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PROSPECTS FOR NUCLEAR POWER IN THE MIDDLE EAST: RUSSIA'S INTERESTS

Valdai Discussion Club
Grantees Report

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Moscow, 2016

LIST OF ABBREVIATIONS

ABWR — Advanced Boiling Water Reactor

ACSIS — Arab Institute for Security Studies (Jordan)

AEOI — Atomic Energy Organization of Iran

AKP — Justice and Development Party (Turkey)

APR — Advanced Power Reactor

AWACS — Airborne Warning and Control System

BOO — Build-Own-Operate

BP — British Petroleum

CENESS — Center for Energy and Security Studies (Russia)

CNS — Convention on Nuclear Safety

Comecon — Council for Mutual Economic Assistance

EAEA — Egyptian Atomic Energy Authority

ENEC — Emirates Nuclear Energy Corporation

EPR — Evolutionary Power Reactor

ETRR — Experimental Training Research Reactor

EU — European Union

FANR — Federal Authority for Nuclear Regulation (UAE)

GCC — Cooperation Council for the Arab States of the Gulf

IAEA — International Atomic Energy Agency

IAF — Islamic Action Front (Jordan)

JAEC — Jordan Atomic Energy Commission

JCPOA — Joint Comprehensive Plan of Action

JNRC — Jordan Nuclear Regulatory Commission

K.A.CARE — King Abdullah City for Atomic and Renewable Energy

KEPCO — Korea Electric Power Corporation

KNF — KEPCO Nuclear Fuels

KNNEC — Kuwait National Nuclear Energy Committee

KOICA — Korea International Cooperation Agency

MEPhI — Moscow Engineering and Physics Institute

MIT — Massachusetts Institute of Technology

NPPA — Egyptian Nuclear Power Plants Authority

NPP — nuclear power plant

NPPD — Nuclear Power Production & Development Company of Iran

NPT — Treaty on the Non-Proliferation of Nuclear Weapons

NRRA — Nuclear and Radiological Regulatory Authority (Egypt)

PBO — Plan and Budget Organization of Iran

PDA — Project Development Agreement

SESAME — Synchrotron-Light for Experimental Science and Applications in the Middle East

TASAM — Turkish Asian Center for Strategic Studies

TEPCO — Tokyo Electric Power Company

TURKSAM — Turkish Centre for International Relations and Strategic Analysis

UAE — United Arab Emirates

UN — United Nations

UNESCO — United Nations Educational, Scientific and Cultural Organization

UNIDIR — United Nations Institute for Disarmament Research

VVER — Russian version of Pressurized Water Reactor (PWR)

WANO — World Association of Nuclear Operators

WMD — Weapons of Mass Destruction

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Wadi Rum Desert, Jordan

FOREWORD

Of all the nuclear energy newcomers, i.e. countries that have only just started to develop nuclear energy, Middle Eastern states are making the most dynamic progress. In September 2011 Iran became the first country in the world in past 15 years to have connected its first nuclear power reactor to the national grid.[1] In July 2012 the UAE became the first country in past 27 years to start building its first-ever NPP. Extensive preparations have already been made to start building Turkey's first nuclear power plant as part of the Akkuyu project. The procedure of choosing the technology supplier for the first NPP in Jordan has been completed. A project development agreement to implement the first part of the project to build a two-unit NPP in Jordan's central Zarqa Province was signed in September 2014. In Saudi Arabia, work has begun to develop a national nuclear infrastructure required for effective and safe peaceful use of nuclear energy. Despite several recent changes of government and ongoing security problems in the country, Egypt remains committed to nuclear energy development.

Among all the nuclear newcomer countries, the Middle Eastern nations have some of the most ambitious nuclear energy plans

Of all the nuclear newcomer countries, Middle Eastern states also tend to be the most ambitious (although whether some of the announced plans and deadlines are realistic is another matter). Iran, Saudi Arabia and Turkey have announced they will build from 16 to 23 nuclear power reactors apiece in less than 20 years.

The goal of this study was to analyze the impact of the developments and transformations in the Middle East that began in late 2010 — early 2011 (i.e. the events that are often referred to as the Arab Spring) and of the Fukushima nuclear accident on plans and prospects for nuclear energy development in the region, as well as Russia's potential role in implementing those plans.[2]

United Nations documents and UN General Assembly resolutions do not contain an official definition of the Middle East. IAEA reports define the Middle East as the territory that stretches from Libya in the West to Iran in the East, and from Syria in the North to Yemen in the South; it does not include Turkey.[3]

There is no common definition of the Middle East in the expert community, either. Academician Evgeny Primakov, a renowned Russian expert on the Middle East, opines in his book "Confidential: Middle East on the Stage and Behind the Curtains" that the region comprises all the Arab states (including those in North Africa) plus Israel and Iran.[4]

Some experts in the region believe that in view of the latest trend for the blurring of national boundaries, the appearance of new states, and the growing influence of non-state actors, the term "Middle East" in its traditional sense is becoming irrelevant.

For the purposes of this study, we have defined the Middle East as all the Persian Gulf states (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE), plus Egypt, Israel, Jordan, Lebanon, Palestinian National Authority, Syria, Turkey, and Yemen.

The study was conducted by a team of researchers from Russia and the Middle East countries. A significant contribution was also made by reviewers and consultants from Russia and other countries who verified the accuracy of the data used in this paper and reviewed the drafts. A series of interviews conducted by the members of the research group with experts and officials from Bahrain, Iraq, Iran, Israel, Jordan, Kuwait, Qatar, Saudi Arabia, the UAE, and other Middle Eastern states played an important role in the gathering of primary data.

Interim results of this study were unveiled for a broad discussion at several international conferences, workshops, and round tables held in November 2012 — December 2015, including the workshop hosted by the United Nations Institute for Disarmament Research (UNIDIR) and the Moscow Non-proliferation Conference.[5]

The members of the research group would like to thank the Foundation for Development and Support of the Valdai Discussion Club, whose support was instrumental.

In 2005–2010, 13 Middle Eastern states announced plans to build about 90 nuclear power reactors at 26 different sites by 2030

The opinions, assessments and conclusions presented in this paper do not represent a consensus. They primarily reflect the view of the editor-in-chief and do not necessarily reflect the positions of all the members of the research group, the organizations they represent, or the Foundation for Development and Support of the Valdai Discussion Club.

This study was largely completed in September 2015, with the latest edits and minor updates added in January 2016.

1. PROSPECTS FOR NUCLEAR ENERGY DEVELOPMENT IN THE MIDDLE EAST

1.1. GROWING INTEREST TO NUCLEAR ENERGY IN THE MIDDLE EAST: 2005–2010.

Facts and figures

According to the International Atomic Energy Agency (IAEA), as of September 2010 there were 441 nuclear power reactors in operation in 29 countries. The share of nuclear energy in the overall electricity generation was the highest in Western Europe (27%) and the lowest in Southeast Asia and the Middle East, where it stood at zero.[6] IAEA documents also mentioned, however, that 65 new countries had expressed interest in developing nuclear energy. About a fifth of those countries are Middle Eastern states.

By late 2010, amid a strong resurgence of interest in nuclear energy around the world, almost every single country in the Middle East had announced plans of using nuclear technologies to meet its national energy needs. The only two exceptions were Lebanon and the Palestinian National Authority. Some of the states that unveiled nuclear energy plans, such as Egypt and Turkey, had already had decades of relevant experience and formidable expertise in that area. Others, such as Bahrain, Jordan, Kuwait, Saudi Arabia, the UAE, and Yemen, had not previously demonstrated any great interest in peaceful nuclear energy.

In December 2007 members of the Gulf Cooperation Council (GCC) held a meeting to discuss plans for joint implementation of nuclear energy programs. In practice, however, each of these countries has begun to implement its own national program, without any meaningful coordination with the other GCC states. In fact, there is more of competition than cooperation in these countries' relations as far as nuclear energy programs are concerned.

The Masjid al-Haram during hajj, *Mecca, Saudi Arabia*

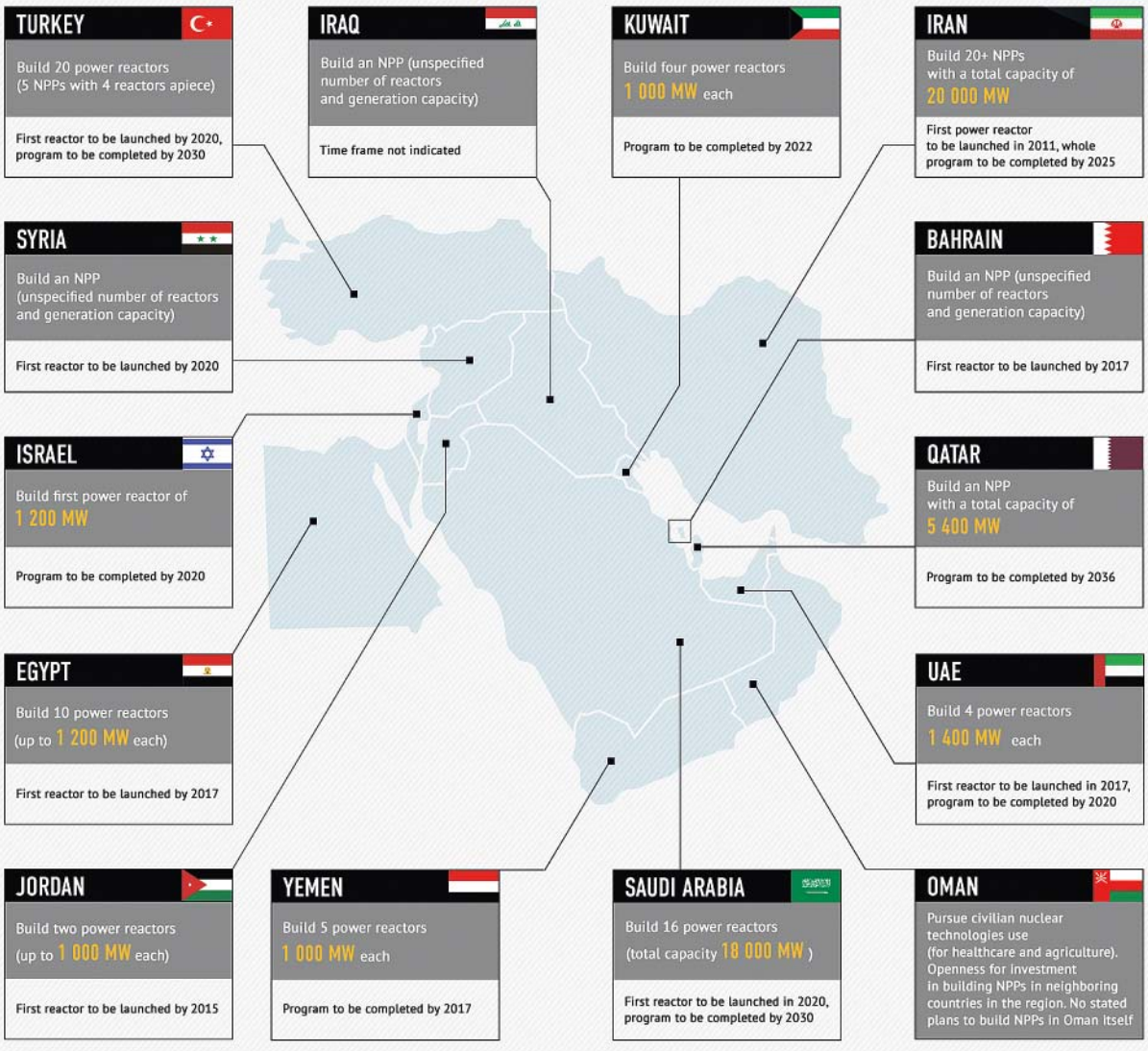
According to all the statements made by Middle Eastern leaders and senior officials in the first decade of the 21st century (mainly in the late 2000s), there were plans to build approximately 90 nuclear power reactors at 26 sites (NPPs) in 13 states in the region over the following 20 years (i.e. by 2030). Six countries — Bahrain, Egypt, Iran, Jordan, the UAE, and Yemen — were planning

to launch their first nuclear power reactors by 2017. An average of six new power reactors were to be launched in the Middle East every year between 2018 and 2030. For more details, *see Fig. 1 'Nuclear Energy Development Plans in the Middle East before Fukushima and the Arab Spring'.*[7]

When the global nuclear energy sector was at its peak in the late 1970s and early 1980s, there was an average of 22 nuclear reactors being launched in countries around the world every year. As many as 34 reactors were launched in 1984. As of late 2010 — i.e. before the Arab Spring and the Fukushima accident — the Middle Eastern countries had very ambitious nuclear energy plans. They accounted for about 20% of the global plans for building new nuclear energy reactors. These programs jointly were probably as ambitious as the ones pursued by the developed countries during the golden age of nuclear energy in the 1970s and 1980s.[8]

NUCLEAR ENERGY DEVELOPMENT PLANS
IN THE MIDDLE EAST BEFORE FUKUSHIMA AND THE ARAB SPRING

FIGURE 1



Reasons and incentives to pursue nuclear energy

The most universal reasons for Middle Eastern countries to launch nuclear energy programs in 2005–2010 included their growing demand for electricity, their desire to diversify their energy sources, and the growing public acceptance of nuclear energy.

Growing demand for electricity

Economic and population growth in the Middle Eastern countries has led to a fivefold increase in their demand for electricity since the 1980s. In 2000–2010, their electricity demand was growing by an average of 2% every year, which is more than in most other parts of the world.[9] The figures were even higher in the largest oil and gas producing countries in the region: 4% in Iran, 5% in Kuwait and Egypt, 8% in Saudi Arabia, and 9% in the UAE.[10]

According to various estimates, these trends will continue over the coming decades. The World Energy Council believes that the global electricity demand will rise by 27–61% in 2010–2050. In the Middle East, the figure will be in the 81–114% range, depending on the scenario.[11] According to projections by BP, energy demand in the Middle East will rise by 77% by 2035.[12]

According to a forecast by the World Energy Council, global demand for electricity will increase by 27-61 per cent in 2010-2050, but the projected growth figures for the Middle East are as high as 81-114 per cent

As a result, the Middle Eastern governments are looking for ways to meet the growing energy demand of their economies and populations. Building nuclear power plants is seen as one of the available options.

Diversification of energy sources

In the Middle East, reliable access to electricity is crucial not only to keep homes lit and electric appliances working. It also means access air conditioning and to fresh water since many countries rely on energy-hungry desalination plants for their water supply. In Saudi Arabia, half of all electricity generated in the country is used to run air conditioners; in the scorching summer months, when temperatures reach 50 °C, that proportion is even higher.[13] The region is home to about 4% of the planet's population, but it has only 1% of the global supply of fresh water.[14] As a result, about 50% of the global water desalination capacity is situated in the Middle East.[15] Electricity blackouts can there fore wreak havoc not only to the region's industry but to its life support systems as well. This has obvious implications for the public perceptions of the energy security problem and its possible solutions in the Middle East.

The region's largest oil and gas producers are almost entirely dependent on hydrocarbons for their electricity production. In Saudi Arabia, natural gas-burning power plants account for 43% of electricity production; the rest of the country's power plants burn oil and petrochemicals.[16] In the UAE, 97% of electricity is generated by burning gas; oil accounts for the remaining 3%. In Egypt, 70% of power plants burn gas, 20% oil, and 10% use hydroelectric energy and other renewables[17]. In Iran, which has the largest installed electricity generation capacity in the region, gas accounts for 67% of electricity production, oil 27%, and other sources (including hydro and nuclear energy) 6%.[18]

These countries aim to diversify their energy sources in order to increase the reliability and resilience of their national energy systems and reduce CO2 emissions. Most of the region's countries are developing alternative energy sources, but these sources cannot replace nuclear energy due to such considerations as scale, reliability, and uninterrupted energy production. At the same time, according to some estimates for the largest oil-producing countries in the region, the cost of nuclear energy will be twice as high as the cost of energy produced by burning fossil fuel.[19]

Burj Khalifa skyscraper,
Dubai, UAE

According to UAE energy plans, the proportion of natural gas in electricity generation is to fall to 71% by 2030; the proportion of nuclear energy and coal-burning plants is to increase to 12% apiece, and solar energy to 5%.[20] Countries such as Egypt, Iran, and several others also say that another reason to diversity their national energy systems is to limit the domestic use of oil and gas for electricity generation in order to release more of these valuable resources for exports. For most countries in the region, these exports are the main source of budget revenue. Oil and gas account for 85% of export earnings in Qatar and Saudi Arabia, and about 60% in Iran.

Meanwhile, the net importers of energy, such as Jordan and Turkey, aim to diversity their energy sources in order to reduce their dependence on imports of oil or gas. For example, Turkey is severely dependent on gas imports. Until recently, the same was true of Jordan. Turkey generates almost half of its electricity by burning natural gas imported from Russia or Iran. A few years ago it faced a major disruption of gas supplies from Iran, which accounts for a third of Turkey's gas imports. In Jordan, up to 90% of electricity was generated by burning natural gas imported via a pipeline from Egypt. After the fall of the Hosni Mubarak government, imports from Egypt were completely interrupted on several occasions because of armed attacks on pipeline infrastructure in Egyptian territory. Jordan is more than 95% dependent on imports of primary energy sources.

Growing public acceptance of nuclear energy

Public opinion and its policy implications are more important for the nuclear energy industry than for almost any other industry. The nuclear accidents at the Three Mile Island and Chernobyl nuclear power plants have amply demonstrated the power of public opinion to reverse nuclear industry development trends.

Negative public perceptions of nuclear power reached their peak in the late 1980s and 1990s. In the first decade of the 21st century, however, attitudes began to change because

of the growing problems of global warming and energy security. In most countries in Western Europe, the level of public support for the nuclear industry increased by 15% or even more over the indicated period, reaching 50% in Sweden and 75% in Hungary.[21] In the United States the figure increased by 20 percentage points to 62% in 2007.

According to various surveys, campaigns emphasizing that nuclear power plants to not contribute to global climate change have increased Saudi public support for nuclear energy plans by almost 10 percentage points

The nuclear industry received an important positive signal from the United States that have the largest fleet of NPPs in the world. In April 2005 President George W. Bush called for a review of America's long-term energy strategy, with a greater role to be given to nuclear energy generation.[22] Up until that statement, there were no new nuclear reactor construction starts in the United States since 1977.

The aforementioned trends had forced many countries, including those that had previously abandoned peaceful nuclear energy plans (such as Italy), to consider a change of policy. The practical effects of the growing public acceptance of nuclear energy became quite obvious on a global scale in 2006–2010, when the number of nuclear power reactors starts each year rose from 4 to as many as 16 (the average annual number increased from 2.6 in 2001–2005 to 10 in 2006–2010). The last time more than 15 nuclear power reactors had been started in a space of a single year was in 1985, i.e. shortly before the Chernobyl accident.[23]

Middle East was no exception in terms of growing public acceptance of nuclear energy. According to a survey, public support for nuclear energy in Saudi Arabia increased by almost 10% thanks to explaining to public that nuclear power plants do not contribute to global warming.[24] The high level of public support (85%) for the industry in the UAE remained unchanged for several weeks even after the Fukushima accident.[25] Of all the potential nuclear newcomer countries that are close to launch their first NPP project, public support for nuclear energy was the highest in Egypt.[26] Three decades previously, strongly negative public opinion was one of the reasons for the Egyptian government's decision to shelve its plans for building NPPs in the wake of the Chernobyl disaster.

Some of the Middle Eastern countries also had their own individual reasons to pursue nuclear energy (i.e. reasons that did not necessarily apply across the region). These included regional competition and the factor of prestige associated with having nuclear power plants; the availability of capital looking for investment opportunities; and finally, the desire to build scientific, technological, and industrial capability in the nuclear sphere, which could later be used to build nuclear weapons.

Capital looking for investment opportunities

In 1973–1974, Iran's oil export revenues rose by a staggering 400%.[27] As a result, by the mid-1970s the country was faced with the question of how to invest that windfall to the best possible effect. It began to look for promising investment projects, both domestically and abroad. The Iran's Plan and Budget Organization (PBO) intended to invest 21 bn dollars in foreign projects over a five-year period. The priorities included investment in high-tech industries, such as the acquisition of stakes in the car giant

Mercedes, the household appliances maker Krupp, and uranium enrichment companies in Europe and the United States.[28] Some of these investment projects were implemented before the 1979 Islamic Revolution; for example, Tehran bought a stake in Eurodif, an international uranium enrichment consortium.

It cannot be ruled out that at some point in the future, Qatar will also come to regard a nuclear energy program as a good investment opportunity

At the same time, the country was looking for domestic investment opportunities. In particular, the government decided to use the historically opportune moment to diversify the Iranian energy sector and launch an ambitious nuclear energy program. To a certain extent, the Shah and his government were swayed in favor of such a decision by their foreign advisors and by Iran's own industrialists, who wanted the oil-rich country to become a nuclear industry powerhouse.

A very similar situation had arisen in Saudi Arabia by the late 2000s as a result of the high oil prices. The Kingdom announced plans to invest about 100 bn dollars in the construction of 16 nuclear power reactors. It also launched other major investment projects, such as building a metro in the capital Riyadh. The first stage of the project will cost an estimated 20 bn dollars; the Saudis hope it will stimulate economic growth, stabilize the employment situation, alleviate the transport problem, and help the environment.[29]

It cannot be ruled out that at some point in the future, Qatar will also come to regard a nuclear energy program as a good investment opportunity. It has already announced a plan to build a nuclear power plant by 2036. In the first half of 2014, Qatar invested 10 bn dollars in foreign assets. It currently holds more than 120 bn dollars of various investments in Britain, France, Germany, and the United States.[30] It must be taken into account, however, that Qatar is a small country, which could be a natural limiting factor for the development of its nuclear energy industry.

The prestige factor

Prestige is another factor that drives nuclear energy programs in the Middle East. In the mid-1970s the Iranian Shah had an ambitious aspiration for his country to acquire the most advanced technologies in the world, including Concorde supersonic airliners, AWACS aircrafts[31], nuclear reactors, enrichment technologies, and nuclear submarines. By investing its oil export revenues

Panoramic view of Tehran in daylight, *Iran*

in high-techindustries, Iran hoped to become "West Asia's Japan" and the world's fifth-largest industrial power.[32] It regarded nuclear energy as one of the ways of achieving superiority over its Arab neighbors. The then Iranian deputy foreign minister Jafar Nadim was quoted as saying that nuclear energy "help us to get the respect we feel we deserve. You should understand, we Persians have a very ancient, very advanced culture, yet we have been a victim of so many insults and invasions, and now we have to stand up."[33]

The connection of the Bushehr NPP to the Iranian national grid in 2011 has stimulated other Middle Eastern powers to explore their own nuclear energy plans

In view of the fierce regional competition and rivalry, the connection to the national grid of the first reactor of the Bushehr NPP in September 2011 has stimulated other large Middle Eastern powers to explore their own nuclear energy plans. The region's first NPP in Iran has probably been a tangible factor behind the ongoing NPP construction projects in the UAE and Turkey. The same consideration probably applies to Egypt and Saudi Arabia, even though their nuclear energy plans have not yet entered the practical phase.

For several Middle Eastern countries, possession of NPPs or concrete nuclear energy plans has served as a ticket to a series of Nuclear Security Summits held in 2010–2016 in the United States, South Korea, the Netherlands, and the United States again. Membership of such an elite club is certainly a factor of prestige. It also serves as an incentive for other states in the Middle East and beyond to build national nuclear infrastructure.

Desire to build scientific, technological, and industrial capability

Yet another incentive for nuclear energy development that may well feature prominently in Middle Eastern countries' domestic debate is the desire to acquire a scientific, technological, and then industrial nuclear capability that could later be used for weapons purposes, if a political decision is made to that effect.[34]

It is entirely possible that Iran's real strategy ever since the mid-1970s has always been to develop peaceful nuclear energy in parallel with the acquisition of nuclear weapons capability, i.e. the science, technology and resources that would enable it to build nuclear weapons. According to former Iranian foreign minister Ardeshir Zahedi, before the Islamic Revolution the Iranian government thought it necessary to have the kind of nuclear capability

NPP Fukushima Daiichi accident consequences

that would enable it to build nuclear weapons within 18 months of the political decision being made.

Recent examples of foreign interference in sovereign states' affairs under various pretexts, and diverging interpretations of fundamental principles of international law when launching military campaigns against Yugoslavia, Iraq, and Libya have forced several countries (especially those who have fraught relations with the United States) to think hard about their own deterrence capability.

Meanwhile, Israel, which possesses nuclear weapons, remains outside the NPT. All these considerations could well serve as a catalyst for some Middle Eastern states to give the go-ahead to their nuclear technology development programs. The conclusions drawn by some Middle Eastern researchers have dire implications for the nuclear nonproliferation regime. These researchers argue that third-world countries must acquire nuclear weapons if they want to remain sovereign states, because only nuclear weapons can guarantee non-interference by foreign powers.[35] Many experts in the Middle East, including Iran, regard the deposal of Col. Gaddafi shortly after he relinquished his WMD programs as something much more than a mere coincidence.

1.2. MAJOR FACTORS OF INFLUENCE: 2010–2015

Most of the Middle Eastern states' plans, however, appeared overly ambitious in view of the limited technological capability of the majority of the countries involved, including their lack of specialists. As of late 2010, only four states, Egypt, Iran, Israel, and Turkey were operating research reactors. Syria had a miniature neutron source used for experimental work. For details, *see Fig. 2 'Nuclear Research Reactors and Critical/ Subcritical Assemblies in the Middle Eastern States'.*

Iraq had also operated research reactors in the past. The Al Tuwaitha Nuclear Research Centre located near Baghdad had two research reactors: IRT-5000 supplied by the Soviet Union, and a Tammuz-2 supplied by France. As a result of the Desert Storm operation in 1991 Iraq was found to be pursuing undeclared nuclear activities. In accordance with UN Security Council Resolution 687 (1991) of April 3, 1991, all Iraqi nuclear materials, equipment, and facilities were to be removed and destroyed.[36]

Most of Middle Eastern scientists until recently educated in nuclear physics and related areas of science in foreign countries were forced to pursue a career elsewhere upon their return home because of lack of demand for their expertise.

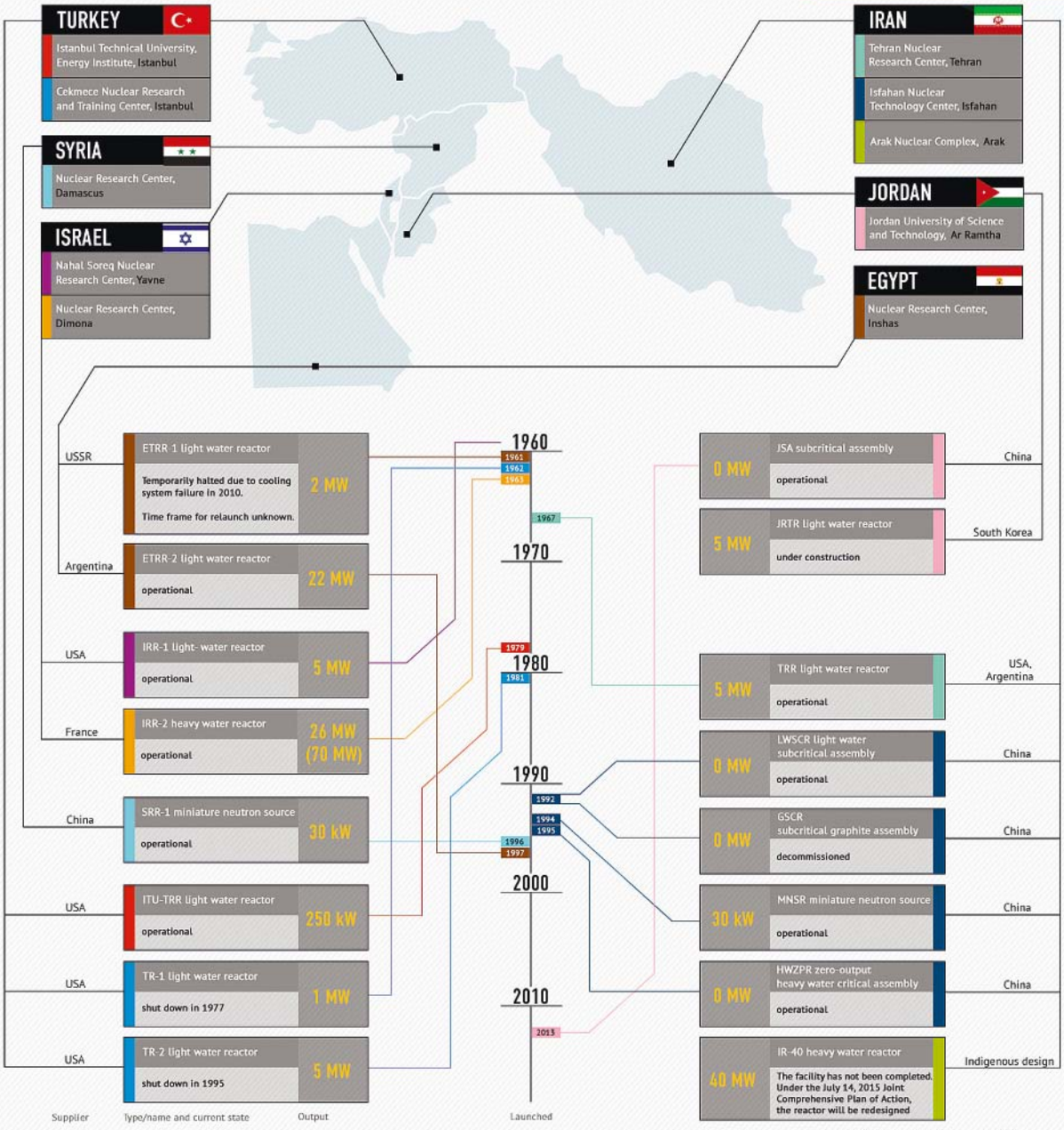
Yemeni army soldiers join protesters during mass demonstrations against the incumbent president,
Yemen, June 2, 2011

Some of the statements made by Middle Eastern leaders on nuclear energy plans were clearly dominated by political considerations, and were not sufficiently thought through. For example, under some of those plans, the first nuclear power reactors were to be launched at a completely new site within seven or eight years (i.e. much sooner than the 10–15 years time frame projected by the IAEA), even though the host countries lacked the necessary legal framework, a nuclear regulatory system, a pool of qualified specialists, or secure sources of financing.[37]

NUCLEAR RESEARCH REACTORS AND CRITICAL/SUBCRITICAL ASSEMBLIES IN MIDDLE EASTERN STATES

FIGURE 2

As of January 1, 2016, unless otherwise indicated



This table is based on materials from the IAEA Research Reactor Database

Several statements also ignored the security situation in the host country and the wider region. For example, some Iraqi officials spoke in the early 2010s about the possibility of building an NPP despite the lack of any tangible progress in stabilizing the situation in the country, the ongoing power vacuum, and a deep domestic political crisis. Also, some of the statements appeared to be confused on the distinction between the terms "nuclear power reactor" and "nuclear power plant."

Plans for nuclear energy development in the Middle East have been affected by the nuclear accident at the Fukushima NPP and the transformations in the region that are frequently referred to as the "Arab Spring", which began in 2010, spreading to almost the entire region and continuing to this day

Nuclear energy development plans have been affected by the accident at the Fukushima NPP in March 2011, as well as the transformations in the region variously described as the Arab Spring, the Arab Awakening, and the Islamic Awakening (we will stick to the Arab Spring for simplicity's sake in this report) that began in late 2010, gradually spread to engulf almost the entire Middle East, and continue to this day.

Accident at the Fukushima NPP

On March 11, 2011 the east coast of Japan's Honshu Island was struck by a magnitude 9 earthquake, the strongest in decades. The disaster was later dubbed the Great East Japan Earthquake. There were 11 reactors in operation at five nuclear power plants in the affected area.[38] Soon after tremors began, reactors were shut down automatically. All of them switched to auxiliary cooling systems for the removal of residual heat.[39] Less than an hour after the earthquake, the coastline was struck by a powerful tsunami wave. At eight of the 11 reactors, power supply of the cooling systems remained intact thanks to high-voltage grid connections and reserve generators working on diesel. The Fukushima Daiichi NPP, however, was struck by a 14 meter tsunami wave; its flood defenses were designed to withstand

Protest held on the 3rd anniversary of the Fukushima NPP accident, *Manila, Philippines*

waves of only 5.7 meters.[40] As a result, reserve diesel generators at the No 1, 2 and 3 reactors shut down, leaving the emergency cooling system without power.[41] The plant's No 4, 5 and 6 reactors were undergoing scheduled maintenance at the time.[42]

Failure of the cooling system due to the power cut led to a major meltdown of the reactor core at the No 1, 2 and 3 reactors. The spent fuel storage facility of the No 4 reactor was also affected. As a result, large amounts of radiation were released into the environment. According to IAEA estimates, the release of radiation at Fukushima reached up to 10% of the Chernobyl level.[43]

According to IAEA, however, the Fukushima accident merely slowed down than reversed nuclear energy development in nuclear newcomers countries

More than 185,000 people who lived within a 20 km radius from the NPP were evacuated.[44] According to Japanese experts by the Fall 2013, the Fukushima accident may have caused up to 80 bn dollars worth of damage.[45] The World Bank has estimated the damage caused by the earthquake and the ensuing tsunami at up to 235 bn dollars.[46] The Fukushima accident itself did not directly cause any fatalities. Two members of staff at the Fukushima Daiichi NPP (operators of the turbine hall) were killed by the tsunami wave. According to conclusions by IAEA experts, no serious cases of radiation sickness caused by the accident have been found.[47] Japan's police service has reported that 16,000 people were killed by the earthquake and the tsunami (including 1,599 in Fukushima Prefecture), and another 8,000 went missing.[48]

On May 20, 2011, TEPCO, the operator of the Fukushima Daiichi NPP, announced that the No 1, 2, 3 and 4 reactors would be decommissioned, and plans to build the No 7 and 8 reactors cancelled.[49] In December 2013 it has also made a decision to decommission slightly damaged units 5 and 6. As of January 1, 2016, only 2 of 54 nuclear power reactors operated in Japan before the Great East Japan Earthquake were restarted.[50]

As a result of the Fukushima accident in Japan, 12 nuclear power reactors were shut down in several other countries in 2011. The world's total installed nuclear generation capacity fell from 375 GW to 368 GW, and the number of nuclear power reactors in operation fell to 435 as of September 2012.[51] According to IAEA projections, however, the Fukushima accident will merely slow down rather than reverse nuclear energy development.[52] In his September 2012 report IAEA Director-General Yukiya Amano said that eighteen months after the accident, it was clear that nuclear energy would remain an important option for many countries. Later IAEA projections show a steady rise in the number of nuclear power plants in the world in the next 20 years.[53] According to the IAEA, most of the nuclear newcomers, i.e. countries that are considering projects to build their first nuclear power reactor, still intend to press ahead with these programs.

The effects of the Fukushima accident on the Middle Eastern states' nuclear energy plans are threefold.

1. The smallest countries in the region, Bahrain and Oman, as well as Kuwait, have abandoned these plans (or "postponed them indefinitely", in the case of Bahrain). Kuwait has abolished the National Nuclear Energy Committee (KNNEC), the national agency in charge of implementing the country's nuclear

energy strategy. The main reason for these decisions boils down to concerns related to the small size of these countries' territory and their inability to ensure adequate public safety measures if the nuclear power plants were to be built after all. Bahrain's territory is only 765 sq km, whereas Japan had to evacuate population from an area of more than 1,200 sq km after the Fukushima accident.

2. Several countries in the region have adjusted their nuclear energy plans to make them more realistic. For example, Jordan, which has no nuclear energy expertise or trained specialists, initially wanted its future NPPs to double as desalination plants and hydrogen production facilities for future hydrogen cars. In theory, such a combination is possible, but it has yet to be implemented anywhere in the world. Jordan has since abandoned these ambitions, and plans to use its future NPPs only for electricity generation.

3. The Fukushima accident has led to the introduction of more stringent nuclear safety requirements, raising the technological bar and making third-generation reactors the minimum acceptable level of technology. China, which has the technology to build second-generation reactors, was regarded as a potential nuclear exporter to the Middle East and a competitor to the traditional nuclear suppliers as recently as 2010. Now, however, China has dropped out of the list of potential technology suppliers for the next five or 10 years. The suppliers who are wooing the region's governments most energetically — such as Russia, France, Japan, and South Korea — are offering Generation III or III+ reactors.

In order to improve nuclear safety on a global level, Russia has been using various international platforms, including the IAEA, to advocate the introduction of minimum standards requiring the use of Generation III+ or above for new NPP projects.

The Arab Spring

The effects of political upheavals in the Middle East on nuclear energy plans have also been threefold.

1. Political transformations in the region have forced Middle Eastern states to postpone decisions on various mega-projects, including the construction of NPPs. There have been obvious reasons for such delays, including a change of government in several countries, etc. For example, in August 2010 Egypt completed preparations for a tender to choose the technology supplier for the country's first nuclear power plant. That tender, however, was postponed because of a wave of protests and the ensuing change of government. All work on the NPP project itself was frozen because of unrest in the country. Officials and experts in Jordan also say that growing instability on the country's borders, including the influx of refugees from other Middle Eastern states, could force the government to postpone the NPP project.

2. Turbulence in the Middle East, which is a large exporter of hydrocarbons, has exacerbated concerns about the reliability of energy supplies — including concerns felt by countries in the region itself. This has strengthened the argument in favor of nuclear energy. A case in point is Jordan. Since the change of government in Egypt the pipeline used for Egyptian gas exports to Jordan (as well as Israel) has suffered more than 20 separate bombing attacks. As a result, according to various reports, Jordan received only 10–25% of the natural gas it was supposed to receive under the contract. Gas-burning power plants account for up to 90% of electricity generation in

the country. In addition, the new Egyptian government revised the financial side of the contract, making Egyptian gas supplies much more expensive. According to the Jordanian government, the country suffered losses of more than 5 bn dollars as a result.[54] These developments served to strengthen the argument of nuclear energy advocates, especially since Jordan, which currently imports 95% of its primary energy, has its own uranium reserves.

Recent events in the region have forced Middle Eastern states to postpone decisions on various mega-projects, including the construction of NPPs

Another example is Turkey. Events in Syria have led to a deterioration in Turkish-Iranian and Turkish-Russian relations. Natural gas imports currently account for about a half of Turkey's energy needs, and about a third of those imports are sourced from Iran. This has increased concerns about the reliability of gas supplies and the nation's energy security. Turkey already has first-hand experience of the dire consequences of dependence on gas imports. In January 2008 gas supplies from Iran first fell well below the figures agreed in the contract, and then stopped altogether for a certain period because the Iranian government had imposed a temporary ban on gas exports. Turkey therefore has good reasons to diversify its energy basket and speed up nuclear energy development.

3. Public opinion on nuclear energy is becoming a more influential factor for the region's governments. In some cases legitimate public concerns are becoming more prominent. In others, politicians merely exploit the issue to score political points. For example, some forces in Jordan are prone to criticizing plans to build a nuclear power plant merely because those plans have the king's support.

After the change of government in Egypt, locals in the region of El-Dabaa occupied the site that was chosen back in the 1980s for the construction of the country's first NPP. It was previously believed that the issue had been settled, and an agreement on various forms of compensation had been reached with the local residents who had properties and land in the future NPP's exclusion zone. Egyptian specialists believe that if the government were to be forced to choose a new site, plans for the construction of a nuclear power plant could be delayed by another four or five years.

1.3. PROSPECTS FOR NUCLEAR ENERGY DEVELOPMENT IN THE MIDDLE EAST IN THE 2030 HORIZON

To summarize, the Fukushima nuclear accident has had a salutary effect on the Middle Eastern states' nuclear energy plans, without removing the fundamental causes of their interest in nuclear energy. These causes include rising energy demand, environmental and climate challenges, and energy security concerns. At the same time, long-term plans for the numbers of new reactors and the time frame for their launch will have to be adjusted to reflect the technological and financial capabilities of the region's economies, as well as their actual demand for nuclear energy. This is especially true of countries such as Iran, Saudi Arabia and Turkey.

The effects of the Arab Spring on the Middle Eastern states' nuclear energy plans have been more ambiguous. For energy-dependent countries in the region, the ongoing turbulence strengthens the argument in favor of bolstering their energy security and pursuing nuclear energy. In other countries —

especially those that have already undergone a change of government — the ongoing centrifugal trends could force delays in the implementation of nuclear energy plans due to domestic instability, security challenges, and economic problems.

Another development that will have an impact on the prospects for nuclear energy development in the Middle East is the sharp fall in the world prices for hydrocarbons that began in mid-2014 and shows no signs of reversal throughout 2015. This has reduced budget revenues in most of the region's countries and made it more difficult for nuclear energy to compete with fossil fuel-burning power plants.

Under the optimistic scenario for the nuclear energy industry in the Middle East six countries will have built 9 NPPs with a total of 33 reactors by 2030

The state of nuclear energy programs in the Middle East as of January 1, 2016 is summarized in *Fig. 3 'Current State of Nuclear Energy Programs in the Middle East'*.

Detailed information about NPP projects being implemented in the Middle East is contained in *Fig. 4 'NPP Projects Under Way in the Middle East'.*

The next chapter will focus on the history, distinctive features, and potential for nuclear energy development in individual Middle Eastern countries that are the most likely regional candidates to build NPPs in the foreseeable future and fall within the first six categories specified on the *Fig. 3* (Egypt, Iran, Jordan, Saudi Arabia, Turkey, and the UAE).

It is very likely that over the next 10 years, the UAE and Turkey will launch their first nuclear power plants (each consisting of four reactors). However, the deepening crisis in Russian-Turkish relations may become a factor that affects the outlook for Turkey's nuclear energy development program. The crisis was triggered when the Turkish Air Force shot down a Russian Su-24 bomber near the Syrian-Turkish border in November 2015. It is also likely that by the early 2020s, Abu Dhabi will have become the regional leader in terms of installed nuclear generation capacity.

Egypt, Jordan, and Saudi Arabia, which are also showing great interest in nuclear energy, are unlikely to launch their first NPPs before 2025. Over the same period, Iran may build another two reactors at the existing Bushehr NPP.

Under the optimistic scenario for the nuclear energy industry in the Middle East, Iran, Turkey, the UAE may launch their second NPPs (each consisting of four reactors) by 2030.

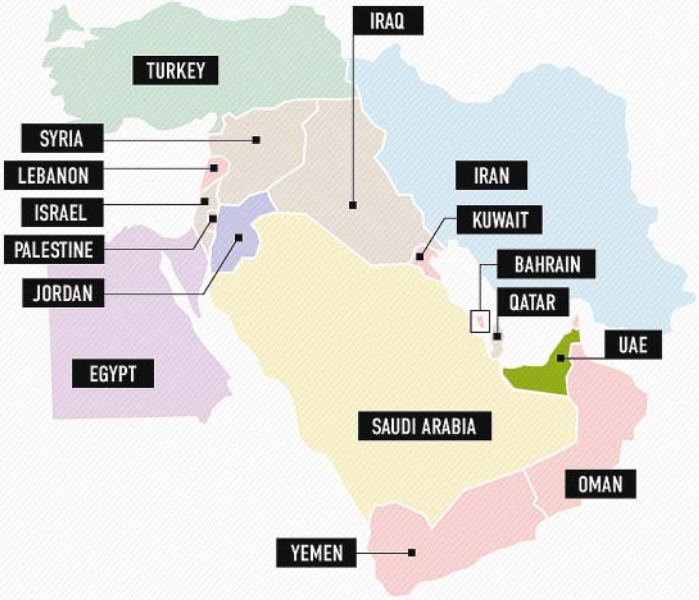
To summarize, six Middle Eastern countries will have built nine NPPs with a total of 33 reactors by 2030 under the optimistic scenario.

Under the pessimistic scenario, only Iran, the UAE, and Turkey will have built one NPP each with a total of 11 reactors by 2030. A more conservative scenario is possible if relations between Russia and Turkey fail to improve reasonably quickly.

While in 2005–2010, 13 Middle Eastern countries announced plans to set in operation about 26 NPPs with about 90 reactors by 2030, in fact, only about a third of the reactors announced in 2005–2010 will be launched during the indicated period under the optimistic scenario, and 10% under the pessimistic scenario.

CURRENT STATE OF NUCLEAR ENERGY PROGRAMS IN THE MIDDLE EAST

FIGURE 3

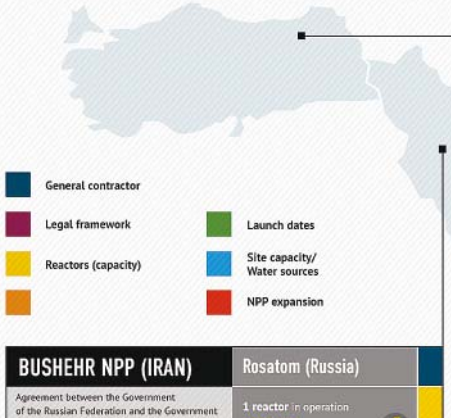


STATE OF NUCLEAR ENERGY PROGRAM

- First nuclear power reactor already operational
- First NPP under construction
- Contract signed for NPP construction. Legal and regulatory framework put in place; licensing of the construction of first NPP under way
- Contractor to build the first NPP already chosen. A project development agreement to implement the first part of the project to build a NPP was signed
- The implementation of the project to build the country's first NPP has been delayed for domestic political reasons.
- Work has begun to put in place the national nuclear infrastructure, including legal framework and regulatory mechanisms. Nuclear energy development plans being drawn up
- No plans to build NPPs in the medium term. Nuclear energy is seen as one of the options for meeting national energy requirements
- No nuclear energy development plans

NPP PROJECTS UNDER WAY IN THE MIDDLE EAST

FIGURE 4



General contractor
Legal framework
Reactors (capacity)
Launch dates
Site capacity/ Water sources
NPP expansion

BUSHEHR NPP (IRAN)

	Rosatom (Russia)
Agreement between the Government of the Russian Federation and the Government of the Islamic Republic of Iran on Cooperation in Peaceful Use of Nuclear Energy (August 24, 1992). Agreement between the Government of the Russian Federation and the Government of the Islamic Republic of Iran on Cooperation in the Construction of a Nuclear Power Plant in the Territory of Iran (August 25, 1992). Contract between Zarubezhatomenergostroy and the IAEO for the completion of the No 1 reactor of the Bushehr NPP (January 8, 1995). Protocol to the Agreement between the Government of the Russian Federation and the Government of the Islamic Republic of Iran on Cooperation in the Construction of a Nuclear Power Plant in the Territory of Iran of August 25, 1992 (November 11, 2014). Contract between NIAEP-ASE and Nuclear Power Production and Development Company of Iran (NPPD) to build the second stage of the Bushehr NPP (November 11, 2014).	1 reactor in operation 1000 MW. Contract signed to build two 1000 MW reactors. Commercial operation of the first unit. First unit: Physical launch: May 8, 2011. Electricity production commenced: September 3, 2011. 6 reactors/ Persian Gulf. The Russian-Iranian legal framework is sufficient to build up to eight new reactors in Iran, including 4 units at the Bushehr site.

AKKUYU NPP (TURKEY)

	Rosatom (Russia)
Agreement between the Government of the Russian Federation and the Government of the Republic of Turkey on Cooperation in Peaceful Use of Nuclear Energy (August 6, 2009). Agreement between the Government of the Russian Federation and the Government of the Republic of Turkey on Cooperation in Building and Operating a Nuclear Power Plant at the Akkuyu Site in the Republic of Turkey (May 12, 2010). Contract between Atomstroyexport and ENVY on building the Akkuyu NPP (May 20, 2011).	4 reactors planned 4800 MW. 2013 – electricity production license issued. 2016 – NPP construction permit, first concrete to be poured. 1st: 2020 2nd: 2021 3rd: 2022 4th: 2023. 4 reactors/ Mediterranean. No information available about NPP expansion plans.

BARAKAH NPP (UAE)

				KEPCO (South Korea)	
Agreement between the Government of the United Arab Emirates and the Government of the Republic of Korea on Peaceful Use of Nuclear Energy (June 22, 2009). Contract between ENEC and KEPCO for the construction of four nuclear power reactors (December 27, 2009).	4 reactors planned 5600 MW	1st reactor – first concrete poured in July 2012. 2nd reactor – first concrete poured in May 2013. 3rd reactor – in September 2014. 4th reactor – in September 2015.	1st – 2017 2nd – 2018 3rd – 2019 4th – 2020	8 reactors/ Persian Gulf	One of the options on the table is to build a second stage of the NPP, consisting of another four reactors.

2. DISTINCTIVE FEATURES AND POTENTIAL FOR NUCLEAR ENERGY DEVELOPMENT IN MIDDLE EASTERN COUNTRIES

2.1. EGYPT

Egypt's demand for electricity is rising at a rapid pace, but the country's own energy resources are limited. There is very little room left for increasing the country's output of hydroelectric energy. Egypt's energy sector is heavily dependent on oil and gas. Egyptian specialists believe that even though the country is rich in renewable energy resources such as wind and solar, these resources will not be enough to meet growing energy demand. Faced with the need to ensure sustainable and long-term development in the interests of future generations, Egypt is increasingly looking to nuclear energy as a solution.

Egypt was one of the first developing countries to launch a research program of using nuclear energy for electricity production and water desalination

Background of the Egyptian nuclear energy program

Egypt has been pursuing peaceful nuclear energy research for almost 60 years. It was one of the first developing countries to launch a program of using nuclear energy for electricity production and water desalination. The Egyptian government started to show interest in nuclear energy soon after U.S. President Dwight Eisenhower announced the Atoms for Peace program at the UN General Assembly on December 8, 1953. In 1955 Egyptian president Gamal Abdel Nasser ordered the creation of the Egyptian Commission for Atomic Energy, the forerunner of the Egyptian Atomic Energy Authority (EAEA). The main task set before that agency is to facilitate peaceful use of nuclear technologies, especially for electricity production.[55]

Thanks to close relations with the Soviet Union under President Nasser, Egypt built a nuclear research center in Inshas, Al Sharqia Governorate. The center operates an ETRR-1 research reactor, a 2 MW light-water unit. In 1964 Egypt released technical requirements for a proposed nuclear power plant that was to double as a desalination plant. The facility was to be built in Borg El Arab, a city on the Mediterranean coast 30 km west of Alexandria. It was to

Cairo, Egypt

have 150 MW of generation capacity, and produce 20,000 cu. m. of fresh water every day. The project was frozen after the Six-Day War in June 1967. After President Nasser's death in 1970 he was succeeded by Anwar Sadat, who had little enthusiasm for nuclear energy. That, as well as the freezing of the NPP project, triggered the exodus of many nuclear scientists from Egypt.[56]

The Nile river, Cairo

In 1974 Egypt tried to sign a peaceful nuclear energy cooperation agreement (the so-called 123 Agreement) with the United States. Such an agreement was expected to put in place the legal framework for a project to build up to eight American-designed nuclear power reactors in the country. Washington, however, was insisting on very stringent terms for such an agreement; the talks were taking place shortly after India conducted its first nuclear weapons test using heavy water of U.S. origin to produce weapons-grade plutonium, so the United States was determined to tighten its export controls. Cairo believed that the terms proposed by the Americans were unfair, and the negotiations took seven years to complete.[57]

In 2007 Egypt unveiled an ambitious program of building nuclear power plants. It intended to build up to 10 nuclear power reactors

Egypt's nuclear program received a fresh impetus following the arrival of President Hosni Mubarak in 1981.[58] The country resumed talks with several nuclear suppliers, but the Chernobyl accident in 1986 dampened its interest in nuclear energy. Many nuclear projects were frozen, with a notable exception of the 1992 agreement with Argentina to build a 22 MW light-water research reactor at the nuclear research center in Inshas.[59]

Modern days:
renewed interest in nuclear energy

In September 2006 Egypt announced its intention to relaunch the nuclear energy program. The government made the decision in view of the growing oil and gas prices, improving public perceptions of nuclear energy, and the depletion of national reserves of natural gas. To ensure the energy rights of future generations, it decided to press ahead with a two-pronged strategy that focused on nuclear and renewable energy.

In 2007 Egypt unveiled an ambitious program of building nuclear power plants. It intended to build up to 10 nuclear power reactors, the first of which was to be launched in 2017. In 2009 the Egyptian Nuclear Power Plants Authority (NPPA) and Australia's Worley Parsons Ltd. signed a consulting agreement under which Egypt was to receive

expert advice in choosing the nuclear technology supplier.

In March 2010 Egypt adopted a comprehensive law on nuclear and radiation regulation (Law No 7 of 2010). In 2012 the country set up an independent nuclear regulation authority — Nuclear and Radiological Regulatory Authority (NRRA). The new regulator was tasked with creating a national system of nuclear material control and accounting. It was also to serve as a coordinator between the central government, the local authorities, and international organizations.

Egypt is making energetic efforts to develop its human resources in cooperation with the IAEA and nuclear technology suppliers. As part of preparations for building a NPP at the El Dabaa site, in 2010 the country turned to the Korea International Cooperation Agency (KOICA) with a request for assistance in training nuclear personnel. It also launched consultations with foreign specialists about possible modernization of the nuclear research center in Inshas, including the 2 MW light-water reactor.

All the Egyptian nuclear facilities are currently operated by the EAEA. These facilities include:

- ETRR-1, a 2 MW research reactor built with Soviet assistance;
- ETRR-2, a 22 MW research reactor built with Argentine assistance;
- A pilot nuclear fuel production facility;
- A nuclear fuel research laboratory;
- A hydrometallurgical R&D unit;
- A nuclear chemistry research laboratory;
- Two gamma-irradiators (one of them is still being built).[60]

Egypt is a member of SESAME, a UNESCO-sponsored initiative to create a regional research center in Jordan. At the heart of that center is a synchrotron that is scheduled for launch in 2016. One of the goals of the project, which was founded in 2003, is to build trust between the Middle Eastern states by pursuing joint nuclear research. The list of SESAME participants includes

Protesters throwing stones at the police,
Cairo, Egypt, January 25, 2011

Meeting between Russian President Vladimir Putin and Egyptian President Abdel Fattah el-Sisi,
Novo-Ogaryovo, Russia, February 13, 2014

Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian National Authority, and Turkey. Britain, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russia, Sweden, Switzerland, and the United States have been given observer status.

All of these national projects and plans, however, have felt the impact of the radical changes in the country's politics, economy, and security situation in 2010–2015. The Egyptian project to build the country's first nuclear power plant has slowed down.

Impact of the Fukushima accident and the Arab Spring

A revitalization of Egypt's nuclear energy program in the late 2000s led to an upsurge in anti-nuclear sentiment over safety concerns. That sentiment first appeared after the Chernobyl disaster, leading to the government's decision to postpone the NPP project. By the late 1990s, however, the issue was no longer a subject of much controversy, thanks partly to a national campaign to increase awareness of the benefits of nuclear energy.[61]

The Fukushima accident in March 2011 coincided with a period of major political transformations in Egypt, and reignited public concerns over nuclear energy's safety record.[62] The debate about the pros and cons of building nuclear power plants in the country came to the fore once again. Some of the opponents of nuclear energy are proposing solar and other types of renewable energy as an alternative.

Political and security situation in Egypt, limited financial resources of the state budget and anti-nuclear protests by local residents in El Dabaa, the site of the future NPP, are the main obstacles to a speedy implementation of that project.

The tender for the contract to build Egypt's first NPP has been postponed on several occasions. As of January 1, 2016, that tender had yet to be announced. If and when that happens, the first reactor is expected to be built within 10 years, with subsequent reactor being launched every in two years. The Egyptian government will try to stick to the following timeline:

- 6–9 months: time given to would-be general contractors to prepare their bids;
- 12–14 months: technical and financial assessment of the bids;
- 3–6 months: negotiations and the signing of the contract with the winner;
- 5–7 years: building the NPP, loading fuel, commissioning and start of commercial operation reactor.

After the Fukushima accident the Egyptian Nuclear Power Plants Authority revised the specifications of the proposed NPPs on

the basis of IAEA recommendations in order to improve their safety. Cairo is showing great interest in technical cooperation projects with the IAEA, with an emphasis on building nuclear power plants, strengthening the country's nuclear regulatory system, facilitating the development of nuclear medicine, improving Egypt's emergency response capability, and developing its human resources.

Success in the implementation of Egypt's program to build nuclear power plants will depend on its government's ability to improve security conditions, attract investment and win the support of the general public

In 2011 Egyptian officials expected the first nuclear power reactor to be launched by 2021. It is now safe to say that this timeline has been pushed back by at least five years. Under current plans, the Egyptian nuclear energy program will rely on pressurized water reactor technology offered by a whole range of suppliers from Russia, France, Japan, South Korea, and the United States. These countries had already expressed interest in working in Egypt before the government postponed the launch of the bidding process in 2011.

The election of the new Egyptian President, Abdel Fattah el-Sisi, in May 2014 has not affected Egypt's resolve to continue its program of building nuclear power plants. The country's political leadership views NPPs as an important and indispensible source of energy that will underpin a sustainable development of the Egyptian economy. On February 10, 2015, during Russian President Vladimir Putin's visit to Cairo, Rusatom Overseas and Egyptian Nuclear Power Plants Authority signed a Project Development Agreement (PDA). Under the terms of that document, Russia and Egypt have agreed to cooperate in building an NPP in Egypt, consisting initially of two 1,200 MW reactors, with a possibility of adding another two reactors at some point in the future. As part of the NPP project, the parties also agreed to build a water desalination plant.

On November 19, 2015, the Russian and Egyptian delegations met in Cairo to sign a bilateral agreement on cooperation in building and operation of a nuclear power plant based of 1,200 MW reactors in Egypt. The two governments are now expected to sign an agreement on credit financing for the project. However, as of January 1, 2016, Egypt has yet to make an official announcement of the tender for the NPP project. Neither has Cairo announced the choice of Rosatom as the general contractor for the project to build the country's first NPP bypassing the tender procedures (as Turkey has done, for example).

Public opinion in the Arab countries is becoming an increasingly important factor; it will have a great impact on the Middle Eastern nations' nuclear energy policies. In Egypt, the national legislature, including the parliamentary committees for foreign affairs, Arab affairs, and national security will play a more important role in the country's policy than they used to in the past. There is no doubt that a lot of attention will be paid to nuclear issues, including those related to peaceful nuclear energy.

Outlook

Egypt has one of the most sophisticated nuclear regulatory systems in the Middle East. By the region's standards, it also has a large pool of qualified specialists. It is therefore one of the most likely regional candidates to build NPPs.

Success in the implementation of the country's program to build nuclear power plants will depend on its government's ability to improve security conditions, attract investment and win the support of the general public. Instability in Egypt itself and in the wider region could yet force further delays in building the country's first nuclear power plant. The act of terror that brought down the Russian A321 airliner flying from Sharm el-Sheikh on October 31, 2015 has raised serious questions about the Egyptian government's ability to provide adequate levels of security at its critical infrastructure facilities amid the growing terror threat. Even under the best-case scenario, the first nuclear power reactor is unlikely to be launched before 2026.

One of the main challenges faced by Jordan is an acute shortage of natural resources

2.2. JORDAN

One of the main challenges faced by Jordan is an acute shortage of natural resources. That shortage has far-reaching implications for the country's domestic and foreign policy. Jordan aspires to be an influential regional actor, but it is severely dependent on oil and gas imports. Meanwhile, the country's economy has been growing at an average annual rate of 5% between 1993 and 2014, putting an ever greater strain on its energy balance.

Jordan also happens to be the world's fourth most arid country. A reliable and sustainable energy source could do much to improve the country's water supply.

As part of its efforts to solve the energy problem, Jordan has conducted a risks and benefits analysis for traditional, renewable, and alternative energy. It has studied such options as solar, wind, and geothermal energy, as well as shale oil production. In 2009 senior Jordanian officials concluded that the most realistic option for ending the energy crisis is nuclear energy.

One of the reasons for such a choice was the country's painful experience of dependence on oil and gas imports from other Middle Eastern states. When Saddam Hussein was in power in Iraq, Jordan served as the gateway for Iraqi oil exports. As a result, the country was able to

Amman, Jordan

buy Iraqi crude at a heavy discount. After the fall of Saddam, Jordan switched to natural gas imports from Egypt, only to face major problems with the reliability of supply due to regular bombing attacks on the Egyptian export pipeline during the Arab Spring. The share of Egyptian gas in Jordanian electricity generation collapsed from 90% to 16%, and then to zero as supplies were halted completely. Jordan was forced to start buying oil on the open market without any discounts, mainly from Kuwait. This led to a rapid rise in electricity tariffs; the Jordanian budget deficit also rose sharply because the government subsidizes electricity for 60% of the country's population. After the government announced a reduction in oil and gas subsidies in September 2012, mass protests broke out in the capital Amman and other cities. Two days later the government was forced to reverse the decision. It was getting increasingly difficult to preserve fragile political and social stability amid rising unemployment and a growing influx of refugees from armed conflict zones in the Middle East.

One of the reasons why Jordan has chosen the nuclear energy option is that there are uranium deposits on the country's territory

The Jordanian government has already approved the decision to build the country's first nuclear power plant. In October 2013 it chose the Al Amra site 70 km east of Amman. Russia's nuclear industry has been awarded the contract to build the NPP.[63] The plant will consist of two 1,000 MW reactors; the first of the two is to be launched in 2023, and the second in 2025. Under the government's ambitious plans, construction works at the Al Amra site are to begin as early as 2017.[64]

Previously, the Korean Institute of Nuclear Energy Research and Daewoo corporation started to build a research reactor at the Jordan University of Science and Technology facility in Ar Ramtha in the northwest of the country.[65] The launch of that reactor is scheduled for 2016. In 2013 Areva signed a contract to supply nuclear fuel for the Ar Ramtha facility.[66]

One of the reasons why Jordan has chosen the nuclear energy option is that there are uranium deposits on the country's territory. According to the Jordanian Atomic Energy Commission, these reserves are commercially viable. Geological exploration results suggest that Jordan can produce up to 35,000 tonnes of uranium concentrate from fields discovered in the central part of the country, which would be enough for the entire lifetime of two 1,000 MW reactors.[67] Jordan also takes part in the already mentioned SESAME project, a UNESCO-sponsored regional research center with a synchrotron facility at its heart. The synchrotron itself is scheduled for launch in 2016.

First steps

Jordan has already taken several practical steps as part of its nuclear energy program. In accordance with the 2001 Law on Nuclear Energy and Radiation Safety, which was amended in 2007, the country has set up the Jordan Atomic Energy Commission (JAEC) and the Jordan Nuclear Regulatory Commission (JNRC).

The amendments approved in 2007 have transferred the regulatory remit from JAEC to JNRC. Under Law No 43/2007 on Radiation Protection, Nuclear Safety and Security, JNRC's regulatory and supervision remit

includes nuclear energy, environmental protection, and compliance with nuclear safety and security requirements.[68]

Work has begun to explore the country's natural uranium reserves, which are seen as an important element of reducing dependence on oil and gas imports and turning Jordan into a net electricity exporter after 2025 (the country has grid interconnections with Egypt, Iraq, and Syria).[69]

Tender for the NPP contract

In 2011 the Jordanian government received applications for a tender to build a 750–1,100 MW reactor from three companies:

- Atomstroyexport (Russia);
- SNC-Lavalin International Inc. (Canada);
- A consortium of Areva (France) and Mitsubishi Heavy Industries, Ltd. (Japan).[70]

South Korea also showed great interest in the Jordanian NPP project, and was in contact with Jordanian officials in various bilateral formats. KEPCO was regarded in Jordan as a serious contender — but then the Korean company won a UAE contract to build four reactors at the Barakah NPP, and lost interest in the Jordanian venture. In the end, it did not even take part in the tender.

One of the reasons why Jordan has chosen Russia as the NPP technology supplier is the integrated nature of the Rosatom offer, which includes the removal of spent nuclear fuel, and Russia's openness to the idea of co-financing the project

Jordan has signed various bilateral agreements and memorandums of understanding on peaceful nuclear energy cooperation with several countries, including Argentina, Britain, Canada, China, France, Italy, Japan, Romania, Spain, and Turkey.[71] It was also in talks with the United States about the signing of a so-called 123 Agreement. Washington insisted, however, that Jordan relinquish its right to enrich uranium in return for U.S. nuclear assistance.[72] In 2009 the two countries signed a memorandum of understanding on nuclear energy cooperation, but as of January 1, 2016, Jordan has not accepted the proposed language for the 123 Agreement.

By April 2013 only two contenders, Atomstroyexport and the Areva-Mitsubishi consortium, were still in the running. The government announced the winner in October 2013,[73] designating Atomstroyexport as the strategic partner of the country's first NPP. According to Jordanian specialists, the Russian company won because it had submitted a comprehensive proposal that included fresh fuel supply and spent fuel removal for the entire life of the NPP, and possible co-financing of the project.[74]

Because the tender process took longer than planned, the original 2020 deadline for the launch of Jordan's first nuclear power reactor has been pushed back to 2023.

Obstacles faced by the Jordanian nuclear energy program

Like many other countries, Jordan is facing major economic problems as a result of instability in the Middle East and the global economic crisis. In 2011 the amount of foreign direct investment into the Jordanian economy fell by 60%.[75] Financial considerations were therefore a major factor in the choice of the general contractor for the NPP project.

Meanwhile, there is a growing debate in Jordan about the pros and cons of nuclear technologies. In May 2012 the Jordanian parliament's select committee for energy and natural resources recommended that the nuclear energy program be abandoned. It argued that the program would "drive

Meeting between Russian President Vladimir Putin and King Abdullah II of Jordan, *Novo-Ogaryovo, Russia, Moscow, April 9, 2014*

the country into a dark tunnel and have irreversible environmental consequences". Later on, the lower chamber of parliament backed the committee's recommendation and urged the government to put the NPP and uranium mining projects on hold pending the outcome of economic feasibility and environmental studies.[76] Shortly afterwards King Abdullah II of Jordan dissolved the assembly.

For Jordan the NPP is seen as an important element of reducing dependence of oil and gas imports and even turning the country into a net electriciy exporter

In his response to the parliamentary resolution, JAEC chairman Khaled Toukan said that it would not have any consequences for the Jordanian nuclear energy program. He criticized the resolution, arguing that it was "premature" to call for a halt of the NPP project because JAEC was still choosing the technology supplier and the site of the future NPP at the time.[77] Dr. Toukan recognized, however, that the decision on whether to build a uranium mine would be largely informed by the findings of the ongoing economic feasibility study.

Choosing the most suitable site for the future NPP is another complex challenge facing the Jordanian government. Initially the government chose a site near the town of Aqaba, on the Red Sea coast. According to some reports, however, that decision has been reconsidered under Israeli pressure.

Meanwhile, public discontent over the government's nuclear energy plans reached a breaking point in July 2012, when locals in Ar Ramtha attacked the site chosen for the research reactor, smashing doors and windows, and burning technical documents. Local residents were vehemently opposed to having a reactor built close to their homes. Several scientists and environmentalists launched a campaign against building any nuclear facilities in the country, and urged the South Korean contractor to pull out of the research reactor project.[78] Greenpeace plays a prominent role in the public debate over Jordan's nuclear energy plans. According to some media reports, the environmental movement's activists have already collected numerous signatures under an anti-nuclear petition submitted to the prime minister.[79]

Jordan's largest opposition political party, the Islamic Action Front (IAF), was also initially opposed to JAEC plans for building nuclear power plants. In April 2012 it said that the goals of the program and the sources of its financing, as explained by the Commission, were vague and misleading.[80] After a meeting between IAF and JAEC representatives in February 2013, the Islamic Action Front said it would review its position on the national nuclear energy program.

The IAF secretary-general, Hamza Mansour, said that the party was in favor of projects aimed at strengthening the national energy sector, and recognized the need to study the proposed nuclear energy program in greater detail. Later on the IAF released a statement outlining 12 conditions JAEC must meet to ensure the effectiveness of the nuclear program. They included environmental protection measures, safe and secure nuclear waste management, a responsible approach to managing the country's water resources, and transparency in the choice of the technology supplier.

Excavation works in a desert in southern Jordan

After Fukushima and the Arab Spring

The Fukushima accident in Japan highlighted the vulnerability of nuclear power plants to natural disasters, thereby strengthening the argument of the opponents of Jordan's nuclear energy program.

Jordanian officials continue to insist, however, that the program is indispensable. Deputy chairman of JAEC Abdul Haleem Wreikat has said that despite the potential risks posed by natural disasters, the government had "no intention of reversing its decision to build NPPs because of the Fukushima accident". He argued that the pressurized water reactor to be built in Jordan represented third-generation technology, which is much safer than the old boiling water reactors at the Fukushima Daiichi NPP. He went on to say that building nuclear power plants "is currently a more preferable option for Jordan than renewable energy, including solar and wind, because renewables still remain a more expensive option." Nevertheless, in response to the Fukushima accident the Jordanian government drew up a new set of safety requirements for the future NPP and ordered additional geological and environmental assessments of the project.[81]

Jordanian officials take into account instability on the country's borders as one of the potential obstacles to the nuclear energy program

Jordanian officials also take into account instability on the country's borders as one of the potential obstacles to the nuclear energy program. As the conflict in Syria took a turn for the worse, Dr. Khaled Toukan said that the project to build the Jordanian nuclear power plant could be postponed, especially in view of the growing number of refugees fleeing to Jordan from Syria.[82]

Outlook

Jordan is one of the few countries in the Middle East to have opted for nuclear energy mainly because of the lack of its own oil, gas, or hydroelectric power resources, with the resulting need to bolster national energy security. Jordan's choice of the nuclear energy option therefore appears entirely reasonable and justified.

The main obstacles to practical implementation of the national nuclear energy program include high seismic activity in large parts of the country; lack of reliable geological data about the Al Amra site chosen for the future NPP; the complexity of attracting investment to finance the project; a shortage of trained specialists; mounting security problems on the country's borders (which could have dangerous repercussions for domestic political stability in Jordan itself); and lingering anti-nuclear sentiment among Jordanians following the Fukushima accident. On September 22, 2014, Rusatom Overseas, a Rosatom subsidiary, and the Jordan Atomic Energy Commission signed an agreement to pursue the Amra NPP project. Under the terms of the document, which was signed on the sidelines of the IAEA General Conference in Vienna, the two sides have undertaken commitments with regard to the first phase of the project to build a nuclear power plant consisting of two 1,000 MW reactors. An actual contract is expected to follow at some point in the future. The Russian contractor will design a water cooling system for the NPP, conduct a technical and economic feasibility study, supervise the assessment of the proposed site, and assess the environmental impact of the project with the next 24–30 months. Russian companies may also participate in the Amra NPP project as coinvestors.[83]

On March 24, 2015 Rosatom Director-General Sergey Kiriyenko and JAEC Chairman Khaled Toukan signed an intergovernmental agreement on cooperation in building and operating Jordan's first nuclear power plant.

First unit of the Bushehr NPP, *Iran*

2.3. IRAN

Iran has long shown steady interest in nuclear energy. Practical efforts in that area began in the late 1950s. Over the past almost 60 years the country's nuclear program has been moving forward in fits and starts. Depending on the state of the Iranian economy, domestic policy, and foreign relations, there have been periods of rapid progress (in the late 1970s and in the 1990s) and stagnation (for example, during the Iran-Iraq war in 1980–1988). In addition to pursuing peaceful nuclear energy, Iran is also known to have done nuclear-related research that can have military applications. These efforts, however, are beyond the scope of this paper.[84]

The key period in the development of nuclear technologies in Iran was the 1970s. That is when the country laid the foundations of nuclear expertise and technological capability that are still very relevant to this day, and which largely underpin Iran's leadership in terms of nuclear energy development in the Middle East.

The Iranian government largely continues to stick to the peaceful nuclear energy development targets unveiled as part of the Shah's program

In the early 1970s Iran adopted a program of energy sector diversification that focused on nuclear energy development. In March 1974 the Iranian Shah Mohammad Reza Pahlavi, unveiled a plan of building 23 nuclear power reactors with a total capacity of approximately 20 GW. The first two of these reactors were to be launched in 1980 and 1981 in the southwest of the country, at a site on the Persian Gulf coast 18 km from Bushehr. The entire program was expected to take 20 years (i.e. until 1994) to complete. It was supposed to bring the share of nuclear energy in the country's energy balance to 25%. The Iranian government largely continues to stick to the peaceful nuclear energy development targets unveiled as part of the Shah's program.

In 1974 the government in Tehran set up the Atomic Energy Organization of Iran (AEOI). That same year it started to build the Nuclear Research Center in Isfahan to train Iranian scientists and engineers and develop nuclear fuel cycle technologies; the project involved French specialists. Previously, in 1967, the United States supplied a 5 MW light-water research

reactor to the Tehran Nuclear Research Center. The reactor was supplied with IAEA assistance as part of the U.S. - led Atoms for Peace program.

In the late 1970s hundreds of Iranian students and young specialists received nuclear physics training in the United States and Western European countries, including Belgium, Britain, France, Italy, Switzerland, and West Germany. The Massachusetts Institute of Technology (MIT), one of America's leading technology schools, launched a special program of training Iranian nuclear energy specialists. In December 1977 the AEOI and the U.S. Department of Energy signed an agreement to train Iranian specialists at the Oak Ridge National Laboratory.

Meanwhile, Iran was also developing its own capability to train specialists for the nuclear energy sector and other high-tech industries. That capability, which was created with the assistance of leading Western schools such as the MIT, is still being used to train highly qualified indigenous specialists. Despite the numerous sanctions imposed on Iran and the absence of diplomatic relations between Tehran and Washington, up until recently Iranian students had sufficient training to enroll on technology courses at the leading U.S. schools, including Harvard, Stanford, the Caltech, the MIT, etc. In 2003 alone, 15 Iranian citizens began postgraduate training at Stanford's Electrical Engineering Department. Most of them were graduates of the Sharif University of Tech-

Mohammad Ahmadian, Director-General of the Nuclear Power Production and Development Company of Iran (NPPD) and Deputy Head of the Atomic Energy Organization of Iran (AEOI), and Aleksandr Glukhov, President of Atomstroyexport, at the Bushehr NPP launch ceremony,
Bushehr, Iran, September 12, 2011

nology, which rolled out nuclear physics training programs in cooperation with the MIT back in the 1970s.[85] The current head of the AEOI is Ali Akbar Salehi, who received PhD in nuclear engineering from the MIT in 1977.

The first nuclear power reactor in the Middle East

The Iranian nuclear energy program was frozen after the 1979 Islamic Revolution. The new Iranian leadership did not show any interest in nuclear energy up until the mid-1980s.

Another round of nuclear talks between Tehran and international mediators, *Baghdad, Iraq, May 23, 2012*

By the time German specialists suspended the project to build the Bushehr NPP in July 1979, the first reactor of that plant had reached 80–85% completion, and the second 50–70%. During the Iran-Iraq war in 1980–1988, the unfinished Bushehr nuclear power plant sustained major damage during several air raids.[86]

In the early 1990s Russian specialists started to work on a project to complete the first reactor of the Bushehr NPP. On August 25, 1992 the Russian and Iranian governments signed an agreement on cooperation in the construction of a nuclear power plant in the territory of Iran. On January 8, 1995, authorized Iranian and Russian organizations signed a contract on the completion of the first reactor of the Bushehr NPP using the VVER-1000 reactor design. In August 1995 Russia and Iran signed a contract under which a Russian company undertook to supply nuclear fuel for the Bushehr NPP for the first 10 years of its operation. At Iran's request, Russian engineers integrated the technologies and equipment supplied in the 1970s by Germany's Siemens into the Russian reactor design after a careful inspection and testing.

Iran was the first country that launched nuclear power reactor in the Middle East

The Russian specialists who worked on the project to complete the first reactor of the Bushehr NPP faced a whole range of technological, technical, political, and financial difficulties. They were compounded by the fact that the contract to finish the Bushehr NPP was Russia's first contract of its kind since the break-up of the Soviet Union and the Comecon trading bloc. Iran had no previous experience in such projects, either. On top of that, the Russian general contractor yielded to the customer's pressure and agreed to overly optimistic project deadlines.

The No 1 reactor of the Bushehr NPP was connected to the Iranian national grid on September 3, 2011. It was the first nuclear power reactor to be launched in the Middle East. Iran was also the first country in the world in 15 years, and only the fourth since the Chernobyl disaster to have launched its first nuclear power reactor. The Bushehr plant reached its maximum output in 2012, bringing the share of nuclear energy in Iran's energy balance to its peak of 2.5%. On September 23, 2013 the Iranian customer signed a preliminary acceptance certificate for the Bushehr NPP; this commenced the two-year warranty period. The No 1 reactor therefore went fully operational 37 years after German specialists began to work at the Bushehr NPP site.

Ceremony to commence activities for reaching the first criticality of Iran's first nuclear power plant in Bushehr,
Iran, August 21, 2010

Prospects for increasing Iran's nuclear energy output

AEOI representatives say that work is under way to choose sites for new Iranian nuclear power plants. The potential candidates include sites on the coast of the Caspian Sea, the Persian Gulf, and the Gulf of Oman; in the Khuzestan Province; and "in the northwest of the country". According to the information at our disposal, the preliminary list of potentially suitable NPP sites includes 16 candidates, including the Bushehr and Darkhovin sites.

The contract to finish the Bushehr NPP was Russia's first contract of its kind since the break-up of the Soviet Union and the Comecon trading bloc

The first large-scale program to identify suitable NPP sites in Iran began in the mid-1970s. These efforts involved leading Western companies. In the end, however, only two sites had been identified by 1979. One was near the town of Bushehr, where the Bushehr NPP has since been built. The other is near the town of Ahvaz, where Iran plans to build the Darkhovin NPP using medium-sized power reactors of its own design, according to the AEOI. There is also a potential site near Isfahan, where Iran wanted to build two German-designed air-cooled reactors since the site lacks access to a large body of water. Because of the technological complexity, however, the reference unit of such a reactor has yet to be built anywhere in the world. In view of the modern safety requirements, the project is unlikely to be implemented ever.

In the 1970 Iran also considered candidate sites near Arak (Shazand Country), Urmia (West Azerbaijan Province), and Saveh (Markazi Province).[87] The future NPP in Saveh was to be built by German companies in the event of a successful completion of the air-cooled NPP project in Isfahan (Saveh

also lacks access to large bodies of water). No decisions were taken on any of these sites before the Islamic Revolution. In the late 1970s the leadership of the Iranian nuclear industry concluded that the initial plans under which the government wanted to build 23 nuclear power reactors with a total capacity of 20 GW were overly ambitious. They reckoned that Iran had enough sites to build only up to 12 GW of nuclear generation capacity.[88]

The main natural limiting factors for nuclear energy development in Iran include, a) high seismic activity in large parts of the country, such as the Caspian coast; b) lack of large bodies of water that are needed to cool the reactors (with such exceptions as the Persian Gulf, the Caspian Sea, and the Karun river); and c) insufficient transport infrastructure and difficult terrain, which makes it difficult to bring heavy equipment to the proposed NPP sites.

In actual fact, Iran is very unlikely to start building new nuclear power reactors at any sites other than Bushehr and Darkhovin before 2025

It appears that the main purpose of the latest attempts to identify new suitable sites for nuclear power plants is to provide justification for the Iranian government's declared plans to build 20 GW of nuclear generation capacity (that target remains unchanged since the times of the Shah). In actual fact, Iran is very unlikely to start building new nuclear power reactors at any sites other than Bushehr and Darkhovin before 2025.

The primary goals of the Iranian nuclear energy development program are currently as follows:

- Build two new power reactors of 1,000 MW each at the Bushehr site using the VVER-1000 reactor design.
- Build the Darkhovin NPP using indigenously designed 360 MW reactors. Develop an indigenous reactor design for that project and create an industrial capacity to build such reactors without any foreign assistance.

Bushehr NPP

Iranian specialists have now recognized that it was a mistake to integrate German equipment and components into the Russian reactor design at the Bushehr NPP. The decision was made at the time under pressure from the AEOI. The approach has led to delays, increased the cost of the project, and created technological challenges during its implementation.

Iran plans to build another two 1,000 MW reactors at the Bushehr NPP. The site can accommodate up to six reactors, including the one that has already been launched and the unfinished German-designed No 2 reactor (which will never be completed, in all likelihood). According to comments by the AEOI, Tehran is prepared to pay in cash for the new reactors,[89] whereas all the current NPP projects by Rosatom in foreign countries involve government — or government controlled bank-provided credit financing.

Russian companies are regarded as the most likely contractors to build the new Bushehr reactors. On November 11, 2014 the Russian and Iranian governments signed a Protocol to the August 25, 1992 bilateral agreement on cooperation in the construction of a nuclear power plant in Iranian territory. That completed the establishment of the legal

framework required to build the No 2 and 3 reactors at the Bushehr NPP (the document allows for the construction of up to eight new reactors). On the same day, the two sides signed a contract for the construction of two reactors at the Bushehr NPP.

Darkhovin NPP

The Darkhovin site, which sits on the bank of the Karun river near the town of Ahvaz, Khuzestan Province, was chosen back in the mid-1970s. French specialists began to work at the site in the late 1970s. They commenced excavation works and started to build the necessary auxiliary facilities, staff accommodation, infrastructure, and access roads. The plan was to build two 900 MW reactors in Darkhovin. French specialists left the site shortly before the 1979 Islamic Revolution.

The main natural limiting factors for nuclear energy development in Iran include, high seismic activity, lack of large bodies of water and insufficient transport infrastructure

In the 1990s Iran hoped to build a 300 MW power reactor at the Darkhovin site with Chinese help (according to some sources China is building similar reactors at the Chashma NPP in Pakistan). In 1997, however, Beijing refused to continue peaceful nuclear energy cooperation with Iran as part of China's package agreement with the United States. By the time that cooperation broke off, China had already delivered some of the NPP engineering documents to the AEOI.

Iranian politicians and officials now talk about plans to build an NPP without any foreign assistance using an indigenously designed 360 MW reactor. We believe that as part of the project to build the No 1 and 2 Darkhovin reactors, the AEOI has been tasked with designing a nuclear power reactor using the materials received from China in the 1990s and to acquire all the expertise that is required to build all the subsequent 360 MW reactors independently. In other words, Iran has plans to develop an indigenous nuclear power reactor. According to the information at our disposal, Iranian engineers started to work on that project in 2008.

At this time Iranian specialists are unlikely to have the technological expertise and the industrial capability to complete more than 50% of the work required to design and build an NPP. A successful implementation of the project will therefore require international cooperation and participation of foreign partners. Whether or not Iran can build the Darkhovin NPP will largely depend on its ability to produce large reactor components (pressure vessels, steam generators, etc.) and nuclear fuel, or to acquire them from foreign suppliers. The launch of the research reactor in Arak will be of great help to Iranian specialists in developing and producing nuclear fuel. That reactor is capable of generating a powerful neutron flux, so it can be used for experiments and testing of indigenously produced nuclear fuel. The research reactor at the Tehran Nuclear Research Center is not powerful enough for that purpose.

The Convention on Nuclear Safety

Iran is currently the only country in the world that operates a nuclear power plant but has not signed the Convention on Nuclear Safety (CNS). In recent years Iranian experts have argued that Iran could join the Convention in the event of a comprehensive settlement

of the crisis over the Iranian nuclear program, and that the main obstacles to joining are political. They have to do with Iran's experience of implementing its commitments under the IAEA Safeguards Agreement. In the Iranian leadership's opinion, Tehran faced a prejudiced attitude from its partners, which eventually led to a deep crisis over the Iranian nuclear program. One of the former AEOI leaders says that Iran's stance until recently on the CNS can best be described by an old proverb: "One who's been bitten by a snake is afraid of a black-and-white rope."[90]

Adoption on July 14, 2015 of the Joint Comprehensive Plan of Action (JCPOA) to resolve Iranian nuclear crisis, is expected to facilitate the construction of the second stage of the Bushehr NPP

At the same time, the operator of the Bushehr NPP, the Nuclear Power Production & Development Company of Iran (NPPD), is an actively cooperating member of the World Association of Nuclear Operators (WANO). On November 10–23, 2010 WANO held a pre-launch partner inspection at the Bushehr NPP. WANO also conducted technical support missions at Bushehr in December 2011, June, September, and October 2012, January 2013, and March 2013.

There have been some positive shifts in Tehran's position on joining the Convention on Nuclear Safety following the adoption of the JCPOA in Vienna by the P5+1 (Britain, China, France, Germany, Russia, and the United States) and Iran on July 14, 2015. In particular, in October 2015 the president of the AEOI, Ali Akbar Salehi, reiterated Iran's intention to join the Convention. This, however, had yet to happen as of January 1, 2016.

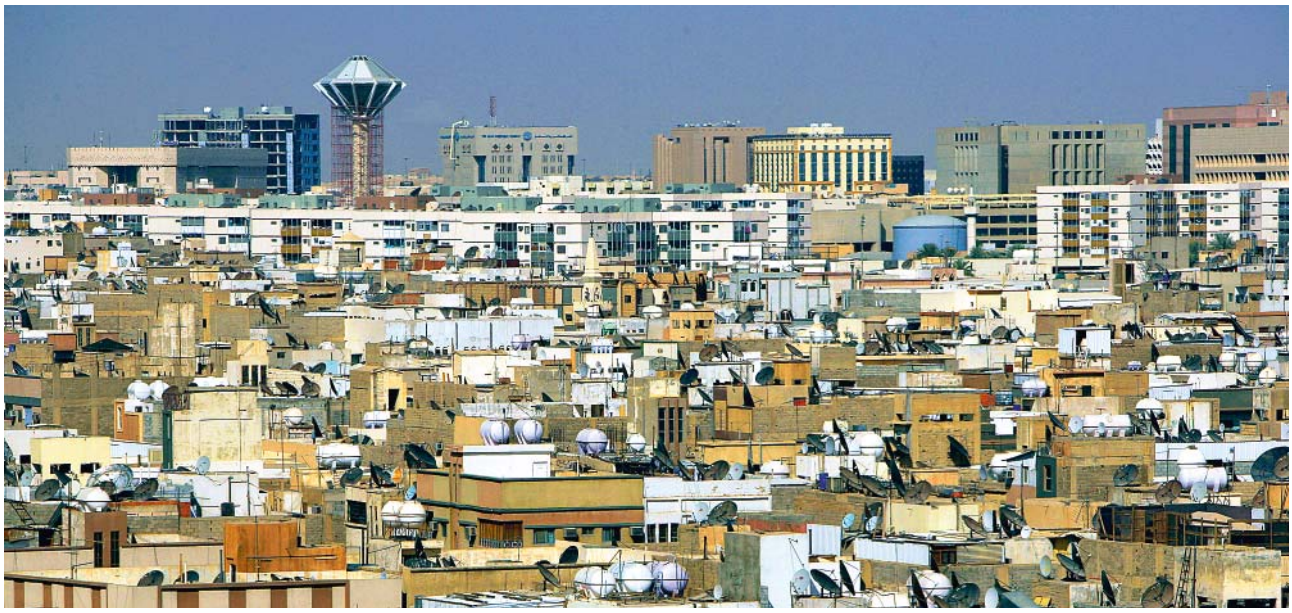
Outlook

Iran is the first, and so far the only country in the Middle East region to have connected a nuclear power plant to the national grid. Nevertheless, the country does not have the required natural and geographic conditions to build a large nuclear energy industry. The Iranian government's aspiration to build 20 GW of nuclear generation capacity appears unrealistic. Even if the crisis over the Iranian nuclear program is fully resolved and and JCPOA is fully implemented, over the next 15 years its nuclear energy industry will probably remain limited to only two NPP sites, Bushehr and Darkhovin. In other words, it can build a maximum of five to seven nuclear power reactors, including the already launched No 1 reactor at Bushehr.

As of January 1, 2016 there are no indications that the Arab Spring (called "the Islamic Awakening" in Iran) has had any effect on Tehran's nuclear energy plans. Nevertheless, in view of the history of devastating earthquakes in Iran, the Fukushima accident has fuelled concerns among the Iranian public about the safety of the country's nuclear facilities, especially the Bushehr NPP. This is very unlikely to force the Iranian government to review its plans for building more nuclear power reactors — but if the AEOI ignores ordinary Iranians' safety concerns, the negative impact of public opinion could yet become more pronounced.

2.4. SAUDI ARABIA

Over the past decade Saudi electricity demand has been growing at an annualized rate of up to 10%. In 2012 and 2013 the figure stood at 9% and 7%, respectively, and there are reasons to believe that such a growth rate will be sustained in the medium



Riyadh, Saudi Arabia

term.[91] Per capita electricity consumption in the Kingdom is nine times as high as in Algeria, Egypt, or Morocco.[92] The country's total demand for electricity is projected to grow from 46 GW in 2010 to 75 GW in 2018 and more than 120 GW in 2030.[93]

Abdulghani Melaibari, coordinator of scientific collaboration at King Abdullah City for Atomic and Renewable Energy (K.A.CARE), announced on June 1, 2011 that to meet its growing demand for electricity, Saudi Arabia intends to build 16 nuclear power reactors by 2030 at a cost of over 100bn dollars. In more recent statements by Saudi officials the deadline was pushed back to 2032, and the expected cost increased to 112 bn dollars.[94] When these plans were announced, the expectation was that the first two reactors would be launched in the early 2020s.

High oil prices over the past decade have provided an incentive for Saudi Arabia to pursue a nuclear energy program

Reasons to pursue nuclear energy

Saudi Arabia pursues a strategy of diversification of its energy sources.[95] The Kingdom believes that since the Saudi economy is almost entirely dependent on oil exports, burning oil to generate electricity for domestic consumption represents a huge opportunity cost, especially in view of high oil prices over the past decade. The Saudi press often voices concerns that growing domestic consumption of oil will affect the country's energy export revenues. The government's energy strategy therefore aims to release additional amounts of oil for exports by developing non-hydrocarbon energy sources. In other words, high oil prices until 2014 have provided an incentive for Saudi Arabia to pursue a nuclear energy program. Apart from nuclear, the Saudi energy diversification strategy also relies on solar and wind power.

The King Abdullah City for Atomic and Renewable Energy (K.A.CARE) was set up in

2010 as part of the national energy strategy. Its goals include facilitating the development of nuclear and renewable energy to meet the growing Saudi population's demand for fresh water and electricity, and to preserve the country's oil wealth for the benefit of future generations. Another objective is to ensure reliable supply of electricity to Saudi homes and businesses.[96] Additionally, according to the K.A.CARE bylaw, Saudi Arabia aims to become a regional exporter of electricity in order to diversify the sources of its export revenues. The King Abdullah City's remit includes nuclear supervision and representing Saudi Arabia at the IAEA.

Partnership with the leading nuclear exporters

Saudi Arabia does not have its own nuclear technology expertise. Implementing its nuclear energy plans will therefore require imports of technology and knowhow from the leading nuclear suppliers who offer services in designing, building, and operating nuclear power plants, as well as training the required specialists.

Since Saudi Arabia lacks any indigenous nuclear expertise, its government plans to rely solely on the international market for all its nuclear needs, including nuclear fuel supplies and personnel

In order to facilitate such imports, in 2008 Saudi Arabia signed a memorandum on peaceful nuclear energy cooperation with the United States. Under U.S. law, American nuclear technology, materials, and equipment are allowed only to those countries that have signed a bilateral agreement on peaceful nuclear energy cooperation with the U.S. government (the so-called 123 Agreement, as defined by Article 123 of the 1954 Atomic Energy Act).

A typical 123 Agreement with non-nuclear states (using the terminology of the Nuclear Non-Proliferation Treaty) is a subject to Congressional review. For example, securing Congressional approval was the main reason why the United Arab Emirates undertook a commitment not to pursue sensitive stages of the nuclear energy cycle, including uranium enrichment.[97] The text of the U.S.-UAE 123 Agreement does, however, contain a provision that the UAE has the right to launch negotiations with Washington on changing the terms of the agreement if Washington signs a similar document with another country on more liberal terms at some point in the future. This is why the United States is trying to turn the 123 Agreement with

Russian President Vladimir Putin and Crown Prince Salman bin Abdulaziz Al Saud, Deputy Prime Minister and Minister of Defense of Saudi Arabia, at a working meeting of heads of delegations of the G20,
Brisbane, Australia, November 15, 2014

the UAE into a template (a "gold standard", as they say in Washington) for talks with other countries, such as Saudi Arabia.[98] As of January 1, 2016, Saudi-U.S. negotiations on the 123 Agreement were still ongoing.

In 2013 Toshiba, Westinghouse, the Exelon Nuclear Partners (the largest NPP operator in the United States) signed a memorandum of understanding that includes the possibility of preparing a joint offer to the Saudi Arabian government on the construction and operation of NPPs. Since Saudi Arabia lacks any indigenous nuclear expertise, its government plans to rely solely on the international market for all its nuclear needs, including nuclear fuel supplies.[99]

The excessively onerous terms for supplying nuclear technology and knowhow on which the United States seems to insist may help nuclear exporters from other countries to win the Saudi market. Russia appears to be in a good position to secure Saudi contracts because it already has a wealth of experience in implementing such projects in other countries of the region, while Riyadh wants to diversify its suppliers, especially in view of the deteriorating relations with Washington. Moscow and Riyadh have lately stepped up their political contacts on the subject of providing support to Egypt and solving Syrian crisis. These contacts may prove conducive to closer bilateral cooperation on nuclear energy. A bilateral agreement on peaceful nuclear energy cooperation between Moscow and Riyadh was initialed in 2014 and signed on June 18, 2015.

Impact of Fukushima and the Arab Spring

After the nuclear accident at the Fukushima NPP, Saudi Arabia reiterated its commitment to energy diversification. The Fukushima accident led to a tightening of safety requirements for building and operating NPPs, as well as choosing NPP sites. During the initial screening, several potentially suitable sites were identified in the west of Saudi Arabia, on the Red Sea coast. The eastern coastline was completely ruled out because it hosts a large number of oil infrastructure facilities, and also because it lies too close to other Persian Gulf countries, who all want to minimize nuclear safety risks related to the future Saudi NPPs.

After the outbreak of the Arab Spring the Saudi government made efforts to reduce the risk of political turmoil in the country by launching expensive social programs and raising the wages of state servants. These measures could potentially reduce the amount of Saudi financial resources available for investment into nuclear energy projects. On the whole, however, the Arab Spring has not had any discernable impact on Saudi nuclear energy plans.

Outlook

Saudi Arabia has announced an ambitious project to build 16 nuclear power reactors at a cost of 112 bn dollars by 2032. These plans appear overly ambitious, and are unlikely to be implemented within the indicated deadline.

Saudi Arabia does not have the trained specialists, expertise, technology, or legal and regulatory framework required to pursue NPP projects on its own. The country will be completely reliant on the leading nuclear technology suppliers from other countries, and preparations for building the country's first nuclear power plant are bound to take a long time. The Saudi nuclear energy program makes use of the IAEA recommendations outlined in Document NG-G-3.1 "Milestones in the Development of a National Infrastructure for Nuclear Power."[100]

We believe that even under the best-case scenario Saudi Arabia is unlikely to launch its first nuclear power reactor before 2025.

2.5. UNITED ARAB EMIRATES

The UAE had 10.49 GW of electricity generation capacity in 2013; a minimum of 9.7 GW was needed to supply domestic demand. Natural gas accounted for 97% of the country's electricity generation, and oil for another 3%.[101] In the summer months, up to 50% of the natural gas produced in the UAE is used by gas-fired power plants. Renewables make up only a small fraction of the country's energy balance. In 2010 the UAE had about 2 MW of renewable capacity, which translated into 0.02% of its total electricity generation capacity.

The country's electricity demand is projected to grow at an annualized rate of 9% over the next few years. It is expected that 40 GW of generation capacity will be required to meet domestic demand by 2020.[102] *See Fig. 5 'UAE electricity generation and consumption in 1980–2010' for more details.*[103]

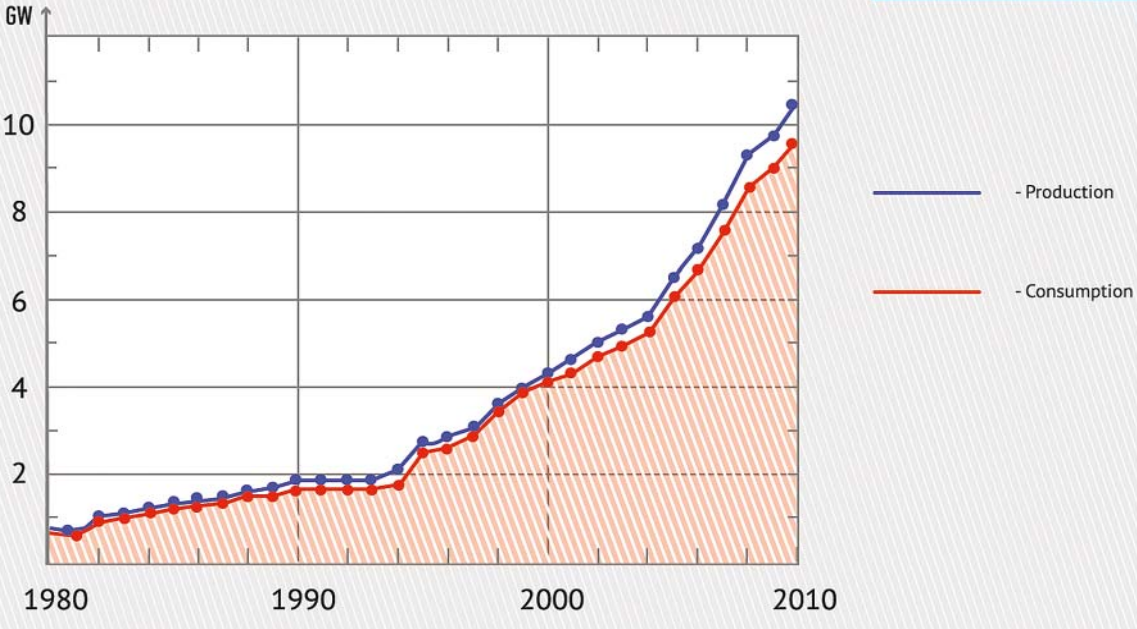
The UAE government has therefore decided to add the generation capacity by building nuclear power plants. The UAE has become the first country in 27 years to have started building its first nuclear power reactor.[104] The government's nuclear energy strategy enjoys a broad public support. According to some surveys, 82% of those polled said they were in favor if using nuclear energy to produce electricity.[105]

Legal framework, regulatory documents, and international agreements

In March 2008 the UAE government allocated 100 mln dollars for nuclear energy preparations. It developed a comprehensive policy on nuclear energy.[106] The document declares that the country will pursue nuclear energy for peaceful purposes and in the conditions of complete transparency, in cooperation with the IAEA, and in compliance with all nuclear material nonproliferation requirements. It will rely only on third-generation light-water reactor technology,

UAE ELECTRICITY GENERATION AND CONSUMPTION IN 1980-2010

FIGURE 5



and use nuclear fuel only from "reputable foreign suppliers".

In December 2009 the establishment of the Emirates Nuclear Energy Corporation (ENEC) was announced. The company is in charge of building and operating the country's future NPPs. In accordance with IAEA recommendations, the UAE has also set up the Federal Authority for Nuclear Regulation (FANR).

UAE has the most developed and detailed program of nuclear energy development in the Middle East, including the program's targets and the nuclear laws and regulations that underpin it

The UAE has signed peaceful nuclear energy cooperation agreements with Argentina, Australia, Britain, Canada, France, Japan, Russia, South Korea, and the United States.

Barakah NPP

Following an international tender for a contract to build and jointly operate the UAE's first nuclear power plant, in December 2009 the UAE signed a 20 bn dollar deal with a South Korean consortium led by Korea Electric Power Corp. (KEPCO). The NPP will consist of four reactors with a total capacity of 5.6 GW.

The decisive factor in the choice of the winner was the price. According to the information at our disposal, the price per KW of installed capacity was 2,300 dollars for the Korean offer, which was based on the APR-1,400 reactor technology. The corresponding figure for the French offer (based on EPR-1,600 reactors) was 2,900 dollars, and for the American offer (ABWR reactors) 3,600 dollars per KW. Several experts believe that the South Korean consortium intentionally underpriced its bid in an effort to secure the contract and enter the Middle Eastern market (in fact, the Barakah NPP is KEPCO's first foreign NPP project).

As of January 1, 2016, the four reactors of the Barakah NPP were already being

TIMETABLE FOR BARAKAH NPP CONSTRUCTION

FIGURE 6

Unit	Type	Capacity (MW)	Start of construction	Expected term for putting into operation
Barakah 1	APR-1400	1 400	July 2012	May 2017
Barakah 2	APR-1400	1 400	May 2013	2018
Barakah 3	APR-1400	1 400	September 2014	2019
Barakah 4	APR-1400	1 400	September 2015	2020

built *(see Fig. 6 'Timetable for Barakah NPP construction')*.[107]

The Barakah site was chosen in 2010. The first reactor is scheduled for launch in 2017, with the subsequent units to be launched at one-year intervals.[108] By 2020 nuclear energy is expected to account for up to a quarter of the UAE's electricity generation.[109]

The share of nuclear power in the UAE energy balance is expected to reach up to 25% by 2020

The Emirates Nuclear Energy Corporation (ENEC) has chosen seven foreign companies for the Barakah NPP fuel supply chain over the first 15 years of the plant's operation. Canada's Uranium One Inc. (a Rosatom subsidiary) and Britain's Rio Tinto will supply natural uranium, America's ConverDyn — uranium conversion services, the URENCO international consortium — uranium enrichment services, and Russia's Techsnabexport and France's AREVA — uranium concentrate and uranium conversion and enrichment services. Low-enriched uranium will be supplied to KEPCO Nuclear Fuels (KNF) facilities, where it will be turned into nuclear fuel. KNF is a member of a KEPCO-led consortium of general contractors. The overall value of the nuclear fuel contract (not counting the KNF part of the job) is estimated at 3 bn dollars.[110] In 2012 Techsnabexport and ENEC signed a 15 year contract for enriched uranium product for the Barakah NPP. That contract will cover more than 50% of the total Barakah project requirement.[111] In 2014 the first batch of low-enriched uranium that will be turned into nuclear fuel for the Barakah NPP was shipped to South Korea from the Russian port of Vostochny, Primorsky Region.

Impact of Fukushima

The nuclear accident at the Fukushima NPP has not had any tangible impact on the UAE's nuclear energy plans. After the accident the UAE government set up a special nuclear safety assessment commission consisting of ENEC and FANR specialists.[112] The commission confirmed the choice of the site of the future NPP and the project deadlines. The commission also used lessons learnt from Fukushima to make changes to the technical project of the NPP and safety procedures to be used during the plant's operation. One of the key changes was to improve the plant's resilience to a loss of power supply.[113]

Sheikh Zayed Grand Mosque,
Abu Dhabi, UAE

The Arab Spring has not had any significant impact on the UAE's nuclear energy program.

Outlook

The UAE has the most developed and detailed nuclear energy program in the Middle East, including the program's targets and the nuclear laws and regulations that underpin it. The country's first NPP is already under construction. The first of its four reactors is scheduled for launch in 2017, and the last in 2020.

According to the country's Integrated Energy Strategy,[114] the share of nuclear power in the UAE energy balance is expected to reach 12% by 2030.[115] The possibility of building another NPP is being considered in the longer term. The most likely option is to build the Barakah 2 NPP in direct proximity to the UAE's first nuclear power plant. Another possible site is in the desert in Fujairah Emirate, where the necessary engineering and geological surveys have already been done. The proposed site has access to a large body of water, and nuclear fuel and equipment can be brought conveniently by ship. No final decision has yet been made on building the second NPP. Taking into account the state of the UAE energy market, the project is unlikely to commence before the completion of the Barakah NPP.

The National flag of the Republic of Turkey

2.6. TURKEY

As of July 1, 2014, Turkey has just under 67 GW of installed generation capacity. In 2013, natural gas accounted for 44% of electricity generation in the country, coal 25.4%, hydroelectric energy 24.8%, wind 3.1%, oil 1.6%, and other sources 1.1%.

Turkey's growth of electricity demand is one of the fastest in the world, averaging 8% every year.[116] The country's demand for electricity is expected to reach 100 GW by 2023, which will require about 100 bn dollars of investment. Installed generation capacity will have to increase by 4–5 GW every year.[117]

Turkey's growth of electricity demand is one of the fastest in the world, averaging 8% every year

Turkey is currently reliant on gas imports, two thirds of which come from Russia and one third from Iran.[118] The country aims to reduce its dependence on imports of hydrocarbons. Another goal is to improve energy efficiency through various means, including

the use of modern energy-saving technologies.

Nuclear energy development plans

The main goals of Turkey's national energy strategy are set out in the Strategic Plan for 2010–2014 developed by the country's Ministry of Energy and Natural Resources.[119] According to that document, "By the year 2023, the 100th anniversary of the foundation of the Turkish Republic, nuclear power should account for 5% of national electricity production; additionally, Turkey will develop the coal industry and the hydroelectric industry, as well as build wind turbines. […] Turkey will aim to reduce its dependence on energy imports […] and diversify its energy sources, as well as maximize the use of domestically produced and renewable energy sources in electricity generation, to which end it will build nuclear power plants."[120] In other words, Turkey, which does not have sufficient reserves of hydrocarbons, regards nuclear energy development as an important requirement for economic growth and energy independence.

Further destabilization of the Middle East and the threat of hydrocarbons supply disruption are forcing the energy importing countries such as Turkey to look for ways of strengthening their energy security

Ankara has declared an ambitious goal of building eight nuclear power reactors with a total capacity 10 GW.[121] The government plans to launch the first two NPPs and start building a third by 2023.[122] Preparations have already begun for the construction of the 4.8 GW Akkuyu NPP, which will consist of four reactors. The first of these reactors is scheduled for launch by 2020. In the longer time frame, 20 reactors are to be built at five different sites.

Akkuyu NPP

After winning another victory in the 2007 election, the ruling Justice and Development Party (AKP) said that investment in the energy sector would be a key element of its economic strategy. In 2007 the Turkish parliament adopted Law No 5710 "On construction and operation of the nuclear power plant and the sales of generated electricity."[123] After several delays in selecting the general contractor, the Turkish government eventually chose Russia as the foreign partner for the Akkuyu NPP project. The tender for the contract to build the country's first NPP

Russian Energy Minister Aleksandr Novak and Turkish Energy and Natural Resources Minister Taner Yildiz at the signing of joint documents after a sitting of the High-Level Russian-Turkish Cooperation Council, *Ankara, Turkey, December 1, 2014*

near the town of Akkuyu was announced back in 1996. [124] In May 2010 the two governments signed an agreement on cooperation in building and operating an NPP at the Akkuyu site.[125] In July 2010 the agreement was ratified by the Turkish parliament, and in November by the Russian Federal Assembly. Shortly afterwards, a special company was registered in Turkey to implement the Akkuyu NPP project.

Under the terms of that agreement, Rosatom has been chosen to build and operate the Akkuyu NPP. Russia will supply fresh fuel for the plant, and remove spent fuel back to its own territory. It is planned that Rosatom will build four 1,200 MW reactors using the AES-2006 design, one of the latest Russian reactor designs. The first reference unit of that reactor has yet to be finished at the Novovoronezh NPP-2 until the end of 2016.

Ankara's position on Syria has also led to an upsurge in tensions with Iran and Russia, on whom Turkey is heavily dependent for oil and gas supplies

In November 2011 the Turkish company in charge of implementing the Akkuyu project filed applications for the licenses required to build and operate an NPP. The government also launched environmental vetting of the project. As part of the company's personnel training program, 600 Turkish students will be trained at Russia's MEPhI National Nuclear Research University. As of January 1, 2016, about 300 of them have already begun their training. IAEA senior officials visited the Akkuyu site in September 2012.[126] The launch of the first reactor is expected in 2020, with the remaining three reactors to follow in 2021-2023.

In 2013 the Turkish government said that the country's second NPP, situated on the Black Sea coast near the town of Sinop, will be built by a consortium of Japan's Mitsubishi Heavy Industries and Itochu and France's GDF Suez. Construction work at the site is to commence in 2017, and the first reactor is to be launched by 2023.

Public opinion

Even before the Fukushima nuclear accident, some Turkish scientists criticized the government's nuclear energy plans, including the Law No 5710 "On construction and operation of the nuclear power plant and the sales of generated electricity".[127] The criticisms mainly focused on the agreement signed with Russia rather than the nuclear energy development program as a whole. The critics complained that, first, the government had not informed the public about the details of the deal being signed. They also pointed at the lack of information as to whether the deal would involve technology transfer, which is seen as an important element of cooperation. Second, the critics said that the deal would only exacerbate Turkey's energy dependence on Russia.

According to a public opinion survey conducted by A&G Research Company shortly after the Fukushima accident in 34 Turkish provinces, 64% of the 2,469 respondents said they opposed nuclear energy development.[128] At about the same time, Turkey's Energy Minister Taner Yildiz said that postponing or cancelling the Akkuyu NPP project was not on the table, despite criticisms by the county's antinuclear movement.[129] To improve the nuclear program's perception among the public, the ruling AKP party launched an information campaign to explain

the advantages of nuclear energy. As part of that campaign, the Turkish Asian Center for Strategic Studies (TASAM), an influential Turkish research institute, released a report headlined "Turkey's Strategic Vision to 2023" in support of the prime minister's position. In September 2012 the center also hosted the International Congress on Nuclear Technology Transfer.[130] To improve public awareness of the benefits of nuclear energy, in December 2012 Rosatom opened an Information Center in Mersin Province.

The Arab Spring

The oil exporter countries affected by the Arab Spring remain in a state of political and economic turbulence. This is forcing the importer countries, including those in the Middle East (such as Turkey) to look for alternatives. One of these alternatives is nuclear energy.

It is expected that the Russian-backed Akkuyu NPP project will rely on an innovative build-own-operate (BOO) approach

Amid a wave of revolutions and mass protests in the Arab world, Turkey's relations with several of its neighbors have deteriorated very sharply. Ankara's position on Syria has also led to an upsurge in tensions with Iran and Russia, on whom Turkey is heavily dependent for oil and gas supplies.

At the same time, the Arab Spring has not had any notable effects on electricity prices in Turkey. The economic sanctions against Iran, that were in place until very recently, including unilateral US and EU measures, are a much more important cause of the complications in Turkey's supplies of hydrocarbons. This is yet another incentive for Turkey to develop nuclear energy and try to reduce its dependence on oil and gas imports.

The post-Fukushima syndrome

The Turkish leadership has been pursuing a deliberate information policy emphasizing that the plans of building nuclear power plants in the country remain unchanged. Speaking at the International Economic Forum in St. Petersburg in 2012, senior officials of the Turkish Ministry of Energy and Natural Resources reiterated their country's intention to build a nuclear energy industry. They insisted that "abandoning nuclear energy is not possible at this time. We need nuclear energy to ensure stable and uninterrupted electricity supplies. Our resolve on this issue is unshakeable."[131]

The Turkish company in charge of the Akkuyu NPP project has vowed to learn the lessons of the Fukushima accident, and to develop a plan of action and procedures for emergency situations based on IAEA recommendations and international experience.

As part of a cooperation program with the EU, representatives of Armenia, Belarus, Croatia, Russia, Switzerland, Turkey, and the EU held a meeting on June 23, 2011. During that meeting they agreed that the Turkish Atomic Energy Authority would sign a joint declaration on conducting stress tests as part of an EU nuclear safety program. The Turkish national report on the stress test program has already been drafted.[132]

Outlook

Up until now, the Fukushima accident has not had any major impact on the Turkish government's nuclear energy plans. That government is firmly convinced of the need to build nuclear power plants.[133] A lot of work has already been done to prepare for the construction of the Akkuyu NPP; it is expected that construction works will begin in 2016. The general contractor to build the second NPP has already been selected.

It is expected that the Akkuyu NPP project will use the innovative build-own-operate (BOO) approach, under which Russia will supply fresh nuclear fuel and remove spent fuel back to Russia for the entire life of the NPP.

The Arab Spring, which has been a source of political and economic instability in several Middle Eastern states, has strengthened the argument of Turkish nuclear energy proponents. Increasing the use of renewable energy sources and building nuclear generation capacity are the two central elements of Turkey's energy strategy.[134]

The factors that hamper the implementation of the project to build Turkey's first NPP include the apparent conflict between choosing Russia as the general contractor for the project and Turkey's overall drive to diversify its energy sources; the shortage of qualified Turkish specialists required to operate the future NPP.

The deepening crisis in Russian-Turkish relations may become a new factor that affects the outlook for Turkey's nuclear energy development program. The crisis was triggered when the Turkish Air Force shot down a Russian Su-24 bomber near the Syrian-Turkish border in November 2015. Two Russian servicemen were killed as result of the incident. On November 28, 2015 the Russian President signed a decree that imposed restrictions on economic cooperation with Turkish companies. As of January 1, 2016, these economic sanctions have not had any direct effect on the Akkuyu NPP project. We believe, however, that it would be very difficult to build Turkey's first nuclear power plant in accordance with the original plans and schedule if relations between Russia and Turkey fail to improve.

3. RUSSIA'S ROLE ON THE WORLD MARKET FOR NUCLEAR TECHNOLOGIES AND POTENTIAL FOR COOPERATION WITH MIDDLE EASTERN COUNTRIES

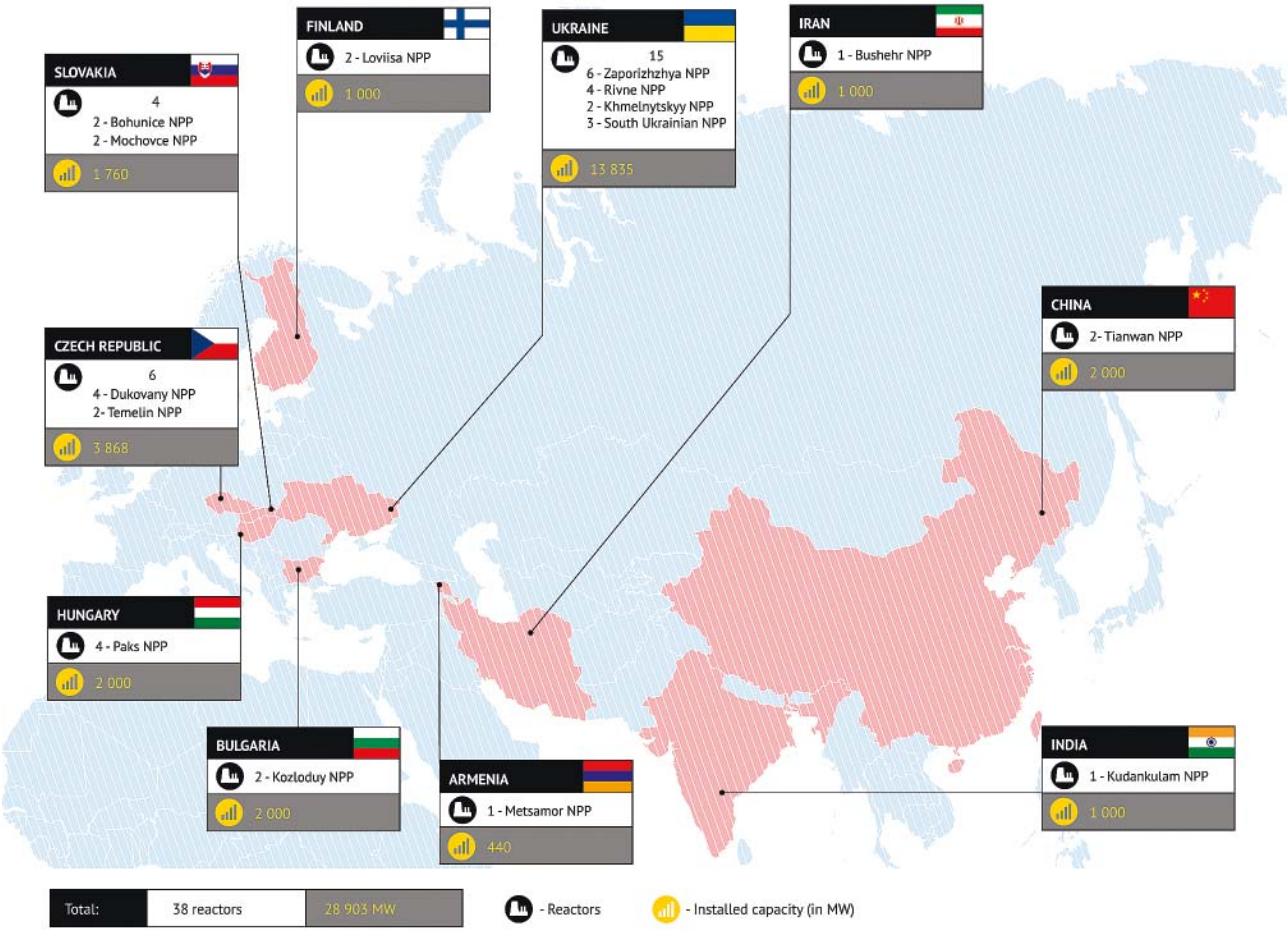
Russia is one of the world's leading nuclear exporters. It controls 40% of the global market for uranium enrichment, 17% of the market for nuclear fuel, and 25% of the market for nuclear power plants.[135] There are 38 reactors of Russian design currently in operation in 10 foreign countries.[136] For more details, *Fig. 7 'Nuclear power reactors of Russian design in operation abroad'.*

3.1. RUSSIAN PLANS FOR BUILDING NPPS ABROAD

Export contracts generate about a third of Rosatom's revenues. In 2011–2014 the Russian nuclear industry's aggregate revenues stood at more than 18 bn dollars. It fulfilled annually about 5 bn dollars worth of contracts in 2013 and 2014.[137] The target for 2015 revenues from foreign contracts

NUCLEAR POWER REACTORS OF RUSSIAN DESIGN IN OPERATION ABROAD

FIGURE 7



was 8.5 bn.[138] The Rosatom State Nuclear Energy Corporation currently holds a 100 bn dollar portfolio of long-term foreign contracts.[139]

At present, exports of uranium products (including uranium enrichment and conversion services, as well as deliveries of enriched uranium product) and nuclear fuel account for about 85% of export revenues. Contracts for building NPPs abroad account for another 14%.[140] In accordance with existing plans, the share of NPP contracts should rise to more than 40% of export revenues by 2022.[141]

As part of its strategic planning to the 2030 horizon, Rosatom aims to build up to 30 nuclear power reactors abroad

3.2. PLACE OF THE MIDDLE EAST IN THE RUSSIAN NUCLEAR INDUSTRY'S EXPORT PLANS

As part of its strategic planning to the 2030 horizon, Rosatom aims to build and launch up to 30 nuclear power reactors abroad. The company is working to increase its portfolio of foreign contracts for building NPPs. In December 2013 Rosatom signed a contract to build one reactor of the Hanhikivi NPP with Finland's Fennovoima. In 2014 Russia and Hungary signed an intergovernmental agreement for the construction of two reactors at the Paks NPP. The legal framework has been put in place and a contract has been signed to build another two reactors at the Bushehr NPP in Iran. In 2015, bilateral agreements were signed on building the Amra NPP in Jordan (two reactors) and the El Dabaa NPP in Egypt (up to four reactors).

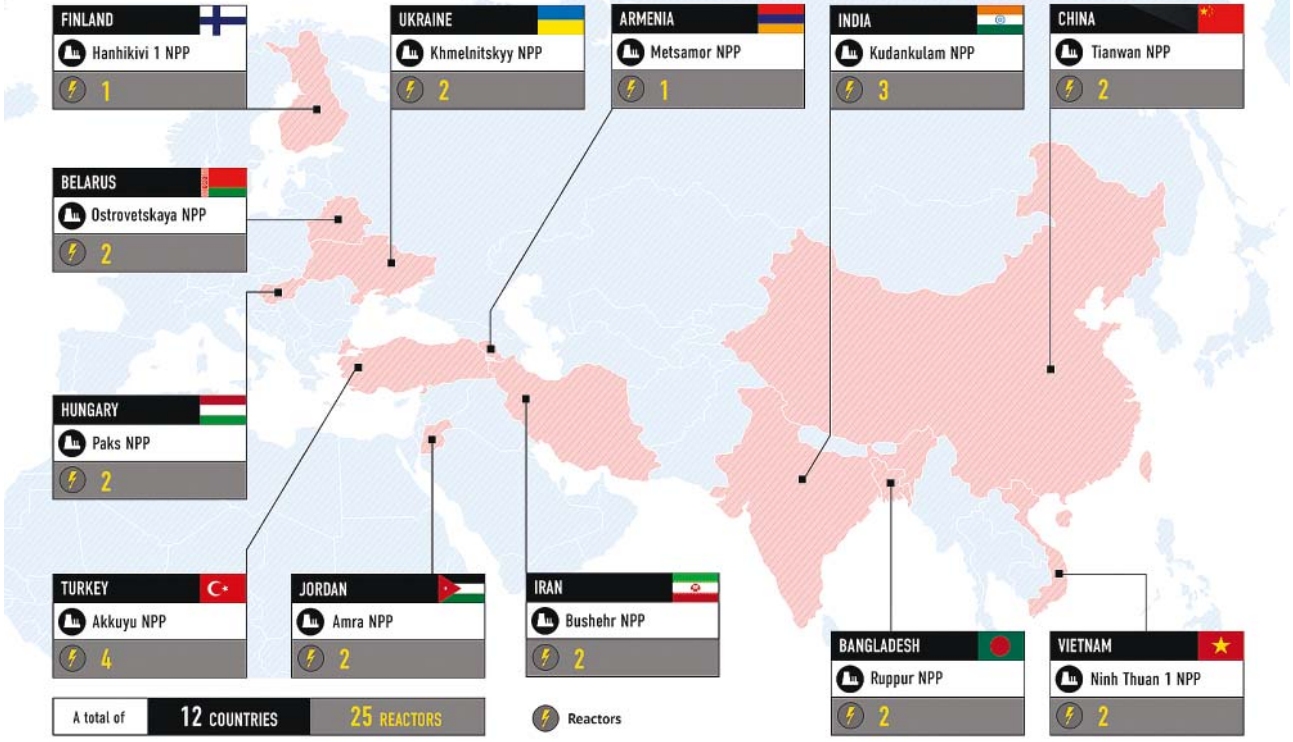
As of January 1, 2016, the Rosatom portfolio of contracts to build nuclear power plants consists of 25 nuclear power reactors. For more details, *see Fig. 8 'Rosatom projects for NPP construction abroad'.* About a third of the NPP contracts in the long-term Rosatom portfolio have been signed with customers from the Middle East *(see. Fig. 9. 'Current status of Rosatom NPP projects underway in foreign countries').*

Additionally, in 2015 Rosatom took part in negotiations or tender procedures for projects to build another 25 nuclear power reactors. The company was also involved in preliminary consultations on a further 34 reactors. The latter figure includes projects to build eight nuclear power reactors in the Middle East (two in Egypt, two in Saudi Arabia, and four in Turkey). To summarize, Russia is showing substantive interest in building 16 nuclear power reactors in the Middle East; in fact, Russian technology

Opening of the IAEA General Conference, *Vienna, Austria, September 22, 2014*

ROSATOM PROJECTS FOR NPP CONSTRUCTION ABROAD

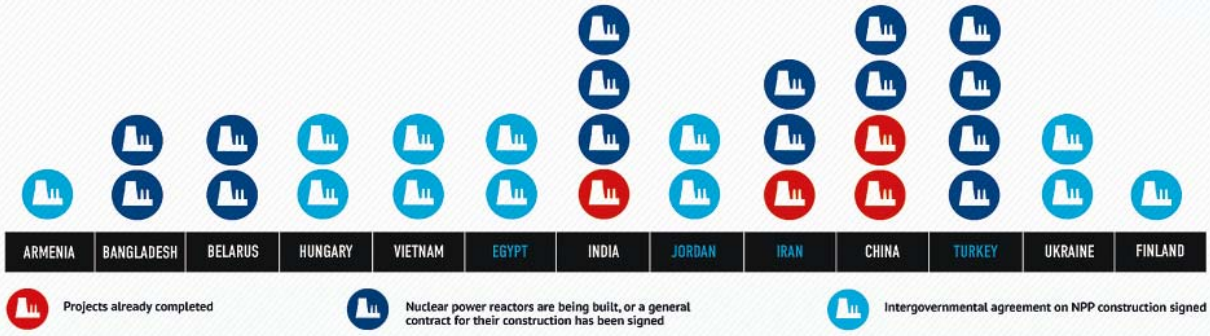
FIGURE 8



In September 2015 the Ukrainian parliament formally revoked the June 9, 2010 agreement with Russia on cooperation in building the No 3 and 4 reactors of the Khmelnytskyy NPP. Nevertheless, we believe that Rosatom and its subsidiaries have the best chances of winning the Ukrainian contracts for the completion of these reactors. The No 3 reactor is 75-per-cent complete, and the No 4 reactor is 25-per-cent complete. The estimated cost of completing these two reactors is 3.5 bn euros, whereas building two similar-sized reactors from scratch would cost more than 10 billion

CURRENT STATUS OF ROSATOM NPP PROJECTS UNDERWAY IN FOREIGN COUNTRIES

FIGURE 9



has already been chosen for eight of these future reactors. For more detailed information about the current state of Russian nuclear industry projects in the Middle East, *see Fig. 10 'Rosatom involvement in Middle Eastern NPP projects'.*

ROSATOM'S INVOLVEMENT IN MIDDLE EASTERN NPP PROJECTS

FIGURE 10

NPP	Reactors	Project
BUSHEHR NPP (IRAN)	1 REACTOR	Commercial operation
AKKUYU NPP (TURKEY)	4 REACTORS	Preparations for building an NPP
BUSHEHR-2 NPP (IRAN)	2 REACTORS	Preparations for project launch
AMRA NPP (JORDAN)	2 REACTORS	Agreement signed to implement the first phase of the project to build an NPP consisting of two reactors, to be followed by a contract to build the NPP
EL DABAA NPP (EGYPT)	2 REACTORS	A bilateral agreement has been signed to build and operate an NPP consisting of four reactors. Two reactors will be built during the first stage of the project
SAUDI ARABIA NPP-1	2 REACTORS	Preliminary consultations
TURKEY-3 NPP	4 REACTORS	Preliminary consultations

A total of 16 nuclear power reactor projects are at the various stages of negotiations or preparations. One reactor is already in operation.

3.3. LEGAL FRAMEWORK FOR PEACEFUL NUCLEAR ENERGY COOPERATION BETWEEN RUSSIA AND MIDDLE EASTERN COUNTRIES

According to the existing practice a three-tier legal framework to be put in place for projects to build NPPs in foreign countries. First, the two respective governments must sign a bilateral agreement on cooperation in peaceful use of nuclear energy. Second, the two governments must sign an agreement on building an NPP. And third, the two countries' authorized companies and organizations must sign an actual contract to build an NPP. *See Fig. 11 'Structure of the lefal framework for projects to build NPPs using Russian technology abroad'.*[142]

As of January 1, 2016, Russia had signed eight intergovernmental agreements on peaceful nuclear energy cooperation with the Middle East states (with Egypt, Iraq, Iran, Jordan, Saudi Arabia, Syria, Turkey, and the UAE). Israel has also shown interest in cooperation in nuclear medicine (the use of isotopes in medical treatment and diagnostics). Such cooperation, however, is unlikely because Israel remains outside the Nuclear Non-Proliferation Treaty, which translates into restrictions on cooperation imposed by Russia's own laws and its commitments in the Nuclear Suppliers Group framework.

Rosatom has signed memorandums of understanding on peaceful nuclear energy cooperation with authorized organizations of four Middle Eastern states (Bahrain, Qatar, Kuwait, and Oman). On July 1, 2011, the Russian Cabinet issued Resolution No 1136-r "On signing an agreement between the Government of the Russian Federation and the Government of Kuwait on peaceful nuclear energy cooperation." The resolution was adopted in accordance with a memorandum of understanding between Rosatom and Kuwait's National Committee for Nuclear Energy. The actual bilateral agreement, however, was never signed because the Kuwait government abandoned its nuclear energy plans following the Fukushima accident. The country's National Nuclear Energy Committee (KNNEC) has since been abolished, and its remit has been taken over by the Kuwait Institute of Scientific Research.[143]

Russia has also signed agreements on building nuclear power plants with Egypt, Iran, Jordan and Turkey. On November 11, 2014 the Russian and Iranian governments signed a protocol to their August 25, 1992 agreement on cooperation in building an NPP in Iranian territory. The protocol and the original agreement have created the legal framework for the construction of up to eight VVER-type nuclear power reactors in Iran, including four reactors at the Bushehr NPP and another four reactors at another site.[144] For more details about the legal framework of peaceful nuclear energy cooperation between Russia and Middle Eastern states. *See Fig. 12 'Legal framework for peaceful nuclear energy cooperation between Russia and Middle Eastern states'.*

Ali Akbar Salehi, Vice President of the Islamic Republic of Iran and President of the Atomic Energy Organization of Iran, and Sergey Kiriyenko, Rosatom Director-General, at a ceremony to sign a package of documents on broader peaceful nuclear energy cooperation between the two countries,
Moscow, Russia, November 11, 2014

3.4. OUTLOOK FOR RUSSIAN NUCLEAR EXPORTS TO THE MIDDLE EAST IN THE 2030 TIMEFRAME

Nuclear energy is rapidly gaining momentum in the Middle East, with several NPP projects in the pipeline. Several of the region's countries have sufficient financial resources to invest in large infrastructure projects. The Middle East is therefore a promising market for Russia's Rosatom corporation, which is currently the world's largest exporter of nuclear power reactors.

As of January 1, 2016, Russia had signed eight intergovernmental agreements on peaceful nuclear energy cooperation with the Middle East states

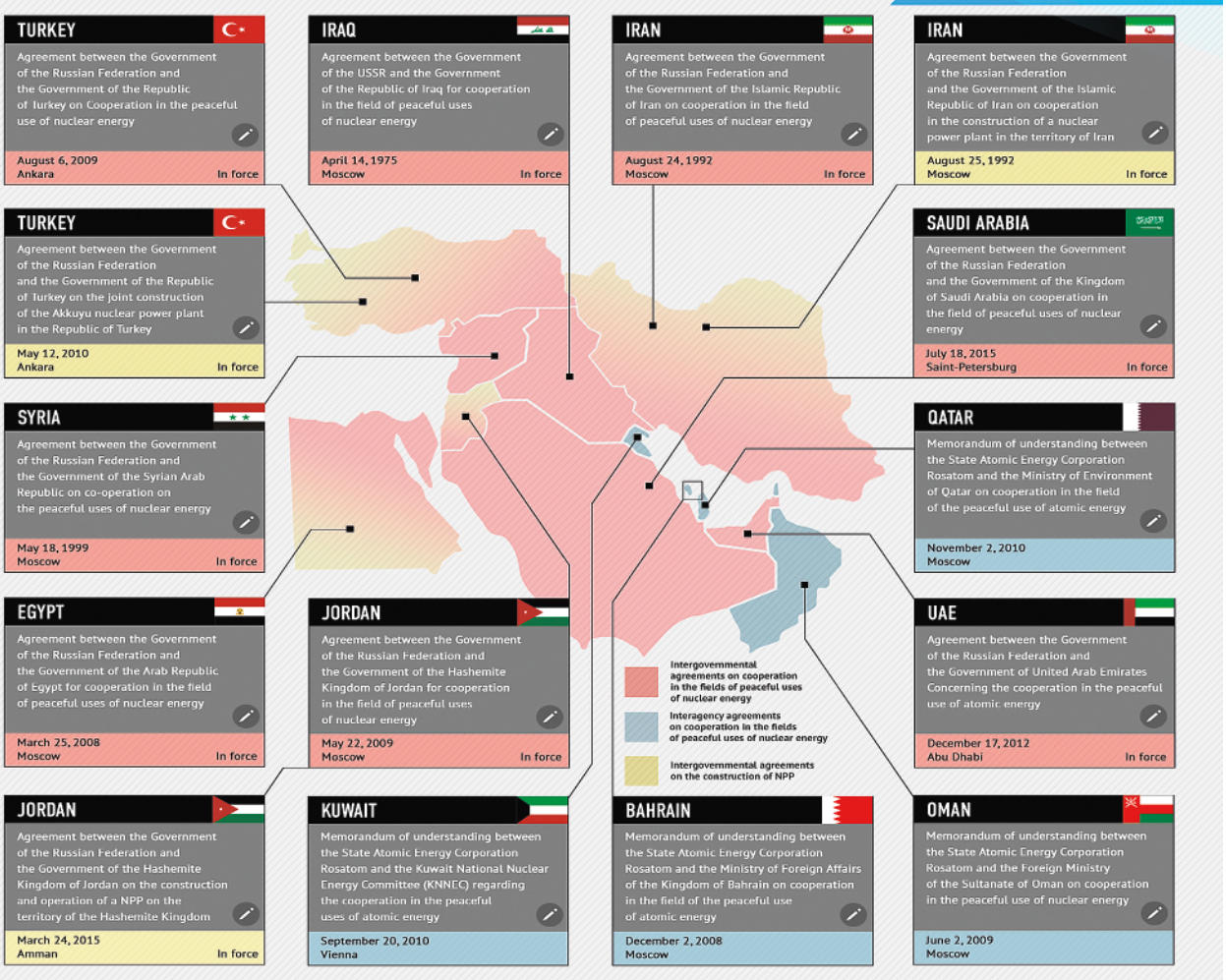
As already mentioned, the only operational nuclear power plant in the region, the Bushehr NPP in Iran, was built by Russian specialists. Rosatom is making preparations to start building the Akkuyu NPP in Turkey, which will consist of four reactors. Techsnabexport has signed a long-term contract for uranium conversion and enrichment services for the Barakah NPP in the United Arab Emirates. A contract has been signed to build the No 2 and 3 reactors of the Bushehr NPP. An intergovernmental agreement has been signed on cooperation in building and operating the Amra NPP in Jordan, which will consist of two reactors. The signing of the general contract to build the NPP is expected some time in 2016–2017.

STRUCTURE OF THE LEGAL FRAMEWORK FOR PROJECTS TO BUILD NPPS USING RUSSIAN TECHNOLOGY ABROAD

FIGURE 11

LEGAL FRAMEWORK FOR PEACEFUL NUCLEAR ENERGY COOPERATION BETWEEN RUSSIA AND MIDDLE EASTERN STATES

FIGURE 12



Note: The figure does not show the November 19, 2015 Russian-Egyptian bilateral agreement on cooperation in building and operating an NPP in Egypt; or the November 11, 2014 Protocol to the August 25, 1992 Russian-Iranian agreement on cooperation in building nuclear power plants in Iran.

Rosatom is also in preliminary consultations on building a further eight nuclear power reactors in the Middle East. It is very likely that the Russian nuclear industry will secure involvement in the El Dabaa NPP project in the Egypt, once the political, security and economic situation in the country improves. As for Saudi Arabia, Russia could supply some of the enriched uranium required for the production of nuclear fuel for future Saudi NPPs, i.e. become involved in the same way that it already has in the UAE.

Seven nuclear power reactors of Russian design have been launched in four different countries over the past eight years

Under the optimistic scenario for nuclear energy development in the Middle East in the 2030 time frame (i.e. 33 reactors to be built by 2030 at nine NPPs in six countries), Russia could become involved in four countries (Egypt, Iran, Jordan, and Turkey) by supplying the reactor technology, delivering fresh nuclear fuel, and removing spent fuel back to its own territory. It could also participate in the UAE and Saudi Arabian nuclear projects by supplying enriched uranium and nuclear fuel cycle services.

Under the pessimistic scenario (i.e. the implementation of only three NPP projects in the same time frame, with work on all three already under way) Russian contribution will include reactor technology, fresh fuel deliveries, and spent fuel removal services for the Bushehr and Akkuyu NPPs, plus enriched uranium deliveries for the Barakah NPP project. Success of the Akkuyu project depends on progress in Russian-Turkish relations at the political level.

Let us now look at Russian nuclear industry's strengths and weaknesses in the Middle East market.

STRENGTHS

1. A series of successful projects over the past decade.

Two reactors of the Tianwan NPP built using the VVER-1000 design began commercial operation in China in 2006–2007. The first reactor of the Bushehr NPP was connected to the Iranian national grid in September 2011. The No 1 reactor of the Kudankulam NPP was connected to the grid in India in October 2013.[145] Also, three reactors were launched in 2010–2014 in Russia itself (the No 2 and 3 units of the Rostov NPP and the No 4 unit of the Kalininskaya NPP). To summarize, seven nuclear power reactors of Russian design have been

Reactor pressure vessel made by Izhorskiye Zavody being shipped via the Gulf of Finland, *Novmber 24, 2012*

launched in four different countries over the past eight years. No other nuclear exporter has such an impressive record. The Russian nuclear industry has also proved its ability to cope with various technological, political, and financial challenges by completing the Bushehr NPP project.

The Russian nuclear industry has already demonstrated its ability to implement politically, financially, and technologically challenging projects by launching the first reactor of the Bushehr NPP

2. A broad range of financing options for NPP projects in other countries.
Depending on the customer's economic and financial situation, Rosatom and its subsidiaries can offer at least four different financing options for NPP projects, which greatly improves their chances of winning the contract. For example, low-interest, long-term loans were offered by the Russian government to finance the projects in Bangladesh, Belarus, and Vietnam. A co-financing option is offered for the Hanhikivi-1 NPP in Finland, whereby a Russian company will not only become the general contractor but also own a minority stake in the future NPP. It is worth noting that Rosatom has been allowed to draw up to 10% of the money held in Russia's Sovereign Wealth Fund to finance its projects. For example, the Fund will allocate 100 bn roubles for a 20 year term for the Hanhikivi-1 NPP project. It is expected that the Akkuyu NPP project in Turkey will rely on the Build-Own-Operate (BOO) option, whereby Russian companies will hold a majority stake in the future power plant. Another option is for the customer country to provide the required investment capital; that is the option proposed for any future reactors of the Bushehr NPP and for projects in Saudi Arabia.

3. Highly competitive technology. The Russian nuclear industry offers Generation III and III+ VVER-type reactors.
The Akkuyu and likely El Dabaa projects will use VVER-1200 (AES-2006) reactors, which represent Generation III+technology. The Russian nuclear industry is currently developing a VVER TOI design, which has improved technical and economic characteristics. Meanwhile, China, which is also

Search and rescue operation at a residential building destroyed by earthquake,
Van, Turkey, October 23, 2013

aspiring to become an exporter of nuclear power reactors, is currently able to offer only the older 2nd generation reactor technology.

4. Complete, in-house nuclear fuel cycle at Rosatom facilities.

This offers Russian companies a clear competitive advantage, especially when dealing with customers that are only just beginning to develop a nuclear energy industry, and do not have their own expertise or infrastructure to produce nuclear fuel and manage spent fuel. All the Middle Eastern customers without exception fall into that category. This Russian capability contrasts sharply with competitors such as South Korea's KEPCO, which does not have its own uranium enrichment and spent nuclear fuel reprocessing facilities. Rosatom, on the other hand, can offer a comprehensive proposal that includes deliveries of fresh fuel and removal of spent fuel for the entire life of the NPP. Such an option has been implemented as part of the Russian-Iranian bilateral agreement on building the Bushehr NPP. It is planned that it will also be used for the Akkuyu NPP project in Turkey, the Amra NPP project in Jordan, the El Dabaa NPP project in Egypt.

5. Russian government's political support for Rosatom export projects.

Russia's nuclear exports potential has become a regular item on the agenda of foreign visits by President Vladimir Putin and Prime Minister Dmitry Medvedev in recent years, helping Rosatom to promote its products and services in foreign countries. In 2015 the possibility of nuclear energy cooperation was raised during the Russian president's visit to China, Egypt, and Hungary. This marks a radical departure from the Russian government's approach in the late 1990s and early 2000s, when the then prime minister, Mikhail Kasyanov, avoided any nuclear-related topics during his foreign visit. He believed that Russia had a limited export capability in this area, and that building NPPs abroad using Russian credit financing was too risky.[146]

WEAKNESSES

1. Russia's relatively weak economic and trade ties in the region.

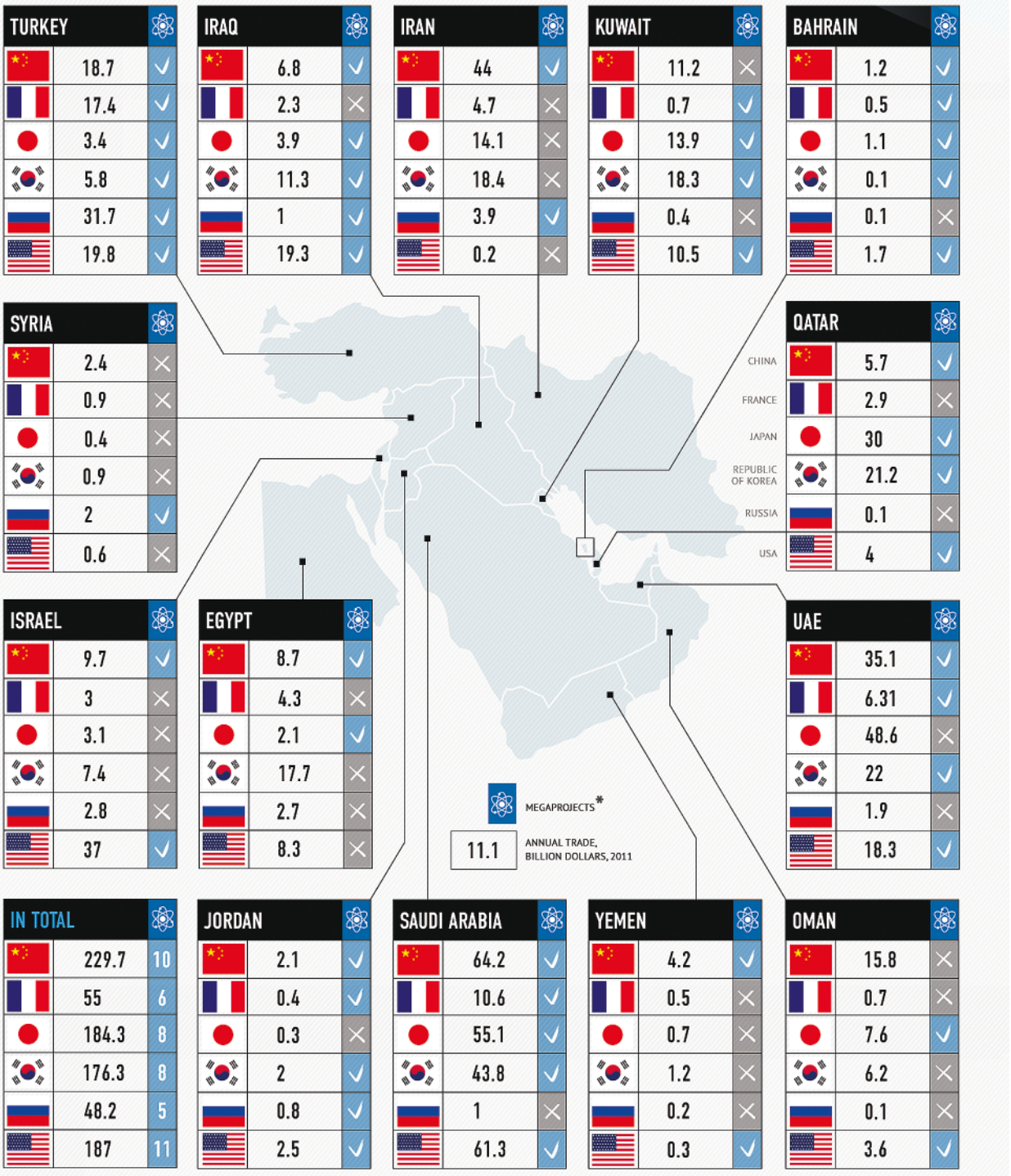
The United States and other Western countries, as well as China, South Korea, and Japan, have already built strong economic and political relations with the Gulf monarchies. That gives them a distinct business advantage. Large corporations from China, South Korea, and Japan are implementing a series of large infrastructure projects in the Middle East, so they have a much better knowledge and understanding of the business environment in the region and in the individual Middle Eastern markets. Russian bilateral trade turnover is comparable with that of the other leading nuclear exporters only in the case of Syria and Turkey. Also, unlike other nuclear exporters, Russia has next to no experience of implementing large projects in the Middle East over the past several decades. For more details about the leading nuclear exporters' trade ties with the Middle East, *see Fig. 13 'Scale of economic cooperation between Middle Eastern countries and the leading nuclear exporters'.*

2. Political instability in several Middle Eastern states, growing activity and influence of non-state actors.

These trends have led to a deterioration of the economic situation in some of the region's countries and the emergence of new security challenges that make it difficult to implement NPP projects. Another negative factor that affects the outlook for nuclear energy development in the Middle East is the appearance in 2013 of the ISIS

SCALE OF ECONOMIC COOPERATION BETWEEN MIDDLE EASTERN COUNTRIES AND THE LEADING NUCLEAR EXPORTERS

FIGURE 13



* 'Megaprojects' are defined as large and expensive projects implemented in the Middle East by companies from the nuclear exporter countries. They include infrastructure projects (industrial facilities, bridges, dams, railways, energy facilities, etc.). In the absence of such projects, the definition also takes into account close cooperation in specific areas (such as the military assistance provided by the United States to most of the countries in the region) worth hundreds of millions of dollars or more; and the presence of foreign military bases in the Middle Eastern states. Information displayed as of 2011

quasistate, which has seized parts of Syria and Iraq, and wants to spread its influence to the entire region and beyond. In Iraq and Syria, plans to build a nuclear power plant is off the agenda for the foreseeable future. In Egypt, meanwhile, the successive governments keep postponing the political decisions required for the country's first NPP project to enter the practical phase.

3. High seismic activity and scarcity of water resources.

The terrain and geology of the region limit the potential for nuclear energy development in the Middle East. For example, large parts of Iran are prone to earthquakes, and there are not many large bodies of water that can be used for cooling the reactors. That imposes natural limitations on the number of NPPs that can be built in Iran. Jordan has identified several candidate sites for its first NPP, only to reject them later for similar reasons.

4. Lack of infrastructure, specialists, and legal/regulatory framework.

Most of the Middle Eastern states have no nuclear infrastructure, including expertise, experience of operating research reactors, or the legal and regulatory framework that is required to build and operate NPPs. Lengthy preparations will therefore be needed before nuclear energy projects can kick off in these countries.

CONCLUSION

1. Amid rising global interest in nuclear energy in 2005–2010, Middle Eastern states announced plans to build a total of about 90 nuclear power reactors at 26 sites by 2030. Six of the region's countries (Bahrain, Egypt, Iran, Jordan, the UAE, and Yemen) were planning to launch their first NPPs by 2017. An average of six reactors were to be launched in the region every year in the 2018–2030 period. These figures for the Middle East represented about 20% of the global plans for launching new reactors, and were on par with the level of nuclear energy ambition displayed by the leading developed countries during the "golden age" of nuclear energy in the late 1970s and early 1980s.

2. The most universal reasons to pursue nuclear energy, i.e. the reasons shared by all Middle Eastern states up to 2010, included rising demand for electricity; the need to diversify energy sources; and growing public acceptance of nuclear energy. Some of the region's states also had their own reasons not necessarily shared by their neighbors. These included the availability of capital looking for investment opportunities; regional competition and the factor of prestige conferred by having nuclear power plants; and, quite possibly, the desire to acquire a military deterrence capability in the wake of the deposal of the Iraqi and Libyan regimes. The latter consideration translated into interest in building scientific, technological, and industrial capability in the nuclear sphere, a capability that could be used at some point to build nuclear weapons, if a political decision is made to that effect.

3. Given the limited nuclear infrastructure in the Middle East, including the lack of skilled personnel or the legal and regulatory framework, the nuclear energy plans announced by Middle Eastern states in 2005–2010 could in most cases be described as overly ambitious. They had a very slim chance of being implemented within the originally expected time frame. Suffice is to say that when these plans were announced, only four of the region's states (Egypt, Iran, Israel, and Turkey) were already operating research reactors.

4. The Fukushima nuclear accident, which triggered a new crisis of confidence in nuclear energy, also had a salutary effect on Middle Eastern countries' nuclear energy plans. These plans have become more realistic. At the same time, the accident at the Fukushima NPP did nothing to alter the fundamental reasons for the nuclear newcomers' interest in nuclear energy, such as rising energy demand, environmental and climate challenges, energy security concerns and diversification of energy sources. In the Middle East Bahrain, Oman, and Kuwait have abandoned their previous plans. Bahrain and Oman are the two smallest states in the region, so their NPP plans were problematic even before Fukushima. In fact, Bahrain's entire territory is only about half

as large as the exclusion (evacuation) zone set up in Japan after the Fukushima accident. Kuwait, meanwhile, has stronger anti-nuclear public sentiment than most of the Middle Eastern states.

5. The effects of the Arab Spring on the Middle Eastern countries' nuclear energy plans have not been uniform. For the countries dependent on energy imports, such as Jordan and Turkey, recent turbulence in the region has further strengthened the argument in favor of energy security and nuclear energy. In states such as Egypt, domestic instability, economic problems and growing security challenges have forced governments to postpone their nuclear energy plans. The growing likelihood of a full-blown political crisis in Jordan could also complicate that country's plans to build its first NPP.

6. Three Middle Eastern NPP projects have entered the active phase. The region's first NPP in Bushehr was connected to the energy grid in September 2011 and began commercial operation. A contract to build another two reactors in Bushehr was signed in 2014. Four reactors of the Barakah NPP in the UAE were laid down in 2012–2015; the No 1 reactor will begin to supply electricity to the grid in 2017. It is expected that construction at the Akkuyu NPP site in Turkey will commence in 2016, once all the necessary permits and licenses have been obtained. These plans, however, may have to be revised in view of the sharp deterioration in Russian-Turkish relations and the Russian economic sanctions against Turkey introduced in November and December 2015, since Russia was chosen to be the supplier of nuclear technology and the majority owner of Turkey's first NPP.

7. Under the most optimistic scenario for nuclear energy in the Middle East, there could be 33 nuclear power reactors in operation at nine NPPs in six states in the region (Egypt, Iran, Jordan, Saudi Arabia, Turkey, and the UAE) by 2030. Under the pessimistic scenario, only Iran, Turkey, and the UAE will be operating one NPP apiece, with a total of 11 reactors, by 2030. In other words, only about a third of the reactors announced in 2005–2010 will have been built under the optimistic scenario, and only 10% under the pessimistic scenario. A more conservative scenario is possible if relations between Russia and Turkey fail to demonstrate progress reasonably quickly.

8. The Russian nuclear industry is now the undisputed global leader in terms of contracts to build NPPs in foreign countries. Over the past several years it has demonstrated its readiness to play the central role in implementing nuclear energy development plans in the Middle East. Russian specialists were heavily involved in the launch of the region's first NPP in Iran. Middle Eastern projects account for a third of the Rosatom corporation's long-term portfolio of contracts to build nuclear power reactors (eight reactors out of 25, to be built in Iran, Jordan and Turkey). Rosatom subsidiaries are taking part in preliminary consultations that could end in the signing of contracts to build another eight reactors in the Middle East (in Egypt, Saudi Arabia, and Turkey).

The Russian nuclear industry is now the undisputed global leader in terms of contracts to build NPPs in foreign countries

9. Rosatom is working hard to facilitate the formation of the international legal framework for closer nuclear energy cooperation with the Middle Eastern states.

Installation of the reactor building dome at the No 2 reactor of the Novovoronezh NPP-2, *November 2014*

Russia has signed intergovernmental agreements on peaceful nuclear energy cooperation with eight countries in the region (Egypt, Iran, Iraq, Jordan, Saudi Arabia, Syria, Turkey, and the UAE). Rosatom has also signed memorandums of understanding on peaceful nuclear energy cooperation with authorized organizations from another four countries (Bahrain, Kuwait, Oman, and Qatar).

Intergovernmental agreements on cooperation in building NPPs have been signed with Egypt, Iran, Jordan and Turkey. The Russian and Iranian governments have signed a protocol to the August 25, 1992 agreement on building an NPP in Iran. That protocol and the original agreement have created the legal framework for building more reactors in Iran.

10. Rosatom's competitive advantages in the Middle Eastern nuclear energy market include the company's ability to make comprehensive offers to its customers, offers that include all the latest financial, technological, and organizational solutions. For example, the Akkuyu NPP is planned to be the first nuclear energy project in the world to use the build-own-operate (BOO) solution, whereby the general contractor builds the NPP, owns it, and runs it. Russian companies could also participate in the Amra NPP project in Jordan as co-investors. The Russian government is expected to provide credit financing for the project to build the El Dabaa NPP in Egypt based on Russian technology.

For the first Egypt and Turkish NPP projects, Russia has offered the latest AES-2006

reactor design. The first AES-2006 reactor is scheduled for launch at the Novovoronezh NPP-2 until the end of the year 2016. In the Iranian, Jordanian, and Turkish projects, Rosatom will build the nuclear power plants, supply fresh nuclear fuel, and remove spent fuel back to Russia for the entire life of the NPP. The same mechanism is proposed for the NPP project in Egypt. This will help to mitigate nuclear proliferation risks. In view of the Middle Eastern countries' limited experience with nuclear energy, Russia is also ready to help train indigenous nuclear personnel and to operate the NPP during the first several years.

11. The challenges Rosatom and its subsidiaries are likely to face in the Middle East include high seismic activity and the scarcity of water in large parts of the region. These factors impose natural limitations on the development of nuclear energy in the region. There is also political instability and growing activity of non-state actors, and the appearance of extremist quasi-states such as ISIS, a radical group (banned in Russia) that has seized large territories in Iraq and Syria. Finally, Russia in some cases does not have strong trade and economic links with the region's countries, and does not know the local business environment very well.

12. Russia is involved in all three NPP projects that have reached the practical phase in the Middle East. The Bushehr NPP and the Akkuyu NPP rely on Russian reactor technology. As for the Barakah NPP, agreements have already been signed under which Russia will supply up to half of the low-enriched uranium required to produce nuclear fuel for that NPP during the first 15 years of its operation. The first low-enriched uranium delivery was made in 2014.

If the project development agreement is fulfilled successfully, in 2016–2017 Russia could also secure the Jordanian contract to build two reactors at Amra. The Russian nuclear industry also has a good chance of securing involvement in the El Dabaa NPP project in Egypt, once the political, security and economic situation in the country improves. As for the Saudi Arabian projects, Russia could provide some of the enriched uranium required to make fuel for the future Saudi NPPs.

To summarize, if the aforementioned optimistic scenario for nuclear energy development in the Middle East comes to pass (i.e. nine NPPs are built in six countries by 2030), Russia could supply the reactor technology for projects in four countries (Egypt, Iran, Jordan, and Turkey), and provide enriched uranium and nuclear fuel cycle services for projects in another two countries (Saudi Arabia and the UAE).

Under the pessimistic scenario, only three NPP projects will have been implemented in the Middle East by 2030. Work on all three has already begun. In that case, Russia could provide the reactor technology for two projects (Bushehr and Akkuyu NPPs), and supply enriched uranium for the Barakah NPP.

NOTES

1. Romania began commercial operation of its first nuclear power reactor at the Cernavodă NPP on December 2, 1996.
2. The Fukushima accident referred to in this report is the series of catastrophic events at the Fukushima Daiichi nuclear power plant in Japan that began on March 11, 2011 as a result of an earthquake off the eastern coast of Honshu Island and the ensuing tsunami.
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