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# Nuclear energy in Saudi Arabia within Vision 2030 Program: Prospects for nuclear energy cooperation and nonproliferation risks

*Inna Rodina*

The research is devoted to the study of developing nuclear energy by one of the key Middle Eastern countries. It is divided into three sections: the driving factors for Saudi Arabia to develop nuclear power and non-proliferation concerns; the review of the nuclear energy suppliers to the Middle East; the Saudi Arabia-Russia cooperation and its prospects.

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**Key findings:**

- **Although Saudi Arabia's nuclear program dates back to the 1960s, the kingdom has demonstrated significant interest in nuclear energy only over the last decade.**
  **The Middle East developments, especially the Iranian nuclear program, are the main factors that influence Saudi nuclear ambitions.**

- **Developing nuclear energy requires Saudi Arabia to import know-how from nuclear supplier countries. However, without modification of the Small Quantities Protocol, the countries that Saudi Arabia has shortlisted as possible nuclear energy partners (the United States, China, France, South Korea, and Russia) are not likely to cooperate with the kingdom.**

- **There are several reasons why the development of nuclear power is of interest to Saudi Arabia: the growing demand for electricity, prestige, the need to diversify the country's economy, create an attractive investment environment, and increase employment.**

- **Any kingdom's partner in the field of nuclear energy has to take all possible precautions to close the Saudis access to the nuclear fuel cycle.**

- **As the only country that returns spent nuclear fuel, Russia could contribute to the nuclear power advancement in Saudi**

**Arabia and guarantee the peaceful nature of the kingdom's nuclear energy program.**

Read

## About the Author

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# Nuclear energy in Saudi Arabia within Vision 2030 Program:

# Prospects for nuclear energy cooperation and nonproliferation risks

*Inna Rodina*

## Summary

Saudi Arabia is considered a nuclear "newcomer". Although Saudi Arabia's nuclear program dates back to the 1960s, the kingdom has demonstrated significant interest in nuclear energy only over the last decade. The Saudi interest in the peaceful use of nuclear energy is due to several reasons, among which both general for all Middle Eastern nuclear "newcomers" and specific only to the kingdom. Under the Saudi Vision 2030, nuclear energy is one of the key components of the kingdom's successful development.

Despite the Saudi ambitious plans in the nuclear energy field that were posed ten years ago, no visible progress has been reached yet. One of the possible reasons is concerns of the nuclear supplier countries and their reluctance to contribute to the nuclear power program in the kingdom. Indeed, Saudi Arabia poses a threat to the nonproliferation regime. The research studies the ways through which the kingdom can acquire nuclear weapons. It concludes that currently, Saudi Arabia has the insufficient infrastructure to build nuclear weapons, as it has no facilities for the conversion, enrichment, or production of uranium fuel, nor any reprocessing facilities. However, Saudi Arabia has ballistic missiles that it has been purchasing from China since 1987.

The kingdom may have taken attempts to acquire nuclear weapons through cooperation with other countries, such as Iraq and Pakistan. Currently, there is no evidence of the Islamabad-Riyadh quid pro quo deal. However, Saudi Arabia's active financial support for Pakistan is evident. The research highlights that the Middle East developments, especially the Iranian nuclear program, are the main factors to influence Saudi nuclear ambitions.

While Saudi Arabia is a State party to the NPT and supports the idea of establishing a zone free of weapons of mass distraction in the Middle East, its cooperation with the IAEA is not viewed as sufficient. In 2009, Saudi Arabia has implemented the IAEA Small Quantities Protocol, which exempts Saudi Arabia from regular IAEA inspections and limits the Agency's authority to verify undeclared nuclear activities. Developing nuclear energy requires Saudi Arabia to import know-how from nuclear supplier countries. However, without modification of the Small Quantities Protocol, the countries that Saudi Arabia has shortlisted as possible nuclear energy partners (the United States, China, France, South Korea, and Russia) are not likely to cooperate with the kingdom.

Russian Rosatom is one of the possible Saudi partners to facilitate developing nuclear energy. Russia has several absolute advantages: the return of its spent nuclear fuel and the International Uranium Enrichment Center that would guarantee the exclusively peaceful nature of the nuclear program. However, the research concludes that it is unlikely that Russia will be the first country to build a nuclear power plant in Saudi Arabia.

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## Introduction

Currently, there are 440 nuclear reactors in operation in some 30 countries around the world.[1] Among the nuclear energy "newcomers," it is the Middle Eastern states that have made the most dynamic progress. Today, the countries of this region demonstrate a deep interest in the development of nuclear energy: energy-exporting states intend to redirect oil and gas for export and diversify their economies, while energy-importing countries need to overcome their dependence on oil, gas, and electricity from abroad.

Since the 1980s, due to economic development and population growth, the demand for primary energy resources in the Middle East has increased more than five times.[2] In recent years, on average, the electricity demand has grown at about 4% per year in Iran, 5 % in Kuwait and Egypt, 8 % in Saudi Arabia, and 9 % in the UAE. [3,4,5,6] According to the World Energy Council forecast, by 2050, electricity consumption in the Middle East will have grown by 81-114 %, while in the rest of the world, it will have increased by 27-61 %.[7]

In the Middle East, electricity is a very sensitive issue as it grants access not only to light and use of electrical appliances, but also to freshwater. While the Middle Eastern population comprises 4 % of the world's population, it has access only to 1 % of the world's water resources.[8] The desalination of seawater is too energy-consuming and harmful to the environment. The combining of a nuclear power plant (NPP) and a desalination plant could be a good solution to this problem.

The above-mentioned facts influence the Middle East countries' perception of the energy challenges and ways to solve them. It is not surprising that the Middle East is the region with the most dynamic rates of nuclear energy development. It is the Middle Eastern states that have the most ambitious plans to develop nuclear energy. Specifically, Iran, Turkey, and Saudi Arabia have announced plans to build from 16 to 23 power reactors in less than 20 years.[9] In September 2011, the Iran's first NPP began to provide electricity to the national grid. [10,11] In July 2012, the UAE became the first country in the past 27 years to start building its first-ever NPP. In August 2020, the UAE has launched operations at the Arab world's first NPP. Nuclear fission has begun in one of four reactors at the Barakah plant.[12] Under a Russia-Turkey intergovernmental agreement for the construction of the Akkuyu NPP, the commissioning of the first NPP unit is planned for 2023.[13] In February 2020, the Egyptian Ministry of Electricity and Renewable Energy confirmed that the NPP authority would obtain a construction license for the El Dabaa NPP from the Egyptian Nuclear and Radiological Regulatory Authority that will allow Rosatom to begin the construction and pour concrete for the first unit of the 4,800 MW plant.

In December 2007, the Gulf Cooperation Council (GCC) held a meeting to discuss plans for a joint program to develop nuclear energy. However, in practice, each member state has started to develop its national program without deep coordination with other GCC states.

Saudi Arabia, as one of the key players in the Middle East, is of particular interest to study. The Saudi nuclear energy program demonstrates the kingdom's ambitious plans to develop the peaceful atom. At the same time, its program provokes non-proliferation concerns.

This research intends to attain the following **objective**: to study the prospects of Saudi Arabia's partners to implement the Saudi nuclear energy projects, as well as to assess the feasibility for Russian nuclear energy cooperation with the kingdom.

Based on the research aim, the following **research questions** have been put:

- Why does Saudi Arabia tend to develop nuclear energy?
- Which countries does the kingdom cooperate with to realize its nuclear energy plans? What are the advantages and disadvantages of cooperating with these partners?
- What are the prospects for cooperation between the Russian Federation and Saudi Arabia?
- What actions should be taken to prevent the Saudi ambitions to acquire nuclear weapons?

## Chapter 1. Development of nuclear energy in Saudi Arabia

### Nuclear energy as an indispensable component of Saudi Vision 2030

The development of nuclear power in Saudi Arabia is due to a number of reasons, such as the growing demand for electricity, prestige, the need to diversify the country's economy, create an attractive investment environment, and increase employment.

Over the past decade, the annual growth in electricity demand in Saudi Arabia has reached 10%.[14] On average, a Saudi resident consumes nine times more electricity than a resident of such Arab countries as Algeria, Egypt, or Morocco.[15] The Saudi generating capacity is more than 60 GW, among which 9.5 GW is accounted for by renewable energy sources (RES).[16,17] While the electricity demand is constantly growing, and by 2032 it is expected to reach 120 GW, Saudi Arabia has limited access to external resources: the Saudi energy networks are not designed to import electricity from abroad.[18]

The kingdom's economy is heavily dependent on oil exports. With high oil prices, the use of hydrocarbons as an energy source in the domestic market entails lost profits. This problem can be solved through the development of non-hydrocarbon energy.[19] Today, energy exporters are experiencing an unfavorable situation in the oil market. However, it could change at any time.[20]

The development of nuclear power in Saudi Arabia depends on both external and internal factors. The internal factors include the hydrocarbon and tribal lobbies, as well as public opinion: there are some other solutions to solve the above-mentioned problems that may be safer than the development of nuclear energy. However, NPP operations in neighboring countries influence the kingdom's plans to develop nuclear power. The financial factor also facilitates the nuclear projects' implementation as Saudi Arabia is one of the world's key economies.[21] [22] Moreover, the development of nuclear energy echoes Crown Prince Mohammed bin Salman's plans to industrialize the country.

**The external factors include the U.S. role in making long-term political decisions, as well as Iran's factor.**

Saudi Arabia's interest to develop nuclear energy dates back to the 1960s. In 1977, the kingdom established King Abdulaziz City for Science and Technology (KACST). A decade later, in 1988, it created the Atomic Energy Research Institute (AERI) to research industrial applications of radiation, radioactive isotopes, nuclear power, reactors, nuclear materials, and radiation protection. Since the late 1970s, Saudi Arabia's scientists have conducted several studies on the feasibility of NPP development for power generation and water desalination.

In 2006, the Gulf Cooperation Council (GCC) summit decided to conduct a study on the feasibility of developing nuclear energy in the region. After the summit, Saudi Arabia renewed its interest in nuclear energy development. In April 2010, King Abdullah issued a decree on the establishment of a new Agency - King Abdullah City for Atomic and Renewable Energy (K. A. CARE). K.A.

CARE was established as "the driving force for making atomic and renewable energy an integral part of a national sustainable energy mix, creating and leveraging the competitive advantages of relevant technologies for the social and economic development of the Kingdom of Saudi Arabia."[23] Dr. Hashim Abdullah Yamani has held the position as the K. A. CARE President since its establishment. Throughout his career, Dr. Yamani was Minister of Industry and Electricity and Minister of Commerce and industry, as well as he chaired the King Fahd University of Petroleum and Minerals Physics Department.[24]

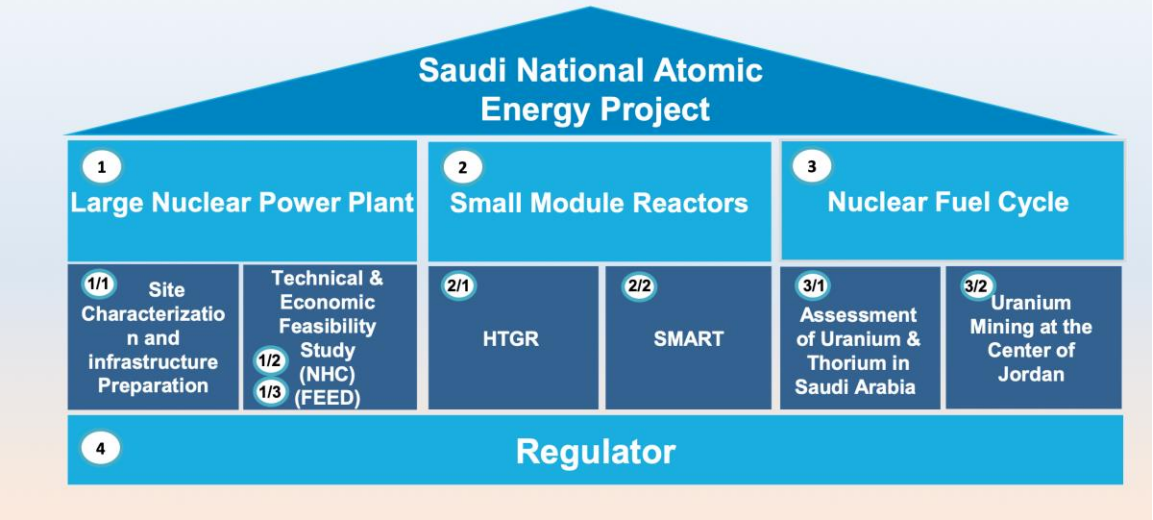
According to the K. A. CARE Charter, it aims to develop nuclear and renewable energy to meet the needs of the growing population for freshwater, electricity, and the preservation of oil resources for future generations; to ensure uninterrupted power supply to the population; to diversify sources of export income.[25] Among the K. A. CARE main functions is the supervision of the kingdom's nuclear energy activities.

In April 2016, Saudi Arabia has announced its national program known as Saudi Vision 2030. The Vision aims to transform the kingdom by reducing its reliance on oil, diversifying its economy, and developing public service sectors such as health, education, infrastructure, recreation, and tourism.[26] In light of Saudi Vision 2030, K.A. CARE proposed a plan to create an energy mix in which atomic energy plays a major role:[27]

In 2011, K. A. CARE coordinator Abdul Ghani Malibari claimed that "Saudi Arabia's objective is to build 16 civilian reactors by 2030 at a total cost of $80 billion."[28] In more recent statements, the timeline was adjusted for 2032 and expected spending increased to $112 billion.[29]

**However, the "great expectations" of the 2010s remain just plans, and as of January 2021, no power reactor has been built.**

The need to develop nuclear energy is reflected in numerous documents. For example, in July 2017, the Saudi cabinet approved the "Saudi National Atomic Energy Project," which includes plans to build large and small nuclear reactors to produce electricity and desalinate seawater.[30]



According to the project, its benefits are expected to be as follows:

• Reduced consumption of the nation's fossil fuel.

• Diversification of the country's economy.

• Contribution to the national energy mix and foster its stability.

• Creation of job with high returns.

• Development of national human capabilities.

• Increasing the level of local industries and services.

• Localization and exportation of the technologies.

• Other applications in medical, agriculture, and industrial fields.[31]

Moreover, the kingdom adopted the National Industrial Development and Logistics Vision Realization Program that aims to transform Saudi Arabia into a leading industrial power and an international logistics platform in several promising areas. The program focuses on four key sectors: industry, mining, energy, and logistics.[32] The King Abdullah Oil Research and Development Center (KAPSARC) estimates that the creation of a nuclear industry in Saudi Arabia will reduce unemployment, increase average wages and help the kingdom to meet its desalination needs.[33]

The kingdom cooperates with the IAEA. In February 2007, the GCC States, at the initiative of Saudi Arabia, agreed to cooperate with the IAEA to prepare a feasibility study for a regional nuclear power and water desalination program. Since its establishment, K. A. CARE has operated under the infrastructure aspects developed and periodically reviewed by the IAEA.[34]

In January 2019, the IAEA released the Saudi Integrated Nuclear Infrastructure Review, where the Agency concluded that Saudi Arabia has reached "significant progress" that included the establishment of a legislative framework and the development of nuclear infrastructure.[35] In September 2020, IAEA Director General Rafael Grossi stated that the Agency supports Saudi Arabia in producing nuclear energy: "Saudi Arabia is interested in obtaining nuclear energy, and we are willing to provide the kingdom with the necessary support."[36]

**Saudi nuclear energy activities as a potential risk to the nuclear nonproliferation regime**

As for many years, energy resources and close ties with the United States were the key factors for the Saudi external security, thus it was not reasonable for the kingdom to launch its independent from the United States military nuclear program. Instead, Saudi Arabia always supported the idea of the establishment of a Weapons of Mass Destruction Free Zone (WMD-FZ) in the Middle East.

However, today concerns about Saudi Arabia's nuclear ambitions have been provoked by the kingdom's confrontation with Iran. It is the Iran's nuclear activities that pose a particular threat to

Saudi Arabia. Mass media constantly release speculations on Saudi Arabia's military nuclear plans. Back in 2008, it was reported that Saudi Arabia "had undeclared nuclear installations and plans to purchase nuclear weapons and delivery systems from another state."[37]

Some suspicions are based on the statements of former Saudi diplomat Mohammed Al Khilewi, who fled to the United States in the 1990s. He revealed thousands of documents copied, according to him, from official Saudi sources. Khilewi claimed that since 1975, the kingdom had sought to acquire nuclear weapons, and after the Yom Kippur War, Saudi Arabia conducted a secret program at a remote military facility near the city of al-Sulayil.[38] [39] In 1998, Khilewi stated that Saudi Arabia had spent millions of dollars supporting Iraq and Pakistan's nuclear weapons programs.[40] Saudi Arabia denies the Khilewi statements. Most of the experts don't rely on the accuracy of the data provided by Khilewi.

*Saudi Arabia's accusations of financial assistance to the Iraqi nuclear program*

According to Khilewi, between 1975 and 1990, the kingdom provided Saddam Hussein with $25 billion to finance the Iraqi clandestine nuclear program.[41] In the exchange, a part of Iraqi nuclear weapons was to be transferred to Saudi Arabia as soon as they were produced. Khilewi claimed that Saudi-Iraqi cooperation came to an end after the Iraq invasion of Kuwait in 1990.

*Saudi-Pakistan deal: quid pro quo*

According to Khilewi and Saudi Arabia's nuclear researchers, the kingdom provided significant financial support to Pakistan's nuclear program to get sensitive nuclear technology in return. According to open sources, since the 1970s, the kingdom has provided financial assistance to Islamabad and exported cheap oil to it when the United States imposed sanctions on Pakistan after its nuclear tests in 1998. However, there is no evidence that Saudi Arabia's financial flows were aimed at the assistance to build a nuclear bomb.[42]

Furthermore, in 1999 and 2002, Saudi Arabia's defense minister Prince Sultan visited a uranium enrichment plant and a missile complex in Kahut.[43] In November 1999, Abdul Qadir Khan, the founder of the Pakistani nuclear program, visited Saudi Arabia.[44] In October 2003, crown Prince Abdullah visited Pakistan. According to Israeli intelligence, the crown prince arrived in Pakistan to negotiate the purchase of Pakistani nuclear warheads in case Iran acquires nuclear weapons.[45] There has also been speculation that such a deal could include the deployment of Pakistani nuclear weapons on the Saudi territory. Both Riyadh and Islamabad denied the accusations.[46]

Crown Prince Mohammed bin Salman constantly visits Pakistan. Only in 2016, he visited it twice. During his January 2016 visit, the two countries signed an unspecified military cooperation agreement. When he stopped over in Pakistan again while en route to China in August 2016, he praised "the depth of the strategic relationship between the two peoples." [47] In February 2019, during his visit to Pakistan, Mohammed bin Salman promised Islamabad $20 billion in investment.[48]

Nonetheless, there is no evidence of a Pakistan – Saudi Arabia secret nuclear deal; experts and analysts can only speculate. According to Gary Samor, Director of the Waltham Research Institute,

"the most likely option, if Pakistan were to honor any agreement, would be for Pakistan to send its forces, its troops armed with nuclear weapons and with delivery systems to be deployed in Saudi Arabia."[49]

*Iran's influence on Saudi Arabia's plans to develop nuclear weapons*

According to many experts, in 2003, due to the changing security environment in the Middle East, Saudi Arabia started to review its strategic policy. In 2003, the Guardian published an article claiming that the Saudis were considering three ways to develop their nuclear policy: "to acquire a nuclear capability as a deterrent; to maintain or enter into an alliance with an existing nuclear power that would offer protection; to try to reach a regional agreement on having the nuclear-free Middle East."[50] Saudi Arabia's government denied the accuracy of this information. However, in 2009, Saudi King Abdullah warned that if Iran crossed the line, "we will get nuclear weapons."[51] Moreover, in 2018, Crown Prince Mohammed bin Salman said: "Saudi Arabia does not seek to possess nuclear weapons, but without any doubt, if Iran acquires such weapons, we will do the same immediately."[52] "Our leaders will never allow Iran to have a nuclear weapon until we have it," added Saudi security analyst Ibrahim Al Marieh. – "If Iran claims to have nuclear weapons, we can't afford to wait 30 years to develop our nuclear weapons. We must announce that we have such weapons within a week."[53]

Saudi Arabia's policy towards Iran is quite contradictory. Until 2015, the kingdom expressed dissatisfaction with the U.S. actions to negotiate a nuclear deal with Iran. Saudi Arabia worried that Barack Obama would be more interested in the contacts with Teheran than with Riyadh. However, in 2018, when the United States declared the withdrawal from the Joint Comprehensive Plan of Action (JCPOA), Saudi Arabia renewed its rhetoric to create a nuclear weapon to defend itself from the Iranian threat.[54]

According to Mark Hibbs, a nonresident senior fellow in Carnegie's Nuclear Policy Program, "if Iran obtains nuclear weapons, Saudi Arabia will react by entering into a nuclear defense pact with Pakistan. U.S. and European officials say privately that they are concerned about how Saudi Arabia would respond to a nuclear-armed Iran, given a lack of transparency in Saudi government decision making and the country's precarious security situation."[55]

*Assessment of Saudi capabilities to produce nuclear weapons*

At this time, Saudi Arabia has only a rudimentary civilian nuclear infrastructure that consists of a 3 MV Tandetron accelerator, a 350 kV light ion accelerator, and a cyclotron. The accelerators are located at the King Fahd University of Petroleum and Minerals and are used for experiments in nuclear physics, while the cyclotron is used for the production of medical isotopes at King Faisal Specialist Hospital & Research Center.[56] The knowledge required to operate such facilities is basic and not sufficient for the development of nuclear weapons. Saudi scientists conduct laboratory research and experiments in nuclear science, including the operation of a cobalt-60 irradiation facility.[57] The kingdom does not have facilities for converting, enriching, or producing uranium fuel, nor does it have reprocessing capabilities. Some AERI laboratories research on physical and chemical separation and radiochemistry, that makes them potentially suitable for small-scale processing of plutonium, "but not in the quantities that would pose a proliferation risk."[58]

However, in August 2020, the Wall Street Journal raised concerns regarding alleged Saudi nuclear sites, including the uranium extraction facility. According to the Wall Street Journal, "Saudi Arabia has constructed with Chinese help a facility for extracting uranium yellowcake from uranium ore, an advance in the oil-rich kingdom's drive to master nuclear technology."[59] The fact that China secretly promotes the development of Saudi nuclear activities provokes suspicions about the true Saudi nuclear plans. The kingdom's Energy Ministry "categorically" denied to the Wall Street Journal the country has built a uranium ore milling facility but acknowledged contracting with Chinese entities for uranium exploration within Saudi Arabia.[60] Chinese Foreign Ministry spokesman Wang Webin said that China and Saudi Arabia are comprehensive strategic partners, who maintain normal energy cooperation. He did not address the suspected yellowcake facility but said that Beijing "will continue [its] strict fulfillment of international obligations in nonproliferation and pursue cooperation in peaceful uses of nuclear energy with other countries."[61]

The issue of Saudi nuclear weapons delivery systems is a crucial part of possible plans to acquire nuclear weapons. Currently, the kingdom does not have the domestic capacity to develop ballistic missiles. Until recently, the Saudi ballistic missile arsenal was limited to the Dongfeng-3 (DF-3; NATO: CSS-2), purchased from China in 1987. Dongfeng-3 is a road-mobile, liquid-fuel, medium-range ballistic missile. With a range of 2500km, the DF-3 has extensive regional reach.[62] However, Dongfeng-3 has several disadvantages. First, it is a highly inaccurate missile that makes it ineffective against discrete military or tactical targets when equipped with a conventional warhead. Second, the kingdom did not ensure the missile's reliability as it has never tested it. Moreover, Saudi Arabia is dependent upon China to maintain and operate the DF-3.[63] In 2007, Saudi Arabia purchased the Chinese Dongfeng-21 (DF-21; NATO: CSS-5) ballistic missile. The missile improves the kingdom's ability to hit regional targets as it is more accurate than the DF-3.[64] [65]

In June 2019, according to CNN, the U.S. intelligence declared that Saudi Arabia had significantly intensified its ballistic missile program with the Chinese help.[66] These developments mark another Saudi Arabia's step in potential efforts to deliver a nuclear warhead were it ever to obtain one.

So, there are suspicions about Saudi Arabia's nuclear ambitions. However, it is worth noting that in 1988, the kingdom signed and ratified the Non-Proliferation Treaty (NPT) as a non-nuclear-weapon State. Additionally, since 1962, it has been an IAEA member. In 2005, Saudi Arabia signed the IAEA Comprehensive Safeguards Agreement (CSA), which entered into force in 2009. This agreement was qualified as the Small Quantities Protocol (SQP), which is a basic safeguards agreement with the IAEA that suspends most reporting and inspection requirements.[67]

The kingdom has almost completed the construction of the first nuclear research reactor with the main purpose being to train technical personnel in the nuclear field. While this reactor marks a significant step in the development of nuclear energy in Saudi Arabia, the Saudis seem not to intend to rescind its SQP.[68]

**The IAEA started to apply the SQP in the early 1970s as a mechanism to stimulate states with little or no nuclear activities to join the NPT without burdensome reporting requirements. SQP is applicable until the country has "nuclear material in quantities**

**exceeding the limits stated" in Paragraph 37 of INFCIRC/153 or has "nuclear material in a facility." INFCIRC/153's definitions state without qualification that a nuclear reactor is a "facility."**

Only the commitment to the IAEA high standards could strengthen trust towards the peaceful nature of Saudi nuclear intentions, and, as a result, contribute to the development of nuclear energy in the country. So, in 2021, the most straightforward approach for Saudi Arabia to meet its future NPT safeguards obligations would be to rescind its SQP and negotiate subsidiary arrangements with the IAEA to permit the IAEA to safeguard the new reactor and its fuel. The best-case scenario would be incorporating an IAEA additional protocol (AP), which is a voluntary legally-binding agreement that gives the IAEA more tools to verify the absence of undeclared nuclear material in a country. The AP ratification would put the kingdom in a superior position over Iran, which concluded an AP back in 2003 but has not yet ratified it.

**Thus, Saudi Arabia has only a rudimentary civilian nuclear infrastructure and it does not have the physical and technological resources to create its nuclear weapons.**

If the kingdom intends to develop nuclear energy, the SQP rescission and putting in force a more advanced IAEA verification mechanism would be the most logical solution. Without such changes, it is highly likely that the states that are on the Saudi shortlist as possible partners to develop nuclear energy, namely the United States, France, South Korea, Russia, China, will not cooperate with the kingdom. The Saudi nuclear weapons ambitions should not be ruled out. That is why any kingdom's partner in the field of nuclear energy has to take all possible precautions to close the Saudis access to the nuclear fuel cycle. Otherwise, the arms race in the Middle East will reach a qualitatively new level, and the "dream" to establish a WMD-FZ in the region will never be realized.

## Chapter 2. Saudi partners to promote the peaceful use of nuclear energy in the country

Saudi Arabia has neither its own nuclear technology, nor experience in the field. So, to realize its ambitious nuclear energy plans, the kingdom cooperates with foreign partners.

The nuclear reactor market is becoming increasingly internationalized: reactor manufacturers from around the world collaborate with each other and form consortia. The following tables show the reactor technologies available for deployment in the Middle East and their characteristics, as well as Saudi partners in developing nuclear power in the country.

**Table 1: Current reactor designs that are currently available for the export market**

| | **Vendor** | **Reactor** | **Capacity (MWe)** |
|---|---|---|---|
| **Russia** | Rosatom | VVER (AES-92)<br>VVER (AES-2006) | 1,000<br>1,200 |
| **South Korea** | KEPCO-KHNP | APR 1400 | 1,400 |
| **China** | China National Nuclear Corporation | CNP-300 | 999 |
| **US/Japan** | Westinghouse<br>GE-Hitachi | AP-1000<br>ABWR | 1,100<br>1,380 |
| **France/Japan** | Électricité de France - Mitsubishi | ATMEA1 | 1,100 |
| **France** | Électricité de France | EPR | 1,650 |

**Table 2: Comparison of the modern reactor designs in the global market** [69]

| | **Design Maturity** | **Middle East Interest** | **Technological Sophistication** |
|---|---|---|---|
| **AP1000** | Medium | Low | Highest |
| **APR** | Medium | Medium | Highest |
| **APR 1400** | Very high | Highest | High |
| **AES-92** | Highest | Medium | Medium |
| **AES-2006** | Medium | Very high | Highest |
| **ABWR** | Highest | Low | High |
| **ATMEA1** | Low | High | Very high |

**Table 3: Saudi Arabia's partners to develop nuclear energy**

| Country | Agreements |
|---|---|
| **United States** | • U.S.-Saudi Arabia Memorandum of Understanding on Nuclear Energy Cooperation (2008). |
| **France** | • Cooperation Agreement on the Development of Peaceful Uses of Nuclear Energy (2011).<br>• An agreement to undertake a feasibility study for building two EPR nuclear power reactors (2015).<br>• Agreements on nuclear safety training and waste disposal (2015). |
| **China** | • Agreement for Cooperation in Peaceful Uses of Nuclear Energy (2012).<br>• K.A. CARE - CNNC agreement for human resource development (2016). |
| **Argentina** | • Cooperation Agreement on Peaceful Nuclear Energy (2011).<br>• The establishment of Invania to develop nuclear technology for Saudi Arabia's nuclear power program (2015). |
| **South Korea** | • Agreement for Cooperation in the Peaceful Uses of Nuclear Energy (2011).<br>• Contracts to support the two countries' cooperation in developing SMART reactors (2015).<br>• Memorandum of Understanding on comprehensive cooperation in nuclear research and development (2019). |
| **Kazakhstan** | • Agreement for Cooperation in the Peaceful Uses of Nuclear Energy (focused on fuel supply) (2016). |
| **Jordan** | • Agreement for Cooperation in Peaceful Uses of Nuclear Energy (2014).<br>• Agreement with the Jordan Atomic Energy Commission for a feasibility study on the construction of two SMRs in Jordan for the production of electricity and desalinated water (2017). |
| **Finland** | • Agreement for Cooperation in Peaceful Uses of Nuclear Energy (2015). |
| **Russia** | • Agreement for Cooperation in Peaceful Uses of Nuclear Energy (2015). |

| | |
|---|---|
| | • A further program of cooperation focused on small and medium reactors, and on building a new research reactor (2017). |
| **Hungry** | • Agreement for Cooperation in Peaceful Uses of Nuclear Energy (2015). |
| **Egypt** | • Agreement for Cooperation in Peaceful Uses of Nuclear Energy (2016). |

**The United States** is viewed as one of the key Saudi partners in regard to developing nuclear energy. The Westinghouse AP1000 is one of the flagship Generation III+ reactor. In 2005, the reactor received certification from the US Nuclear Regulatory Commission (NRC). The reactor is a two-loop PWR generating 1,100 MWe. The AP1000 design increases reliance on passive features that depend on physical phenomena. The reactor can withstand extreme accidents without any release of radioactivity into the environment. Emergency water tanks provide enough water, without any human intervention, to last up to seven days during a severe accident.[70]

Moreover, the Americans can offer the NuScale small modular reactor (SMR). In September 2020, the NRC issued a final safety evaluation report for this reactor, that NuScale Chairman and CEO John Hopkins characterized as "a significant milestone not only for NuScale but also for the entire U.S. nuclear sector and the other advanced nuclear technologies that will follow." He added: "This establishes the leadership of NuScale and the United States in the race to bring SMRs to market."[71] An SMR is considered as the future of the world's nuclear power industry. This type of reactor can be especially relevant for African and Middle Eastern countries that have an interest in the development of nuclear energy. NuScale SMR coincides with the UN program on Sustainable Development Goals.[72]

The NuScale design uses passive processes such as convection and gravity in its operating systems and safety features to produce about 600 MW of electricity. Twelve modules, each producing 50 MW, are submerged in a safety-related pool built below ground level. The NRC has concluded the design's passive features "will ensure the nuclear power plant would shut down safely and remain safe under emergency conditions, if necessary."[73]

SMRs have been gaining significant popularity in the nuclear industry. Indeed, there are multiple motivations to pursue this reactor's type suitable both for developed and developing countries. First, SMRs are factory-produced, transportable, and readily deployable. SMRs' mass production at a centralized location provides better quality controls as well as reduces the risks of cost and time overruns. Second, the upfront capital cost of standard reactors is high that makes them too expensive for many countries. Third, SMR modules allow utilities to start reaping returns from electricity production before reaching the maximum installed capacity at a site. Fourth, an SMR is more suitable for countries with relatively small electrical-grid capacities as a gigawatt-scale reactor could destabilize a small grid. Moreover, SMRs claim to provide greater safety as they rely on passive features that result in the public acceptability enhancement, and they also can be used in small towns, industrial facilities, and submarines.[74,75]

As for the U.S.-designed NuScale SMR, it could be interesting for the Saudis, but given the difficulties in their certification process, the NuScale SMR purchase by the kingdom is unlikely in the foreseeable future.[76] Moreover, as the SMR is a new reactor type, there may be a lack of qualified personnel.

The stumbling block in Saudi- American cooperation is the difficulty to agree on a legal framework: Saudi Arabia's refusal to accept the high American standards of cooperation in the nuclear energy field hinders not only the bilateral cooperation but also the development of the Saudi nuclear industry in general.

In 2008, the United States and Saudi Arabia signed a Memorandum of Understanding on Civil Nuclear Energy Cooperation. According to the Memorandum, the two countries "establish a comprehensive framework for cooperation in the development of environmentally sustainable, safe, and secure civilian nuclear energy through a series of complementary agreements."[77] Furthermore, "the United States will assist the Kingdom of Saudi Arabia to develop civilian nuclear energy for use in medicine, industry, and power generation and will help in the development of both the human and infrastructure resources under evolving International Atomic Energy Agency guidance and standards."[78] The Memorandum states that Saudi Arabia will buy nuclear fuel on the international market instead of developing sensitive nuclear technologies. However, an agreement on joint activities in the nuclear sphere between the United States and Saudi Arabia has not been signed. According to Section 123 of the U.S. Atomic Energy Act (AEA) of 1954, American companies cannot export nuclear technology, materials, and equipment to another country until a bilateral intergovernmental agreement on cooperation in the peaceful uses of nuclear energy is signed.[79]

A 123 Agreement is viewed as a gold standard in the nuclear energy sphere. It sets the terms of reference and authorizes nuclear cooperation between the United States and another side. The President submits any such agreement to the House Committee on Foreign Affairs and the Senate Committee on Foreign Relations. The Department of State provides the President with an unclassified Nuclear Proliferation Assessment Statement (NPAS), which the President is to submit to those two committees. The State Department also provides a classified annex to the NPAS, prepared in consultation with the Director of National Intelligence. The NPAS explains how the agreement meets the AEA non-proliferation requirements. The President must make a written determination "that the performance of the proposed agreement will promote and will not constitute an unreasonable risk to, the common defense and security."[80]

A 123 Agreement requires that any agreement for nuclear cooperation meets nine non-proliferation criteria that are as follow:[81]

- Nuclear material and equipment transferred to the country must remain under safeguards in perpetuity.

- Non-nuclear-weapon states partners must have full-scope IAEA safeguards, essentially covering all major nuclear facilities.

- A guarantee that transferred nuclear material, equipment, and technology will not have any role in nuclear weapons development or any other military purpose, except in the case of cooperation with nuclear-weapon states.

- If a non-nuclear-weapon state partner detonates a nuclear device using nuclear material produced or violates an IAEA safeguards agreement, the United States has the right to demand the return of any transfers.

- U.S. consent is required for any re-transfer of material or classified data.

- Nuclear material transferred or produced as a result of the agreement is subject to adequate physical security

- U.S. prior consent rights to the enrichment or reprocessing of nuclear material obtained or produced as a result of the agreement.

- Prior U.S. approval is required for highly- enriched uranium (HEU) and plutonium obtained or produced as a result of the agreement. An agreement permitting enrichment and reprocessing (ENR) using U.S. provided material requires separate negotiation.

- The above non-proliferation criteria apply to all nuclear material or nuclear facilities produced or constructed as a result of the agreement.

As of 2021, the United States has entered into 23 nuclear cooperation agreements that govern nuclear cooperation with 48 countries, the IAEA, and Taiwan.[82] In the Middle East, the United States signed such an agreement with Egypt, Turkey, the UAE, and Morocco. Proliferation concerns led the United States to conclude a restrictive 123 Agreement with the UAE, under which UAE agreed not to pursue sensitive fuel cycle activities that would produce fissile material useable in nuclear weapons.[83] The United States intends to establish the agreement with the UAE as the model for all future 123 Agreements, including with Saudi Arabia.

In November 2013, Senator Edward Markey urged President Barack Obama to suspend negotiations with Saudi Arabia on a bilateral nuclear cooperation agreement. He stressed that a 123 Agreement is supposed to transfer nuclear technology to Saudi Arabia, and given unclear Saudi ambitions, it would be a mistake to conclude the agreement. In this regard, he asked President Obama to "take all necessary measures to prevent a nuclear arms race in the Middle East."[84] Edward Markey emphasized that in addition to the diplomatic efforts aimed at curtailing the Iranian nuclear program, it is necessary to prevent opportunities for the Gulf countries to acquire nuclear weapons. In his opinion, any bilateral agreement on cooperation in the nuclear field should include a clause stipulating that the country, with which the United States signs a document, is not engaged in activities aimed at developing nuclear weapons.[85]

Thomas Countryman, who was assistant Secretary of State for international security and nonproliferation in the Obama administration, said that his "negotiations with Saudi officials

stalled over their resistance to accepting prohibitions on enrichment or reprocessing, as well as a strict IAEA inspections protocol."[86]

Donald Trump, known for his passion to revise the Barack Obama legacy, made some changes in the policy vis-à-vis the Saudi nascent nuclear program as well. In February 2018, the White House resumed the 123 Agreement negotiations with the kingdom. The Trump administration conditioned a formal deal for civil nuclear cooperation with the Saudis on an Additional Protocol that did not meet all the nine above-mentioned criteria of such a cooperation. However, the Saudi government has made it clear that it seeks to make its nuclear fuel, which would require an indigenous capability to enrich uranium on a large scale. The same technology, that is used to enrich uranium for civilian power reactors, can be used to enrich uranium to weapons-grade.[87]

Furthermore, satellite images showing a nuclear research reactor under construction in Saudi Arabia appeared amid a struggle between the Trump White House and Congress over the sale of nuclear technology to Riyadh, and after it emerged that the U.S. Department of Energy had granted seven permits for the transfer of sensitive nuclear information by U.S. businesses to the Saudi government. A California Democrat Brad Sherman claimed the issuance of the seven permits represented a Trump effort to bypass Congress and spare Saudi Arabia the need to accept a formal agreement that would put strict limits on its nuclear program. He stressed that "there was a bipartisan majority in Congress that would insist the kingdom could buy U.S. nuclear technology only if it agreed to the "gold standard": no enrichment of uranium and no reprocessing of plutonium, and the acceptance of intrusive IAEA inspections."[88]

In 2019, Senators Marco Rubio and Edward J. Markey and Representatives Brad Sherman and Ted Yoho introduced bipartisan bicameral legislation that would strengthen Congressional oversight over any civilian nuclear cooperation agreement with Saudi Arabia: Congress believes that no agreement should be approved unless and until Saudi Arabia is truthful and transparent about the Jamal Khashoggi assassination until it commits to forego any uranium enrichment or spent fuel reprocessing activities within its territory, and until it agrees to implement the Additional Protocol.[89]

By now, the Biden administration's approach towards the nuclear cooperation with the Saudis is not articulated, however, it is highly likely that President Biden will adhere to Barack Obama`s hard line in negotiations with Saudi Arabia. Therefore, as long as the kingdom's nuclear activities do not meet the high nuclear energy cooperation standards, there will be no progress in the U.S.-Saudi nuclear cooperation.

French companies have a traditionally strong position in the Middle East. **France** has the largest NPPs network in Europe and its Électricité de France (EDF) is the most prominent corporation involved in the NPPs construction.[90] However, the EDF has significant difficulties in implementing a new type of reactor, the European Pressurized Reactor (EPR). The EPR vendor opted to increase redundancy by having four independent safety trains that provide emergency cooling and a double containment building. A core catcher allows the EPR to withstand meltdown scenarios. It generates a massive 1,630 MWe. The reactor is capable of load following and of employing a variety of fuels in the core. Units are under construction in Finland, France, and China, but have been bogged down by cost overruns and technical issues.[91]

On February 22, 2011, Saudi Arabia signed with France a Cooperation Agreement on the Development of Peaceful Uses of Nuclear Energy. Under the agreement, the two countries intend to cooperate on the production, use, and transfer of knowledge in the field of the peaceful use of nuclear energy. In 2015, France signed an agreement to undertake a feasibility study for building two EPR NPP, as well as agreements on nuclear safety training and waste disposal. Since 2017, France, along with Russia, South Korea, the United States, and China, has been participating in a tender for the construction of two large nuclear reactors in Saudi Arabia.

In June 2011, Saudi Arabia signed a Cooperation Agreement on Peaceful Nuclear Energy with **Argentina**. The agreement is mostly related to smaller plants for desalination and the subsequent Invania joint venture. In March 2015, state-owned R&D companies from Argentina and Saudi Arabia have set up Invania to develop nuclear technology for Saudi Arabia's nuclear power program. Argentina has a long history of nuclear technology R&D. Today, it generates about 1/10 of the country's electricity from its three pressurized heavy water reactors with plans for more.[92]

**China** has ambitious plans to infiltrate the Middle Eastern nuclear market. Beijing seems to be very interested in cooperation with the Saudis, and there are several reasons for that. First, China intends to further expand its presence in the global nuclear energy market. Second, such cooperation ensures the stability and security of the Saudi oil supplies to China. And third, China works on ousting its main strategic opponent - the United States - from the Middle East in general and Saudi Arabia in particular.[93]

In 2012, Saudi Arabia inked an agreement with China to enhance cooperation between the two countries in the development and use of atomic energy. The agreement sets a legal framework that strengthens scientific, technological, and economic cooperation between the two states. It seeks to enable cooperation in such areas as maintenance and development of nuclear power plants and research reactors, manufacturing, and supply of nuclear fuel elements.[94]

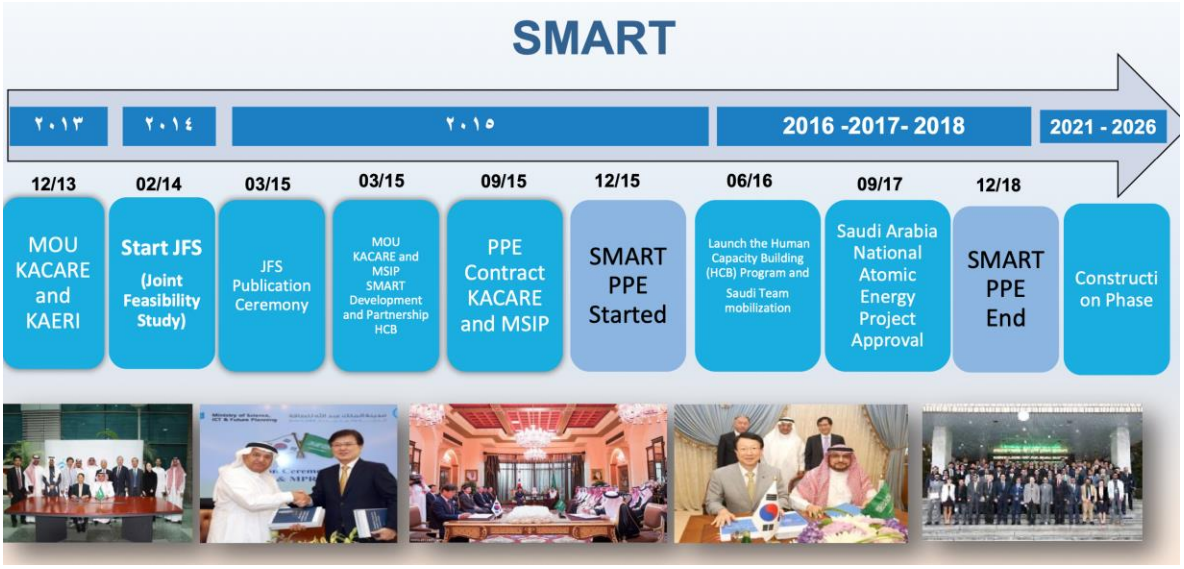
In January 2016, China Nuclear Engineering Corporation (CNEC) and K.A. CARE signed a memorandum of understanding on the construction of a high-temperature gas-cooled reactor (HTGR). CNEC declared: "After 30 years of basic research, experimental reactor operation and demonstration projects, China has now systematically mastered all the key HTR technologies."[95] In March 2017, the two countries signed a Cooperation Agreement for a joint study on the feasibility of HTGRs construction in Saudi Arabia.[96] However, to construct nuclear power plants in the Middle East, China has to gain credibility by successfully launching new reactors in its homeland. Meanwhile, in the Middle East, the status of a "newcomer" does not allow China to implement its ambitious plans. A possible solution for China is to conduct joint projects with the world's major nuclear companies.

The **Korea Electric Power Corporation (KEPCO)**, a state monopoly fully supported by the South Korean authorities, is deeply involved in the Middle East nuclear energy market. The South Korean APR1400 is the only design currently being built in the Middle East (in the UAE). The modular construction of the reactor allows for a shorter and more reliable build schedule of roughly 48 months, a feat in the industry. Different variants of the reactor are under development, notably

the APR-1000 that is targeting the Middle East. It can operate at a higher heat sink temperature than in more typical markets.[97]

In November 2011, Saudi Arabia and South Korea signed an Agreement for Cooperation in the Peaceful Uses of Nuclear Energy. It calls for cooperation in nuclear R&D, including building nuclear power plants and research reactors, training, safety, and waste management.[98] In June 2013, KEPCO offered support for the localization of nuclear technology, along with joint research and development of nuclear technologies if Saudi Arabia purchases South Korean reactors.

In September 2015, Saudi Arabia and South Korea signed contracts aimed at supporting the Saudi-Korean cooperation in developing SMART (System-integrated Modular Advanced Reactor) SMRs.[99] SMART is a 330 MW pressurized water reactor with integral steam generators and advanced safety features. The unit is designed for electricity generation and thermal applications, such as seawater desalination, with a 60-year design life and three-year refueling cycle.[100] In September 2019, the two counties signed a Memorandum of Understanding on comprehensive cooperation in nuclear research and development which implies collaboration on the commercialization of the SMART SMRs.[101] [102] So, SMART makes South Korea one of the most promising Saudi partners to develop nuclear energy in the kingdom.




Thus, Saudi Arabia cooperates with numerous states to develop nuclear energy: among the Saudi partners, South Korea, France, and China stand out. However, the U.S. Section 123 Agreement is viewed as a necessary quality standard for cooperation in the nuclear sphere. Without this agreement, it is highly unlikely that any European state will cooperate with the Saudis. As for South Korea, such cooperation is even impossible without the U.S. approval: the Korean reactors include American technology, and, therefore, under the 1954 Atomic Energy Act, Congress has the right to block the reactor sale. So, a full-fledged nuclear cooperation agreement with the United States is considered crucial to proceeding with Saudi Arabia's nuclear power plans.

## Chapter 3. Russia and its State Atomic Energy Corporation Rosatom (ROSATOM) as a potential partner of Saudi Arabia in the peaceful uses of nuclear energy

### Overview of the Russian activities in the peaceful use of nuclear energy

Russia is one of the world's largest nuclear exporters. The Russian nuclear industry controls 40% of the global market for uranium enrichment, 17% for nuclear fuel, and 25% for nuclear power plants.[103]

State Atomic Energy Corporation Rosatom (ROSATOM) is a global technological leader. It possesses the largest foreign project portfolio with 35 power units at different stages of implementation in 12 countries. In 2019 Rosatom's package of foreign orders exceeded 130 billion dollars. Rosatom is the largest producer of electricity in Russia: it covers over 20% of the country's energy needs.[104] The corporation is responsible for a unified state policy in the nuclear energy field as well as the fulfillment of the Russian international obligations in the sphere.

Rosatom is the only company that provides its international customers with an integrated offer that includes not only the construction of different capacity Russian-designed NPPs and Centers of Nuclear Science and Technologies (CNST) but also the development of nuclear infrastructure, local workforce training and professional development, localization of production in the customer countries, guaranteed fuel supplies for the entire life cycle of NPP and CNST, maintenance and service, spent nuclear fuel (SNF) reprocessing and management, and comprehensive solutions for an NPP and a CNST decommissioning. Rusatom Overseas (RAOS JSC) has established a system to enable direct interaction between customer countries and Rosatom, which not only enhances the integrated offer but also develops new expertise for companies involved in the Russian nuclear industry.[105] Taken the last developments with COVID-19, Rosatom Director-General Alexey Likhachev stated that the corporation had not revised its portfolio of construction projects abroad but it anticipates the coronavirus pandemic may affect some of its contracts.[106]

The Russian nuclear industry has been present in the Middle East for a long time. The first Russian research reactors in the Middle East date back to the 1960s. The Soviet Union built a research reactor in Egypt in 1961, then in Iraq in 1967, and finally in Libya in 1981. Nowadays, Rosatom is actively involved in the Middle East nuclear energy projects. In September 2011, Russian-built NPP Bushehr 1 (**Iran**) was connected to the national grid. Rosatom will complete Bushehr units 2 and 3 are in 2024 and 2026, respectively: the two VVER-1000 units will be built with Generation III+ technology and have a combined capacity of 2100 MWe. According to President of the Iran's Atomic Energy Organization Ali Akbar Salehi, "construction of the two new units will help Iran meet its energy needs, economize on its natural energy resources by avoiding the use of 22 million barrels of oil, and prevent the spread of 14 million tons of pollutants into the air."[107] However, further Russian cooperation with Iran depends on the Iran's compliance with the JCPOA.

In November 2015, Rosatom signed an Intergovernmental agreement with **Egypt**, under which, Rosatom will build four VVER-1200 reactors and supply nuclear fuel throughout El Dabaa NPP entire lifetime; will train personnel and assist its Egyptian partners in the NPP maintenance during the first 10 years.[108] According to "Egypt Today," Egypt will issue a construction license for the planned El Dabaa NPP in the second half of 2021.[109]

Russia implements Turkey's NPP construction under the Intergovernmental agreement with **Turkey**. In April 2018, the first concrete pouring was held at the construction site that marked the start of large-scale work to build Akkuyu NPP. In 2020, the first concrete poured at the NPP unit 2 reactor building foundation slab.[110]

In October 2019, Emirates Nuclear Energy Corporation (ENEC) and Rosatom renewed its 2017 Memorandum of Understanding on cooperation in the field of peaceful uses of nuclear energy. The Memorandum established a general framework for cooperation between Russia and the **UAE** in numerous spheres, such as the creation of a nuclear science center in the UAE, plant development and investment, nuclear fuel cycle management, and training of UAE nationals.[111]

As of 2020, the Russian Federation has signed intergovernmental agreements on peaceful nuclear energy cooperation with 8 Middle Eastern states such as Egypt, Jordan, Iraq, Iran, the UAE, Saudi Arabia, Syria, and Turkey; and memorandums of understanding on peaceful nuclear energy cooperation with authorized organizations of four Middle Eastern states - Bahrain, Qatar, Kuwait, and Oman.

**The table shows Rusatom Overseas projects in the Middle East.**

| **NPP** | **Number of power units** | **Status** |
|---|---|---|
| Bushehr-1 (Iran) | 1 | Under operation. |
| Akkuyu (Turkey) | 4 | Under construction. The first unit is scheduled to be commissioned in 2023. |
| Bushehr-2 (Iran) | 2 | Units 2 and 3 are scheduled to be commissioned in 2024 and 2026, respectively. |
| El-Dabaa (Egypt) | 4 | Permit to construct the NPP is expected to be issued late in 2021. |
| Saudi Arabia | 2 | Preliminary consultations. |

One of the key problems that arise during the NPP operation is spent nuclear fuel (SNF). While the half-life of the SNF radioactive isotopes reaches up to tens of thousands (Pu-239) and even millions (Np-237) of years, neither large-scale SNF processing is conducted, nor SNF geological storage facilities exist. The SNF storage is viewed as a heavy burden for a recipient, both financially and environmentally. One of the major Rosatom advantages is that Russia takes its SNF back on a full scale.

Rosatom has specific NPP construction financing terms. Besides loans, it offers the Build–Own–Operate (BOO) scheme and the alternative Build–Own–Operate–Transfer (BOOT) scheme. While under the BOO, the investor-builder takes the NPP ownership and returns the investment by selling electricity, under the BOOT, after the period stipulated in the contract, the enterprise is transferred

or sold to state ownership. The Adelaide-Darwin railway construction in Australia, the Shajiao Coal-Fired Power Plant in China used the BOOT.[112] The only example of the BOO use is the construction of the Akkuyu NPP. It is not only Rosatom that is ready to apply the BOO scheme: the Chinese CGNPC provides a similar offer. Nevertheless, the BOO and BOOT are one of the Russian advantages: these schemes make possible for states with insufficient financial resources to build NPPs. However, as for Saudi Arabia, the financing advantages are not decisive – the kingdom has enough funds to implement even an expensive NPP project.

Furthermore, Rosatom, as a Russian state-owned monopoly in the field of nuclear technologies, enjoys the full state's support and combines commercial activities with the promotion of the Russian interests abroad. The support's scale is incomparable with the support that, for example, the American private company General Electric or the Japanese company Hitachi has. Moreover, according to the head of the economic department of the Institute of Energy and Finance Foundation Sergey Kondratiev, Russia can offer the Saudis the development of nuclear technologies not only for energy production but also technologies used in related fields such as agriculture, medicine, as well as in non-destructive testing methods.[113]

Russia has a well-elaborated legal framework to build NPPs in foreign countries that consists of three tiers: the signing of a bilateral agreement on cooperation in the peaceful use of nuclear energy; the signing of an agreement to build an NPP; the signing of an actual contract to build an NPP.[114]
As for the cooperation with Saudi Arabia, Rusatom Overseas Vice President Milos Mostecky noted that the main difficulty to implement projects in the kingdom is the lack of infrastructure and trained personnel. From the technical perspective, the most serious problem is high air and water temperature required for cooling an NPP system.[115] Rosatom has considerable experience in operating in the nuclear "newcomers". It has implemented NPP projects in Bangladesh, Vietnam, Turkey, and Iran. Besides, Rosatom can share experience in training specialists, which is especially valuable for Saudi Arabia in the framework of Saudi Vision 2030. Head of Rusatom Overseas Evgeny Pakermanov noted that Rosatom attaches great importance to the training of highly qualified personnel for NPPs.[116] Thus, a comprehensive Rosatom HR Solution system covers the personnel training for the safe and efficient operation of nuclear power facilities. "Given the long-term nature of the national nuclear program, Rosatom assists in the development of nuclear education, thereby providing an opportunity to transfer nuclear knowledge to the kingdom not only through the interaction of the leading educational institutions of the two countries but also through the provision of quotas for free higher nuclear education in the Russian Federation."[117]

Also, Rosatom possesses modern projects that have been already operating for several years (for example, second innovative 3+ generation Novovoronezh NPP-2 power block), which gives it serious advantages compared to other global players that are only building their generation 3+ reactors.

Thus, in the Middle East nuclear energy market, Rosatom has long-term advantages, such as the SNF return, projects' financing, significant state support, experience to work in difficult climatic conditions, and the constructed by Russia NPPs that have already proven their effectiveness. Moreover, Russia has been present in the Middle East nuclear energy market since the 1960s, and it has a reputation as a reliable partner.

**Among the Rosatom competitors, the Chinese corporations and the Korean KEPCO stand out. They all have similar financial support from their home countries and ownership terms.**

But while the Chinese companies are just starting to penetrate the Middle East nuclear energy market, the Korean KEPCO already plays a prominent role there. The KEPCO has several significant advantages over its competitors: South Korea is neutral from the political perspective, it has experience in building energy blocks in the UAE (the NPP in the neighboring country operates successfully, and it is especially important for the Saudis). At the same time, it is worth mentioning that the fuel for Korean reactors is Russian. As for the Chinese companies, their constructed NPPs lack in quality. However, the commissioning of new Chinese reactors in connection with its financial assets and possible cooperation with third countries can radically change the situation in the future.

## Current Russia-Saudi Arabia cooperation

The intensification of Moscow-Riyadh political contacts contributes to the development of cooperation between the two countries in the nuclear sphere. Once Saudi Arabia decided to develop the nuclear energy sector, the kingdom activated its contacts with Russia on this track. In October 2010, the Saudi Arabia Council of Ministers approved an Agreement on Cooperation in the Field of Nuclear Energy with the Russian Federation.[118]

On June 18, 2015, Moscow and Riyadh signed an Agreement on Cooperation in the Field of Nuclear Energy for Peaceful Purposes, under which "the parties shall develop and strengthen cooperation in the field of the peaceful use of nuclear energy in accordance with the needs and priorities of the national nuclear programs of each of the state parties."[119] The document created a legal basis for Russia-Saudi Arabia cooperation in the field of nuclear energy, it opened "prospects for oncoming traffic business initiatives on both sides of a wide range of areas, including: design, construction, operation and decommissioning of energy power and research reactors, such as desalination plants and particle accelerators; nuclear fuel cycle services, including for nuclear power plants and research reactors; spent nuclear fuel and radioactive waste management; radioisotopes production and its application in industry, medicine and agriculture; education and training of specialists in the field of nuclear energy."[120] [121]

The agreement envisages the establishment of a coordination committee for further discussion on nuclear energy use, and the establishment of joint working groups to carry out specific projects and research, the exchange of experts, the organization of seminars and workshops, assistance in education, the training of scientific and technical personnel, the exchange of scientific and technical information. It emphasizes that the export of nuclear materials, equipment, special non-nuclear materials, and related technologies will be carried out in accordance with the obligations of the parties under the NPT, as well as other international treaties and agreements within the framework of multilateral export control mechanisms. Moreover, nuclear material transferred under the agreement is not enriched above the 20% level and is not subject to chemical reprocessing without the prior written consent of the transferring party. Nuclear materials transferred under the agreement shall not be used for the production of nuclear weapons and other

nuclear explosive devices or any military purpose and shall be provided with physical protection measures at levels not lower than those recommended by the IAEA fifth revision of Nuclear Security Recommendation on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225).[122]

In October 2017, in the development of the 2015 agreement, Rosatom and the K.A. CARE signed a "program of cooperation" in the peaceful use of nuclear energy. Rosatom said that Russia and Saudi Arabia plan to "cooperate in small- and medium-sized reactors, which can be used both for power generation and desalination of seawater; in the training of personnel for Saudi Arabia's national nuclear program; and the development of its nuclear energy infrastructure."[123]

On November 20, 2017, K. A. CARE, as a part of a pre-feasibility study program for engineering design to build two large nuclear reactors in the kingdom, issued a request for information to nuclear technology suppliers from South Korea, China, France, Russia, and the United States. Based on the received data, K. A. CARE is developing a request for proposal, which is planned to be launched by the end of December 2021. The estimated cost of an NPP with 2 large nuclear power reactors is expected to exceed $14 billion. Rosatom offers a serial project of the Russian VVER-1200 reactor.[124] Rosatom has passed two qualifying stages in the tender and was invited to participate in the third stage.[125] There is a chance that the Saudis will approve a combined project consisting of proposals from several countries participating in the tender. Rosatom Director-General Alexey Likhachev stated that Rosatom is ready to cooperate with American, European, or Asian companies in the realization of the Saudi project.[126]

On June 10, 2019, in Moscow, during the sixth session of the Russian-Saudi intergovernmental commission on trade, economic, scientific, and technological cooperation, Russian Energy Minister Alexander Novak confirmed the Russian plans to develop an active partnership with Saudi Arabia in the peaceful uses of nuclear technologies and announced the opening of a Rusatom Overseas branch in Riyadh. He said: "Rosatom's presence in the kingdom will ensure effective cooperation with Saudi governmental agencies and private companies as a part of a competitive dialogue on the project to build the first nuclear power plant in Saudi Arabia."[127] "We place special focus on working with Saudi industrial enterprises and scientific and educational institutions, as the Russian side sees great potential for their engagement in the implementation of Saudi Arabia's nuclear energy program," added Rusatom Overseas' President Evgeny Pakermanov.[128]

Thus, Russia and Saudi Arabia have a good basis to develop bilateral cooperation in the peaceful uses of nuclear energy: the two countries created a solid legislative framework as well as conduct regular summits and meetings at the ministries level to discuss the latest developments. Political will and a general trend in the bilateral relations will play an important role for further cooperation in the nuclear energy field. Today, the advanced Rosatom projects and cooperation terms are considered as attractive to develop peaceful nuclear energy in the kingdom. Russia, being the only country that returns SNF, could contribute to the nuclear power advancement in Saudi Arabia and guarantee the peaceful nature of the kingdom's nuclear energy program. Moreover, Russia could offer Saudi Arabia cooperation with the International Uranium Enrichment Center, which would eliminate concerns related to the sensitive nuclear technologies' proliferation.

However, it is hardly possible that Russia goes for full-scale cooperation with the Saudis in case of the absence of the Saudi SQP modification. Russia has always built NPP in foreign countries in full compliance with the nonproliferation precautions. As for Saudi Arabia, its full-scale cooperation with the IAEA is viewed as a necessary component to ensure that the peaceful nuclear program is not diverted into a military scale. Moreover, it is unlikely that Rosatom will bypass the U.S. nuclear energy companies and become the first foreign company to build an NPP in the kingdom. The Saudis are more likely to use negotiations with Russia as leverage for the negotiations with the Americans.

## Conclusion

The Middle East reflects a combination of commerce and geopolitics. The development of nuclear energy in Saudi Arabia is a promising and important task. Russia is a very competent player in the nuclear field. As Rosatom has extensive experience in working with nuclear "newcomers" in difficult climatic conditions with the lack of necessary infrastructure, it has a good chance to become one of the key Saudi partners to develop peaceful nuclear energy. However, many factors influence the state of the Russia-Saudi Arabia nuclear energy cooperation. Among them - the overall development of the Russia-Saudi Arabia bilateral relations with the role of Crown Prince Mohammed bin Salman and his dialogue with President Putin, as well as the kingdom's relations with the new White House administration, and the progress in the Saudi dialog with the IAEA on the modification of the kingdom's irrelevant SQP.

Taking into account the Saudi ambitions for regional leadership, there is always a chance that the kingdom intends to acquire nuclear weapons. Saudi Arabia's further actions in the nuclear sphere largely depend on the regional situation, especially on Iran's developments. In this context, Russia and other applicants for building an NPP in Saudi Arabia should take precautions to minimize nuclear proliferation risks.

The research reached the following **conclusions**:

1. The Saudi nuclear program dates back to the 1960s, but only within the last decade has the kingdom demonstrated significant interest in nuclear energy. Saudi Arabia elaborated on the national development program Saudi Vision 2030 that echoes the Saudi needs in nuclear energy. Under the Vision, the energy sources diversification is one of the most significant kingdom's objectives.

2. There are numerous reasons why Saudi Arabia decided to develop nuclear energy, among them economic, political, and social ones. There is also the role of prestige: such Middle Eastern countries as Iran and the UAE already have an NPP in operation - the Saudis do not want to lag behind them. The kingdom's finance facilitates nuclear energy advancement.

3. Saudi Arabia, within Saudi Vision 2030, has numerous projects to develop nuclear energy that are being implemented by the King Abdullah City for Atomic and Renewable Energy (K. A. CARE), as well as King Abdullah Petroleum Studies and Research Center (KAPSARC), King Abdulaziz City for Science and Technology (KACST), and the Atomic Energy Research Institute (AERI).

4. The objectives for nuclear energy development were outlined in the early 2010s, but in 10 years, no visible progress has been achieved in their implementation. One of the possible reasons for this is the absence of a full-scale nuclear energy cooperation agreement between Saudi Arabia and the United States.

5. While there are uncertainties about the further developments of the Iranian nuclear program, there is a temptation for the Saudis to acquire nuclear weapons. Since 1987,

the kingdom has been purchasing ballistic missiles from China. However, currently, Saudi Arabia has insufficient infrastructure to build nuclear weapons, as it has no facilities for the conversion, enrichment, or production of uranium fuel, nor any reprocessing facilities.

6. According to former Saudi diplomat Mohammed Abdalla al Khilew, Saudi Arabia has made numerous attempts to acquire nuclear weapons through cooperation with other countries, such as Iraq and Pakistan. Today, there is no evidence of the Islamabad-Riyadh quid pro quo deal. Although, Saudi Arabia's active financial support for Pakistan is well documented.

7. The Middle East developments – first of all, the bilateral Riyadh-Tehran relations and the Iranian nuclear program - as well as the policy of the new White House administration on the Middle East track influence the Saudi nuclear ambitions.

8. In 2009, Saudi Arabia has implemented the IAEA Small Quantities Protocol, which exempts Saudi Arabia from regular IAEA's inspections and limits the Agency's authority to verify undeclared nuclear activities. The IAEA considers the SQP obsolete and calls on the Saudis to rescind it. It is the full-scale cooperation with the IAEA that would be the most logical decision if the kingdom intends to develop peaceful nuclear energy. Without the SQP modification, the countries that Saudi Arabia has shortlisted as possible nuclear energy partners - the United States, China, France, South Korea, and Russia - are unlikely to cooperate with the kingdom.

9. Developing nuclear energy requires Saudi Arabia to import know-how from nuclear supplier countries. The United States is one of the kingdom's key partners. It offers the Westinghouse AP1000 and the NuScale Power small nuclear reactor. The stumbling block for the full-scale Saudi - American cooperation is the difficulties to agree on a legal framework for such cooperation, namely, Section 123 of the U.S. Atomic Energy Act. The majority of the potential Saudi partners considers a 123 Agreement as the quality standard for cooperation in the nuclear field.

10. The Kingdom also cooperates with other countries to develop nuclear energy, among which South Korea, France, and China stand out. The Korean KEPCO, which is a state monopoly, holds a prominent position in the Middle East nuclear energy market. The Korean SMART small modular reactors draw special attention – these reactors are viewed as the nuclear energy future, and they perfectly suit the Middle East and Africa. The Électricité de France, being the most well-known corporation engaged in the NPPs construction, holds a traditionally strong position in the Middle East. China is gaining momentum: it is losing out from the NPPs quality perspective, however, the commissioning of the new Chinese reactors with China's financial assets and possible cooperation with third countries can radically change the situation in the future.

11. The cornerstone for Russia-Saudi Arabia's cooperation in the field of nuclear energy dates back to 2015 when Moscow and Riyadh signed an Intergovernmental Agreement on Cooperation in the Peaceful Use of Nuclear Energy.

12. Among the Rosatom's advantages are the following: extensive experience in the NPPs construction both in Russia and abroad; the specialized programs that coincide with the Saudi interests; favorable price conditions. Russia is the only country that returns its spent nuclear fuel and guarantees by that the exclusively peaceful nature of a nuclear program. Moreover, if the kingdom wants to avert suspicions concerning its nuclear intentions in the military scope, Russia can offer its International Uranium Enrichment Center that would guarantee the exclusively peaceful nature of the Saudi nuclear program.

13. Despite the above-mentioned advantages, it is unlikely that Russia will be the first country to build a nuclear power plant in Saudi Arabia. They will not go for semi-legal cooperation with dubious non-proliferation guarantees. However, in the case that the Saudis agree to the necessary IAEA standards, the United States will likely take the project.

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1) construction of the protective wall in the certain areas;

2) possibility of leaks from the combustible gas monitoring system;

3) the ability of the steam generator tubes to maintain structural integrity and tightness during density wave oscillation (DWO) in the second circuit, including an analysis method for predicting thermal-hydraulic conditions in the steam generator from the second circuit and the resulting loads, stresses and deformations at DWO.

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