to the ouster of President Hosni Mubarak and election of Mohamed Morsy, a military coup in 2013, and election of former military chief Abdel Fattah el-Sisi in 2014. It is likely that domestic and economic turmoil will preoccupy Egypt's leaders for some time and that these matters will be placed on a higher agenda than ambitions for advanced nuclear capabilities, making its proliferation risk moderate for the time being. It should, however, be watched closely for signs that it is seeking advanced nuclear capabilities in preparation for a resurgent Iranian program. The United States should continue efforts to keep sensitive nuclear capabilities from being built in Egypt and it should increase pressure on it to ratify the Additional Protocol.

Security Context

Egypt pursued ballistic missile and nuclear weapons capabilities under President Gamel Abdel Nasser's regime in the 1960s, attempting to purchase nuclear weapons or technology from China, the Soviet Union, and Europe. However, these efforts were unsuccessful and ultimately abandoned. Egypt's loss in the 1967 war prevented further attempts.[134] Its forbearance has been an irritant to successive Egyptian governments and senior Egyptian officials have often

[134] Robert J. Einhorn, "Egypt: Frustrated but Still on a Non-Nuclear Course," in *The Nuclear Tipping Point: Why States Reconsider their Nuclear Choices* (Washington, DC: Brookings Institution Press, 2004)

stated to Institute personnel that while it abandoned its nuclear weapons ambitions to match Israel's nuclear weapons, it would be unlikely to continue to resist obtaining nuclear weapons if Iran obtained them.

Egypt has historically held tense relations with Iran and sides with the Arab bloc of Middle Eastern states. Nevertheless, various leaders have pursued warmer Iran relations. Egypt may seek advanced nuclear capabilities in response to either a perceived threat from a resurgent nuclear Iran and to achieve parity with Iran or other proliferant states in the Middle East in terms of regional power.

Egypt's relations with Iran were tense under President Nasser in the 1950s and 1960s, but ties were restored under President Anwar Sadat during the 1970s. However, after the Shah of Iran was overthrown in 1979, Egypt took him in, cutting off relations with Iran. The Shah was a friend of Egyptian President Anwar Sadat and lived out the remainder of his days in Cairo.[135] Relations remained hostile under President Hosni Mubarak, with Iran criticizing Egypt's peace treaty with Israel. Egypt supported Iraq during the Iran-Iraq War.[136] Following Mubarak's ouster in early 2011, the Muslim Brotherhood's Mohammed Morsy assumed a one-year term as president during which a brief thaw in relations occurred. The Iranian regime saw Morsy's less secular regime as a potential partner, despite adhering to different religious sects. Morsy traveled to Tehran in August 2012, marking the first visit by an Egyptian president in decades.[137] This signaled a divergence from the United States, since Egypt under Mubarak traditionally followed the U.S. lead on the Iran issue.

After Morsy was overthrown in a coup in the summer of 2013, current President Abdel Fatah al-Sisi came to power and his regime resumed cold relations with Iran. Egypt remains heavily reliant on Gulf benefactors like Saudi Arabia and the UAE, heavily influencing its Iran policy. Yet, it holds nuanced views. As one Egyptian diplomat expressed to *Ahram Online* in mid-2015, Egypt also seeks "to avoid going as far as being identical with the highly sceptical Saudi position."[138] The diplomat continued, "But of course we cannot turn our back on the direct and clear Saudi demand to show caution over the return of Iran."

Current Plans and Capabilities

[135] Oren Kessler, "Egypt: Iran's Next Sunni Rival," *National Interest*, August 3, 2015, http://nationalinterest.org/feature/egypt-irans-next-sunni-enemy-13474

[136] Mohamed Saied, "Egypt Sets Conditions for Dialogue with Iran," *Al-Monitor*, April 26, 2016, http://www.al-monitor.com/pulse/en/originals/2016/04/egypt-conditions-dialogue-iran-sisi.html

[137] Ernesto Londono, "Visit by Egypt's Morsi to Iran Reflects Foreign Policy Shift," *The Washington Post*, August 27, 2012, https://www.washingtonpost.com/world/middle_east/visit-by-egypts-morsi-to-iran-reflects-foreign-policy-shift/2012/08/27/4baf4b3a-f060-11e1-b74c-84ed55e0300b_story.html

[138] Dina Ezzat, "Wait and see: Egypt's line on Iran," Ahram Online, August 1, 2015, http://english.ahram.org.eg/NewsContent/1/151/136683/Egypt/Features/Wait-and-see-Egypts-line-on-Iran.aspx

Egypt's nuclear infrastructure consists of two research reactors, a two megawatt-thermal (MWth) Russian ETRR-1 reactor and a 22-MWth Argentinian ETRR-2 reactor.[139] The former is temporarily shut down and no information on the expected restart date is available.[140] Egypt carries out limited activities relating to both the front-end and back-end of the reactor's fuel cycle. At the Fuel Manufacturing Pilot Plant, it produces and assembles fuel elements from imported, enriched uranium hexafluoride.[141] At the Hot Laboratory and Waste Management Center (HLWMC), Egypt hosts hot cells and conducts low level spent fuel management of both liquid and solid wastes.[142] There is no report of decommission of the ETRR-1, so the reactor site may still have fuel, both fresh or spent, however none of it is highly enriched uranium. The liquid and solid waste from the ETRR-1 reactor is most likely still at the storage facility at the Inshas site.[143]

Nuclear power plants have been planned by Egypt since the 1980s in order to meet a growing domestic energy demand, diversify the country's power sources, and reduce reliance on limited indigenous fossil fuel resources.[144] Most recently, in 2015, ROSATOM signed an agreement to build Egypt's first nuclear power plant at el-Dabaa. The plant will have four units with a power output of 1200 megawatts-electric (MWe) each.[145] They are due to be completed by 2022 and

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[139] Eng. Nour Abouelhassan, "Overview of Egypt's Nuclear Power Program," *Power Point Presentation at the Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure,* International Atomic Energy Agency, Vienna, January 31 - February 3, 2017, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2017/2017-01-31-02-03-NIDS/Session_1_-_Considerations_for_Nuclear_Energy_Programme_Implementing_Organizations_(NEPIOs)/Session_1_-_Considerations_for_Nuclear_Energy_Programme_Implementing_Organizations_(NEPIOs)/Overview_of_Egypts_Nuclear_Power_Program_-_N._Antar_-_Egypt.pdf

[140] "ETRR-1," IAEA Research Reactor Database, https://nucleus.iaea.org/RRDB/RR/HeaderInfo.aspx?RId=116

[141] W. I. Zidan and I. M. Elseaidy, Atomic Energy Authority of Egypt, "General Description and Production Lines Of The Egyptian Fuel Manufacturing Pilot Plant," IAEA International Nuclear Information System, Uploaded December 2004, http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/36/018/36018095.pdf

[142] M.K.Shaat, Director of ETRR-2 Reactor, Atomic Energy Authority, "Report on, National Situation Report on, National Situation for Decommissioning Activities for Decommissioning Activities in Egypt in Egypt," *PowerPoint Presentation at R2D2P Meeting*, Sydney, Australia, November 12 - 16, 2007, https://www-ns.iaea.org/downloads/rw/projects/r2d2/workshop3/national-presentations/egypt-national-decomissioning-activities.pdf

[143] IAEA, "Management and Storage of Research Reactor Spent Nuclear Fuel," Proceedings of a Technical Meeting held in Thurso, United Kingdom, October 19 - 22, 2009, http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1592_web.pdf

[144] Eng. Nour Abouelhassan, "Overview of Egypt's Nuclear Power Program," *Power Point Presentation at the Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure,* International Atomic Energy Agency, Vienna, January 31 - February 3, 2017, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2017/2017-01-31-02-03-NIDS/Session_1_-_Considerations_for_Nuclear_Energy_Programme_Implementing_Organizations_(NEPIOs)/Session_1_-_Considerations_for_Nuclear_Energy_Programme_Implementing_Organizations_(NEPIOs)/Overview_of_Egypts_Nuclear_Power_Program_-_N._Antar_-_Egypt.pdf

[145] "Russia, Egypt Sign Deal on Construction of Egypt's First Nuclear Power Plant," CNN, November 19, 2015, http://www.cnn.com/2015/11/19/middleeast/russia-egypt-nuclear-deal/

scheduled to begin operating in 2024.[146] Egypt aims to be involved in the fuel cycle of its power reactors. Abdel Aty Salman, former chairman of the Nuclear Materials Authority, runs a website in the Arabic language to promote increasing Egyptian knowledge of uranium and nuclear research. Salman expressed a desire for his country to sustain a "strong, 100% Egyptian nuclear reactor." The website indicates that research has been conducted on uranium deposits in Sinai, and the Eastern and Western Deserts in Egypt.[147] In addition to exploration and evaluation of uranium deposits, Egypt has invested in a uranium extraction plant.[148]

The AEA is the primary body tasked with leading Egypt's nuclear research and development and is overseen by Egypt's minister of electricity and energy. The AEA is divided into three centers: the Nuclear Research Center (NRC), the National Center for Radiation Research and Technology (NCRRT), and the HLWMC (Hot Laboratories and Waste Management Center).[149]

NRC and HLWMC are based in Inshas, a facility investigated by the IAEA for potential safeguards violations, described below, which is located outside Cairo. NCRRT is based in Nasr City, also outside Cairo.[150] Inshas is home to the shut-down ETRR-1 reactor, the operational ETRR-2, the Fuel Manufacturing Pilot Plant, a fuel laboratory, and a heavy-water laboratory, among others. AEA's website indicates the NRC employs "more than 1400 highly qualified academic scientists in various fields of nuclear science and engineering" who enjoy the support of 2,300 technical staff and 1,300 administrative staff.[151]

Egypt has publicly stated it interprets Article IV of the NPT as granting a 'right to enrich' and that Iran's legal enrichment under the nuclear deal legitimizes that stance. Two months after the Joint Comprehensive Plan of Action (JCPOA) was struck, Nabil Fahmy, former Minister of Foreign Affairs, proclaimed that all NPT signatories should maintain the right to domestic uranium enrichment and reprocessing of nuclear material.[152] Prior to this, in 2009, Egypt abstained from voting on an IAEA resolution urging Iran to explain the purpose of its secretly-built uranium enrichment plant at Fordow.[153]

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[146] "Russia to Lend Egypt $25 Billion to Build Nuclear Power Plant," Reuters. May 19, 2016, http://www.reuters.com/article/us-egypt-russia-nuclear-idUSKCN0YA1G5

[147] Abdel Aty Salman, "Nuclear Education," Kenanonline, Web page, Archived via WayBack Machine, https://web.archive.org/web/20161206222902/http://kenanaonline.com:80/absalman. The content was translated for the Institute by Erica Wenig.

[148] Nuclear Energy Agency and the International Atomic Energy Agency, "Uranium 2003: Resources, Production and Demand," OECD, 2003, https://www.oecd-nea.org/ndd/pubs/2004/5291-uranium-2003.pdf

[149] Egyptian Atomic Energy Center, "EAEA Centers," Web page, Accessed August 2017, http://www.eaea.org.eg/centers.html

[150] Shaat, "Report on, National Situation Report on, National Situation for Decommissioning Activities for Decommissioning Activities in Egypt in Egypt."

[151] Egyptian Atomic Energy Authority, "About Us," Web page, Accessed August 2017, http://www.eaea.org.eg/aboutus.html

[152] Nabil Fahmy, "Egyptian Concerns on the P5+1/Iran Joint Comprehensive Plan of Action," Norwegian Institute of International Affairs, September 38, 2015, http://www.nupi.no/en/News/Egyptian-Concerns-on-the-P5-1-Iran-Joint-Comprehensive-Plan-of-Action.

[153] Mark Heinrich, "IAEA votes to censure Iran over nuclear cover-up," Reuters. November 27, 2009, http://www.reuters.com/article/us-nuclear-iaea-vote-idUSTRE5AQ1BZ20091127

Egyptian domestic support for the country obtaining nuclear weapons recently appeared to be unusually high. A poll conducted in 2012, shortly after Muslim Brotherhood President Mohamed Morsi came to power, showed 87 percent of Egyptians believed the country should develop a nuclear arsenal. Despite 90 percent of respondents believing Iran acquiring nuclear capabilities could pose a threat to Egypt, 61 percent said they supported Iran's pursuit of nuclear weapons. In addition, 65 percent supported Morsi's decision to reestablish diplomatic ties with Tehran.[154]

Egypt itself also possesses a series of missiles. As a member of the Missile Technology Control Regime (MTCR), Egypt domestically produces "complete rocket system," "capable of delivering at least a 500 kg [kilogram] 'payload' to a 'range' of at least 300 km [kilometers]," including control systems, software, and production equipment.[155] Although weapons design, and specifically the shape of a hypothetical nuclear weapon play a role, the payload of 500 kilograms make the missiles potentially nuclear-capable delivery systems. It is worth noting that Egypt has cooperated with North Korea in the missile and military realms, making a secret North Korea conduit more possible if Egypt ever sought nuclear weapons assistance.[156]

Undeclared Activity Concerns

In 2004, the IAEA questioned Egypt about the nature of open source publications published by the Egyptian Atomic Energy Authority (AEA) and former officials of the AEA, "suggesting the possibility of nuclear material, activities and facilities in Egypt relating to uranium extraction and conversion, irradiation of uranium targets and reprocessing that had not been reported to the [IAEA]" and were potentially taking place at its Nuclear Chemistry Building at Inshas.[157] Egypt cooperated on the matter. IAEA inspections subsequently found that Egypt had imported uranium and thorium and had conducted uranium conversion experiments, uranium and thorium irradiation, and preparatory activities related to reprocessing. Many of these experiments and projects had been long ongoing.

As a result of the investigation, Egypt had to declare its inventory of nuclear materials and submit design information for three additional locations where nuclear experiments were

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[154] "Egyptians Support Iranian Nuclear Program, Want Own Nuclear Weapons," The Israel Project, October 25, 2012, http://www.theisraelproject.org/egyptians-support-iranian-nuclear-program-want-own-nuclear-weapons-2/

[155] Missile Technology Control Regime, "Introduction - The Missile Technology Control Regime (MTCR)," Annex Handbook, August 2010, http://mtcr.info/wordpress/wp-content/uploads/2016/04/MTCR_Annex_Handbook_ENG.pdf

[156] Gardiner Harris and Declan Walsh, "U.S. Slaps Egypt on Human Rights Record and Ties to North Korea," *The New York Times,* August 22, 2017, https://mobile.nytimes.com/2017/08/22/us/politics/us-aid-egypt-human-rights-north-korea.html?elqTrackId=33cec4f10f954ac89038a4d88350ae1a&elq=576193aecfbd4deea1fc1fc813018327&elqaid=32017&elqat=1&elqCampaignId=19242&_r=0&referer=

[157] IAEA Director General, *Implementation of the NPT Safeguards Agreement in the Arab Republic of Egypt,* GOV/2005/9, February 14, 2005, http://www.globalsecurity.org/wmd/library/report/2005/egypt_iaea_gov-2005-9_14feb2005.pdf

carried out. The IAEA could account for all the declared inventory of nuclear material in Egypt. Egypt subsequently instituted stronger authorities for the AEA to exercise effective control and oversight over all of the country's nuclear activities.[158] In 2007 and 2008, however, an IAEA safeguards inspection revealed the presence of LEU and HEU particles at Inshas. Egypt stated that the particles must have come from contaminated radioisotope transport containers, a claim that the IAEA stated it would seek to verify. No subsequent IAEA reporting on the matter has been made available; the IAEA did not address Egypt in any of its 2009-2016 safeguards reports except to draw conclusions that all nuclear material remained in peaceful uses.

As mentioned, Egypt refuses to sign the Additional Protocol to its safeguards agreements, which would provide the IAEA with greater information and inspection authorities for the country.

Conclusion

Egypt does not need enrichment or reprocessing plants, and U.S. efforts should focus on preventing Egypt from obtaining sensitive fuel cycle capabilities. To increase Egypt's transparency of its nuclear program, the United States should press Egypt to ratify the Additional Protocol. The United States should also work to press nuclear reactor suppliers to Egypt to provide guaranteed lifetime fuel supplies, obviating the need for domestic enrichment. Although the United States should continue its military assistance to Egypt, it should also begin to discuss conditioning it on Egypt ratifying the Additional Protocol and committing not to import enrichment or reprocessing capabilities or facilities. The NSG should also block any such Egyptian efforts to import these technologies and national intelligence capabilities should monitor any covert efforts to import or otherwise develop them. The United States should resurrect, in partnership with Egypt and Israel, regional efforts to study the methods and requirements needed to create a verifiable nuclear weapons free zone in the Middle East. A priority is the strengthening of the JCPOA, particularly by better enforcing the deal and extending the duration of the major nuclear limitations. This would prevent a renewed crisis in which Egypt may be expected to eventually pursue advanced fuel cycle capabilities.

[158] IAEA, *Safeguards Statement for 2008,* https://www.iaea.org/sites/default/files/es2008.pdf