Energy Security Initiative
at BROOKINGS





Models for Aspirant Civil Nuclear Energy Nations in the Middle East

Charles Ebinger
John Banks
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SEPTEMBER 2011
Policy Brief 11-01

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The Energy Security Initiative (ESI) is a cross-program effort by the Brookings Institution designed to foster multidisciplinary research and dialogue on all aspects of energy security today. ESI recognizes that public and private choices related to energy production and use will shape the global economic, environmental and strategic landscape in profound ways and that achieving a more secure future will therefore require a determined effort to understand the likely consequences of these choices and their implications for sound policymaking. The ESI Policy Brief Series is intended to showcase serious and focused scholarship on topical issues in one or more of these broad research areas, with an emphasis on targeted policy recommendations.

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Preface

Country Analyses

While this study refers to "aspirant" nuclear energy countries in the Middle East, some nations have been omitted from the analysis: these include Iran, Israel, Syria, and Yemen. According to the World Nuclear Association (WNA), an international nuclear industry organization, all four of these countries have expressed an interest in civilian nuclear power. Moreover, according to the WNA, two of these countries (Iran and Israel) are further along than some states included in the study, such as Qatar, Oman, and Bahrain. However, given the focus of this paper on models for the responsible and sustainable development of civil nuclear power, the authors determined that a prerequisite for inclusion in the analysis be that subject countries are signatories of the NPT and members of the IAEA in good standing. The IAEA has declared both Iran and Syria to be out of compliance with their safeguards obligations, while Israel is a non-signatory to the NPT. Yemen, which in light of domestic instability is bordering on being a failed state, was excluded from the analysis owing to the slim prospects of the country being able to marshal the necessary institutional, financial, and technical capacity for a civil nuclear program in the near future.

The Impact of The Arab Spring and Fukushima

This study is the result of a one-year research effort looking at models for the development of civilian nuclear power programs for states in the Middle East.[1] During the course of the research, two events occurred that, over time, may play a role in determining if and how the countries of the region pursue nuclear energy. The first is the "Arab Spring", which has seen millions of citizens in the Middle East and North Africa demanding political and economic reforms. The second is the earthquake and tsunami that struck Japan on March 11, 2011 and severely damaged the Fukushima nuclear power facility, causing a failure in its power plants' cooling systems and leading to radioactive waste leaking into the surrounding environment.

At the time of publication the ramifications of these two events were still unclear. The implications of the Arab Spring on nuclear energy development are likely to vary across the region. For instance, the revolution has already toppled the government of Egypt, one of the countries analyzed in this paper. The deposing of President Mubarak is likely to delay Egypt's nuclear energy

[1] The second year of this project will examine the prospects for civilian nuclear energy cooperation between the aspirant nuclear energy states of the Middle East.

goals, despite the contentions and best efforts of Cairo's nuclear energy officials. The economic and financial costs of the revolution in Egypt have made the challenge of building an expensive nuclear power plant more daunting. In neighboring Jordan, a country that has demonstrated keen interest in nuclear energy, the government is now encountering growing resistance to nuclear power from public-interest groups. While this may not fully derail Jordan's nuclear energy plans, the Arab Spring has emphasized to leaders the importance of broad stakeholder involvement. In other countries, such delays are less likely. For instance, it appears that the United Arab Emirates (UAE), the furthest along in its nuclear energy program of those analyzed in this paper, will not experience any significant delays as a result of the Arab Spring.

On the other hand, the Arab Spring may provide further support for serious consideration of civilian nuclear power. The uprisings and their longer-term effects may add a price premium to oil that impacts those countries using oil and gas for electricity generation (gas is indexed to oil in most of the world). For those countries highly dependent on oil and gas imports for electricity generation (especially Egypt, Turkey, and Jordan), the rationale for reducing the use of these increasingly expensive fuels and diversifying their power generation portfolios will be bolstered. For major oil producers, higher oil prices could strengthen the justification to use nuclear power in order to free-up for export the oil and gas used in electricity generation.

The impact of the Fukushima nuclear accident on regional nuclear energy development is also unclear. While some countries outside the region, such as Germany and Switzerland, decided soon after the accident to phase out existing nuclear programs, the situation in the Middle East—as well as in most emerging markets—is less straightforward. Unlike more advanced economies, which face minimal electricity demand growth and have well established, diverse electricity portfolios, the countries of the Middle East are almost exclusively dependent on oil and gas to meet rapidly increasing demand for electricity. This will likely encourage governments to remain committed to atomic energy, as they see a potential to diversify energy consumption and add significant baseload capacity to meet demand, and to address growing environmental concerns associated with oil and gas-fired generation. The Fukushima accident has played a role in one country's decision to abandon nuclear energy for power generation: as outlined in Chapter 6, Kuwait's national nuclear energy plan was in the early stages of its development when the Kuwaiti government—largely influenced by the events in Japan—decided to reverse its policy on nuclear energy. However, for the time being, other countries in this study have, to date, adhered to their respective plans.

Given the uncertainty of the impacts of both the Arab Spring and the Fukushima nuclear accident on the civilian nuclear energy plans of aspirant states in the Middle East, it is difficult to fully address these issues in each country section. Where appropriate, we have discussed the potential implications of these events. However, the two events do not impact the fundamental theme of this paper: the interest in nuclear energy—and the need to find models for its responsible and sustainable development—in the countries analyzed will likely persist as long as rising electricity demand continues to lead to rising economic and environmental costs of petroleum-based power generation.

Executive Summary

Faced with burgeoning electricity demand and the increasing economic and environmental costs of using fossil fuel for power generation, several countries in the Middle East are engaged in, or seriously considering, the development of civil nuclear power. None of the countries examined in this research has a commercial-scale nuclear power plant connected to the grid. The United Arab Emirates (UAE) is the furthest along in the process, having signed a contract for the construction of four nuclear power plants, which are scheduled for completion between 2017 and 2020. Turkey has also signed an agreement for the construction of up to four reactors, while Jordan and Egypt—two countries with significant experience in nuclear research—are in advanced stages of negotiations with potential nuclear vendors. Saudi Arabia has expressed its intention to spend $100 billion on a fleet of 16 nuclear reactors by 2030, and to have two reactors online within ten years. Kuwait and Bahrain have also expressed serious interest in domestic nuclear power programs (although the former's interest has diminished in the wake of the Fukushima nuclear disaster in Japan), while Qatar and Oman have shown interest in potential regional nuclear-power related initiatives.

As the countries of the Middle East embark on the significant commitment involved in planning, implementing, and operating civil nuclear facilities, they face a range of common challenges. Each of the countries assessed in this study has unique characteristics that make its approach to nuclear-power development specific to its own national circumstances. Some, such as Egypt and Turkey, have pursued civil nuclear power programs for decades and have significant experience with nuclear technology through small-scale research applications. Others, such as the higher-income states of the Gulf Cooperation Council (GCC), are relative newcomers to the field of nuclear power development, but, as demonstrated by the experience of the UAE, have the proven ability to move quickly in the development of strategy and the implementation of nuclear power programs. There is variation between the approaches each of the countries is taking to commercial arrangements and international partnerships; to the structuring of their nuclear-related government departments and regulators; and to their efforts in training personnel and building domestic human capacity. There are also differences in the level of resources, both natural and financial, that each country has to bring to any development plan, and differences between states wishing to pursue their own unilateral programs and those smaller states that see advantages in joint projects.

Despite their differences, however, there are several areas in which the countries in the Middle East have the opportunity to adopt some common approaches and to learn from each other's experience. Most of the countries have worked in close cooperation with the International Atomic Energy Agency and are using a version of the agency's report, *Milestones in the Development of National*

Infrastructure for Nuclear Power, in their nuclear power development strategies. Among newcomer nuclear energy countries in the region, including those of the GCC, there is a tendency to articulate the strategy for nuclear power programs in guiding policy documents, which lay out the goals and objectives of the program before work begins. Among those countries that have progressed to the stage of commercial negotiations, there is a clear preference for public-private partnerships with nuclear vendors as well as a desire to involve vendors' host governments as parties to the agreements. There is an acknowledgement on the part of all countries in the region that building and maintaining the necessary human capacity to run both the nuclear programs and the public sector nuclear-related institutions will be a critical component in the sustainability of the programs.

All of the countries in the study have yet to resolve significant aspects of their nuclear program development strategies. Even the UAE, which is the furthest along in the design and execution of its program, has yet to articulate a strategy for long-term fuel supply, or policies for spent fuel management and legal liability. Among the other countries, there are many more unresolved issues, including those of siting, financing, international agreements, and approaches to sensitive aspects of the nuclear fuel cycle. This paper shows that, while there is no universal model for nuclear power development in the Middle East, there are certain principals and practices that can underpin a responsible approach. These include:

- Articulation of plans for civil nuclear power in the form of policy statements, and as part of a broader energy strategy
- Maintenance of administrative and operational independence of nuclear regulators
- Establishment of long-term human resource development program to ensure the sustainability of nuclear power programs
- Design and implementation of strategies for spent-fuel storage and waste disposal at the outset of nuclear program development
- Selection of nuclear vendors according to a set of clear, transparent criteria, removed from political interference
- Adherence to all of the principal international safety, security and liability conventions
- Integration of meaningful domestic stakeholder engagement into the nuclear power-program development process

As the countries of the Middle East tackle the many technical, institutional, and financial challenges of developing civil nuclear power programs, they have the opportunity to learn from each other and from the international community to ensure that their programs are safe, secure, and sustainable.

Introduction

Nuclear energy is a proven source of reliable, scalable, carbon-free power generation. However, it is an option with significant technical, institutional, and operational challenges. While the external perception of nuclear power in the Middle East has been dominated in recent years by the security implications of the Iranian nuclear program, inside the region growing interest in atomic power has centered on common demographic and resource-related challenges. With rising populations and rapidly growing economies, countries such as the United Arab Emirates (UAE), Saudi Arabia, Egypt, Jordan, Turkey and Kuwait find themselves facing a sharp increase in projected demand for electricity and water. Many of these countries rely principally on natural gas for electricity generation; as demand for gas outstrips supply, they are allocating increasing amounts of valuable liquid fuels to domestic power generation with a commensurate increase in economic and environmental costs. Many countries of the region also value nuclear power as a vital technology for transitioning to a low-carbon economy.

As the countries in the region begin to embark on civil nuclear power projects, there is an immense interest on the part of the global community in the approaches they take to the development of safe, secure, and sustainable programs. This study assesses the approaches of nine countries in the Middle East in developing a civil nuclear power program. It is designed to help policymakers in each of the countries under review to make informed decisions on their civil nuclear program development strategies. The countries examined are the United Arab Emirates, Jordan, Egypt, Turkey, Saudi Arabia, Kuwait, Bahrain, Qatar, and Oman. This study seeks to document these countries' approaches to each of the central aspects of nuclear power development, including the creation of policy and legal frameworks; the selection of technology and commercial arrangements; the development of institutional capacity and human resources; and relations with the international community.

The study is structured in two parts. Part I is a descriptive overview of the status of nuclear power development in each of the countries. It begins by documenting the current energy landscape in each country, and provides an overview of the major characteristics of the energy mix and the supply-demand balance, with particular emphasis on the power sector. Having established the domestic energy context, it addresses the various aspects of each country's nuclear power sector, including a history of civil-nuclear developments and details of current plans, with information on principal policy frameworks, commercial arrangements, and construction schedules. This is followed by an examination of the legal and institutional

context, approaches to education and training, as well as the status of international agreements.

Part II attempts to draw conclusions from the information in Part I. It starts from the assumption that any analysis that prescribes a "model" or "best practice" for nuclear-power program development must be viewed with caution. Each of the countries assessed in this study has unique characteristics that make its approach to nuclear power development specific to its own national circumstances. Despite their differences, however, there are several areas in which the countries in the Middle East have the opportunity to adopt some common approaches and to learn from each other's experience. Part II aims to put the experience and approaches of the countries in a comparative context; to draw parallels where they exist; and to highlight differences where they do not. Based on the conclusions, it then offers a series of recommendations for the safe, secure, and sustainable development of nuclear power programs in the region.

This study draws on official documents from each of the countries assessed, as well as material collected in interviews conducted with government officials and non-governmental organizations from the UAE, Jordan, Kuwait, Egypt, Turkey, Qatar, the United States, and the International Atomic Energy Agency. It was also informed by a roundtable event on "Models for Nuclear Power Development in the Middle East" hosted by the Brookings Energy Security Initiative in Abu Dhabi on April 20, 2011. The event involved participation from government, regulatory, and private-sector stakeholders from around the region.

PART I: COUNTRY ANALYSES

Civil Nuclear Power in the United Arab Emirates

Energy Context and Origins of the Nuclear Energy Program

With an estimated 97.8 billion barrels of proven oil reserves, the United Arab Emirates (UAE) is the world's seventh biggest producer of oil and gas. However, despite its vast energy resources, the country faces a looming supply crunch in the power sector as burgeoning economic growth puts further pressure on its already-strained electricity generation capacity. According to the United States Energy Information Administration (EIA), as of January 2011, the UAE had electricity production capacity of 18.747 gigawatts (GW). The vast majority of the UAE's primary energy consumption is in the form of natural gas used in the generation of electricity; in 2008, natural-gas based electricity generation accounted for 2.198 quadrillion British Thermal Units (Btus) of the country's primary consumption of 3.257 quadrillion Btus.[2] Owing in large part to its rising electricity demand, the UAE, which has the seventh largest natural gas reserves in the world and produced 1.865 trillion cubic feet of natural gas in 2009, is now a net importer of natural gas, with imports of around 2 billion cubic feet per day (bcf/d) from Qatar entering the country through the Dolphin Pipeline. The UAE's chronic shortage of natural gas—and the associated negative implications for the power sector and the country's reliance on foreign partners—are projected to continue as the country's primary energy demand is expected to grow by 71 percent by 2019.[3] In the absence of an alternative, the UAE will be increasingly forced to use its valuable liquid hydrocarbons for domestic power generation, incurring a large opportunity cost of forgone sales on global markets.

In light of these fundamentals, there is a clear economic rationale for the country's drive to diversify its sources of electricity generation in order to increase its energy security while preserving gas and liquids for its long-term future and international trade. While Abu Dhabi's Masdar renewable energy city has received worldwide recognition for its efforts in alternative energy technology development and deployment, the emirate plans to have renewable sources account for only seven percent of its electricity generation capacity by 2020.

Facing rapidly rising demand in its power sector, the UAE has turned to civil nuclear power as a

[2] U.S. Energy Information Administration, United Arab Emirates Country Analysis Brief, January 2011.
[3] "The GCC in 2020: Resources for the Future," *Economist Intelligence Unit*, March 2010.

means of electricity generation. While the UAE has been engaged in technical cooperation projects with the International Atomic Energy Agency (IAEA) for many years (the agency advised the Emirates on the formation of a nuclear energy administration in 1977), the country's current drive toward a nuclear power program began with the findings of a national energy study by an interagency working group established by the Economic and Energy Affairs Unit of the country's Executive Affairs Authority (EAA). The working group was tasked with examining options for future energy supply, with particular focus on economics, environmental impact, security of supply issues, and the potential for long-term economic development. The study projected a cumulative annual increase in the country's electricity demand of nine percent to 2020 and a shortfall in power demand of 15,000 to 20,000 MW by 2020.[4] The report looked at various options for meeting this shortfall, including oil, natural gas, and coal. According to EAA officials, the evaluation process attached particular importance to issues of supply security, with a view to minimizing the UAE's vulnerability through increasing the diversity of supply options. In light of these considerations, the EAA working group recommended a portfolio approach to electricity generation in which it projected that Abu Dhabi could generate 30 percent of its electricity from alternative sources, including nuclear power.

2008 White Paper

The findings of the national-level energy study informed the 2008 "Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy." This document, also known as the White Paper, was an attempt by the government to outline the issues and the steps that needed to be taken for the development of a civil nuclear power program. Policymakers in the UAE acknowledge that there was a degree of sensitivity in producing a document that would serve as the first indication to the international community that the UAE was considering civil nuclear power as an option.[5]

The approach to the White Paper was two-fold: to evaluate the feasibility of civil nuclear power as an energy source; and, in the event that it was found to be feasible, to lay out a clear set of actions to achieve it. According to the EAA, policy makers in the UAE solicited input from other major nuclear-power nations and international organizations during the formulation of the 2008 White Paper, with input coming from the United States, the United Kingdom, France, South Korea, Germany, Japan and the IAEA. According to EAA officials, there was an "overwhelming positive response" from the international community to this approach.[6]

The White Paper was released in English and Arabic in April 2008 and was accompanied by briefings to local and international media. The document lays out the framework for the development of nuclear power program in the UAE in terms of six guiding principles:

1. A commitment to complete operational transparency.
2. A commitment to pursuing the highest standards of nonproliferation.
3. A commitment to the highest standards of safety and security.
4. A commitment to work directly with the IAEA and conform to its standards in evaluating and potentially establishing a peaceful nuclear energy program.

[4] "Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy," Ministry of Foreign Affairs, United Arab Emirates, April 2008. (Ministry of Foreign Affairs, 2008)
[5] Brookings interviews with UAE Ministry of Foreign Affairs and Executive Affairs Authority, Abu Dhabi, October 3– 8, 2010.
[6] Ibid.

5. Development of peaceful domestic nuclear power capability in partnership with the governments and firms of responsible nations, and the assistance of appropriate expert organizations.
6. An approach to peaceful domestic nuclear power development in a manner that best ensures long-term sustainability.

The paper outlined concrete steps for action in the areas of legal institutional requirements, international commitments, and technical and financial arrangements. It called for the creation of a Nuclear Energy Program Implementation Organization (NEPIO) to lead an evaluation of nuclear power and the development of related human, technical, and security infrastructure. It also made provision for the creation of an independent regulator and provided a summary of the latter's responsibilities and mechanisms for the maintenance of its independence; and set out the requirements for the legal framework necessary to underpin a nuclear power sector, including for domestic legislation on liability, spent-fuel management, and decommissioning of plants.

The document highlighted the international commitments that needed to be concluded both in connection with the country's evaluation of nuclear power and in the event of its deciding to proceed with civil nuclear power development. With regard to commercial arrangements, the policy document outlined the basis of terms on which nuclear power would be developed in the country. The document expressed a clear preference for a nuclear power program based on third-generation light-water reactor (LWR) technology, with any partnerships with international companies following a Build Own and Operate model predicated on a joint venture agreement between the government and international investors. Importantly, the document included a commitment to "renounce[e] any intention to develop a domestic enrichment and reprocessing capability and undertaking to source fuel from reliable and responsible foreign suppliers."[7]

Roadmap Document

Having laid out the overarching goals of its nuclear program, as well as some concrete details on its approach to nuclear power development, the UAE commissioned a more detailed report that was informed by the goals of the IAEA's *Milestones in the Development of a National Infrastructure for Nuclear Power* paper, which articulates a series of stages for nuclear program development. The UAE's *Roadmap for Success* was developed with input from a team of external experts with a range of regional and historical experience. The Roadmap document built on the principles of the 2008 policy document and was based on the achievement of five goals: complete operational transparency; the highest standards of nonproliferation; the highest possible standards of safety and security; partnerships with governments and firms of friendly nations; and timely, economical power generation. In each area, the Roadmap laid out a series of key recommendations for policymakers. The goals were addressed through a series of concrete steps and actionable recommendations.

Technology and Commercial Model

According to the 2008 White Paper, the business model for the UAE's nuclear program is intended to replicate the partnerships between the government and companies in the water and power sectors. The paper notes that "[u]nder the IWPP [Independent Water and Power Project] structure, new plants are constructed on a build, own and operate (BOO) basis via joint venture arrangements between the government and various international companies." The ownership of each IWPP is split

[7] Ministry of Foreign Affairs, 2008.

between the government and overseas private investors in a 60:40 ownership ratio. The joint ventures are usually run with an experienced private-sector investor as the plant operator. The White Paper makes clear that "IWPPs in the nuclear energy sector would remain fully subject to international standards and regulatory oversight, despite their differentiated shareholding structure."

The 2008 Roadmap document followed up the White Paper recommendation by suggesting a "Construct-Operate-Privatize" model in which there would be 100 percent government funding for the first period of the program, including construction, start-up and proven generation, followed by 60:40 government/private joint venture.

Beyond stating its intentions to deploy light-water reactor LWR-type designs, the UAE approached its nuclear program from a "technology-agnostic" perspective. The Roadmap document set out a series of fundamental criteria for the prime contractor to meet, including an ability to deliver according to schedule, the ability to provide the entire scope of supply, and a willingness to abide by the UAE's contract terms. A process of technology screening produced by the compliers of the Roadmap led to a shortlist of reactor technologies that were likely to be acceptable:

- Areva EPR
- Westinghouse AP1000
- Korea Hydro and Nuclear Company APR1400
- GE-Hitachi ABWR

Contract Negotiations

The Roadmap laid out a detailed set of suggestions for the UAE's approach to choosing a contractor. It advised against the traditional commercial model for nuclear power plant—involving the issuance of specifications, a bidding process, bid evaluation, and contract negotiation—which did not meet the needs of the UAE. Given that the UAE had no history of nuclear power, it was estimated that such an approach, in addition to the requisite site preparation and licensing, would result in a minimum connection period of between 14 and 18 years. To expedite the process, the Roadmap suggested a new approach to the contract negotiations and commercial model for the nuclear program.

Prior to the financial crisis and the resultant economic slowdown of 2008, there was a view that the only option for construction of nuclear plants was on a "cost-plus" basis, through which contractors pass on all expenses to the client; cost overruns like that experienced by Areva at Olkiluoto in Finland had made contractors unwilling to take a fixed-price contract and wary of locking themselves into a predetermined figure. However, the negotiating position changed post-2008; as both potential government and private sector customers retrenched, commercial nuclear providers had to reassess their bargaining position. The UAE took advantage of these circumstances by moving to negotiations based on a fixed-price contract.

In the Roadmap document, the UAE recognized the conflicting imperatives between the shortened timeline associated with a sole-source contract and the increased negotiating power of a competitive bid. The Roadmap recommended a policy of "Competitive Dialogue," a series of interactions with potential bidders run on the basis of technology-neutral requirements linked to a target cost. It also gave guidance on the nature of the contract incentives, which were focused on early delivery, reduction in cost, and maintenance of firs rate quality and safety.

The strong financial position of the UAE also enabled it to determine the structure of the bid. Rather than a bid from a consortium of companies each providing a separate aspect of the system (engineering, procurement and construction, or

EPC, contractors; nuclear steam supply system, or NSSS, providers; plant operators), the UAE demanded an integrated bid with the prime contractor and subcontractors joint and severally liable for the project.

According to energy planners at the EAA, the Korean consortium led by the Korea Electric Power Company (KEPCO) was the most accommodative to this structure of bid. KEPCO, which had relationships with a core group of nuclear-sector subcontractors, already operated a model similar to the one that the UAE was looking to implement. According to the EAA, the established nuclear vendors in Japan and France were less willing to adapt their bids to the new model. South Korea also appealed to the UAE's schedule: in the view of UAE officials, Korean companies had proven themselves able to construct a nuclear fleet in a relatively short space of time and to a predictable schedule.[8] In December 2009, the UAE announced that it had awarded the contract for the construction of four APR1400 reactors, including the associated maintenance, fuel supply and training and education to KEPCO. In November 2010, KEPCO was invited to partner with Emirates Nuclear Energy Corporation (ENEC) in the formation of a new entity to be the UAE plants' operator.

Institutions and Principal Legal Framework

To codify the goals of the 2008 Policy Document and the Road Map document, the government of the UAE instituted the "Federal Law No. 6 of 2009 Regarding the Peaceful Uses of Nuclear Energy" in October 2009. The law, which was produced with input from the international community, institutionalized the "prohibition of the development, construction or operation of uranium enrichment or spent fuel reprocessing facilities within the borders of the UAE"; established the Federal Authority of Nuclear Regulation (FANR); institutionalized the development of a robust system for the licensing and control of nuclear material; and criminalized activities in violation of the law, including the unauthorized use, theft, transport or trade in nuclear materials.[9]

In addition to the Federal Law No. 6, the UAE's existing "Federal Law 13," issued in 2007, provided a basis for the country's nuclear export control legislation. The law authorizes the government to "ban or restrict the importing, exporting or re-exporting of any commodity for reasons related to safety, public health, environment, natural resources, national security or for reasons related to the UAE's foreign policy."[10]

Federal Authority of Nuclear Regulation

Given a legal foundation in Federal Law No. 6 of 2009, the Federal Authority of Nuclear Regulation came into being in September 2009. The law made provision for "the establishment of the 'Federal Authority of Nuclear Regulation' (FANR), a fully independent nuclear safety regulatory authority, which aims to oversee the nuclear energy sector in the state and to promote the highest standards of nuclear safety, nuclear security and radiological protection."[11]

The administrative structure and functions of FANR were informed by several IAEA documents, including the "Milestones in the Development of a National Nuclear Infrastructure," "Evaluation of the Status of National Nuclear Infrastructure Development," and a selection of

[8] Brookings interviews with UAE Executive Affairs Authority, Abu Dhabi October 3-8, 2010.
[9] "UAE President issues law on peaceful uses of nuclear energy," Federal Agency for Nuclear Regulation News Release, October 9, 2009 (http://fanr.gov.ae/en/pressrelease/media-center/press-releases/uae-president-issues-law-on-peaceful-uses-of-nuclear-energy.html). (FANR, 2009)
[10] "UAE President issues law on commodities subject to import and export control procedures," *Emirates News Agency (WAM),* September 2, 2007.
[11] FANR, 2009.

safety and security publications from the IAEA's International Nuclear Safety Group (INSAG), including INSAG-17, "Independence in Regulatory Decision Making."

FANR's organizational structure is headed by a Board of Management modeled on that of the IAEA. The Board, which reports to the Minister of Presidential Affairs, comprises nine part-time members, all UAE nationals; as of October 2010, none of the board members had prior experience in the nuclear industry. The organization is led by a director general, who reports to the Board, and who has oversight of the regulator's two main divisions: the Administration Division (comprising government and international affairs, human resources, education and training, and administration and finance), and the Operations Division (comprising nuclear safety, radiation safety, nuclear security, and safeguards).

As an independent regulator, FANR has oversight of nuclear safety, security, radiation protection and safeguards in the UAE. Its responsibilities include regulation over the following:

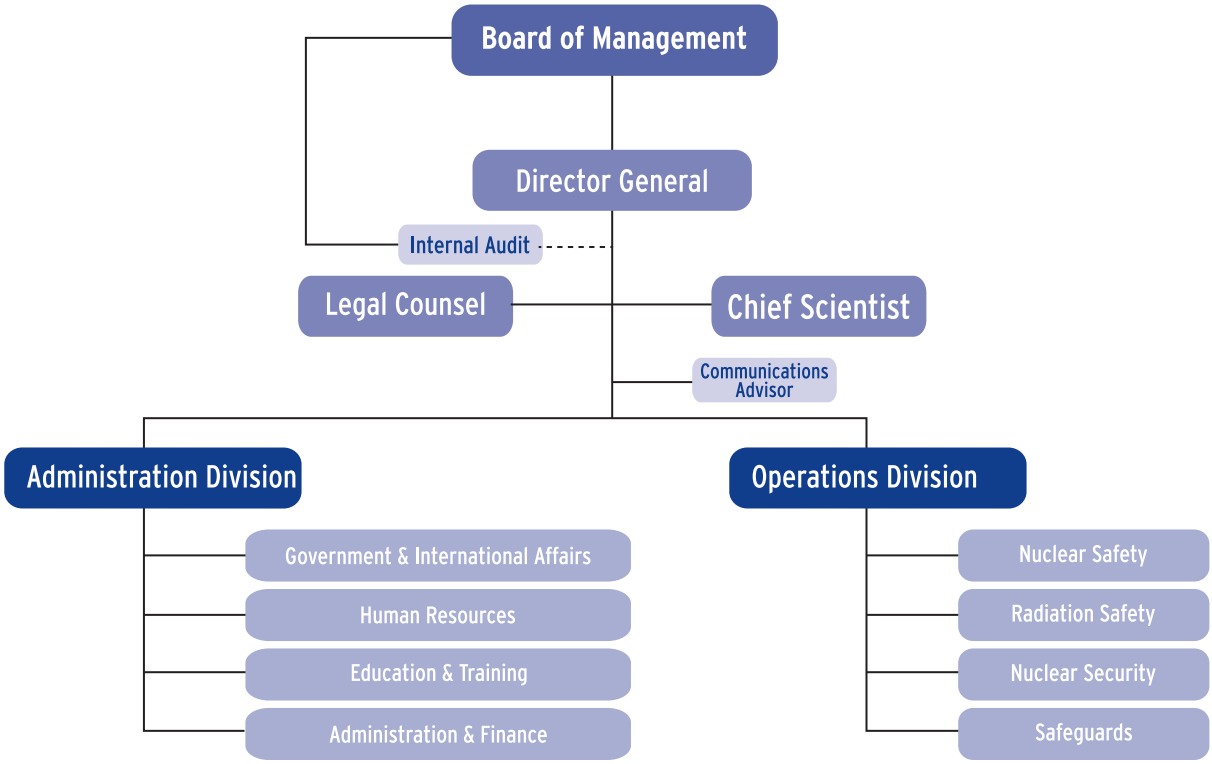
1. Selection of a site for the construction of a nuclear facility,
2. Preparation of a site for the construction of a nuclear facility,
3. Design of a nuclear facility,
4. Construction of a nuclear facility,
5. Commissioning of a nuclear facility,
6. Operation and maintenance of a nuclear facility,
7. Closure or a change in the closure date of any nuclear facility,
8. Decommissioning of a nuclear facility,
9. Modifications having significance to safety of the management system and organizational arrangements or the systems, structures, and components of any nuclear facility,
10. Possession, use, manufacture and handling of any regulated material or part of any regulated material in the State,
11. Import or export of any regulated material into or from the State, subject to any consents required pursuant to the provisions of Law No. 13 of 2007,
12. Transportation of any regulated material within the State,
13. Introduction or removal of any regulated material to or from any nuclear facility,
14. Storage of any regulated material within the State,
15. Disposal of any regulated material within the State,
16. Emergency preparedness relating to any nuclear facility.[12]

According to its executives, FANR has entered into a number of bilateral arrangements with established regulators and other nuclear-sector institutions, including the U.S. Nuclear Regulatory Commission, the Korean Institute for Nuclear Safety (KINS), and the Korean Ministry of Education, Science and Technology. Agreements with the Korea Institute of Nuclear Nonproliferation and Control (KINAC) and others are under consideration. FANR benefits from such bilateral arrangements in the form of licensing documentation, secondment of staff, exchange programs for inspectors, and training of its staff.[13] According to senior FANR executives, the regulator is subject to peer review from both other regulators and the IAEA.

As of October 2010, FANR had 104 employees, 51 percent of whom were UAE nationals. The regulator has a three-phase strategy for workforce development: an initial stage consisting of a core team of experienced international professionals; a

[12] Christer Viktorsson, Federal Authority for Nuclear Regulation, "Establishment of a Nuclear Regulatory Infrastructure in the UAE," Presentation to the IAEA INSAG Forum, September 20, 2010.
[13] FANR, 2010.

Figure 1-1: Organizational structure of FANR



Source: Federal Authority of Nuclear Regulation

second stage in which international professionals are retained and a skilled cadre of UAE nationals is developed; and a long-term goal of a base of domestic expertise supported by international organizations.

In addition to supporting and coordinating the UAE Nuclear Energy Scholarships Initiative (see education section below), FANR conducts in-house technical training for its staff on safeguards, inspections, reviews, and "safety culture."

Emirates Nuclear Energy Corporation

The 2008 White Paper called for the formation of the Emirates Nuclear Energy Corporation (ENEC), the UAE's Nuclear Energy Program Implementation Organization (NEPIO), to be "created by law as a civilian, publicly-held entity with its own legal personality and […] directed by a board of directors with representation from relevant bodies including government entities, utilities, environmental agencies, etc."[14]

ENEC was established in 2008 and has two principal missions: to serve as the entity responsible for deployment, ownership and operation of nuclear power plants in Abu Dhabi; and to serve as an investment arm of the government of Abu Dhabi responsible for investments and collaboration with foreign partners in the nuclear sector, both domestically and internationally.

According to ENEC, the corporation currently has over 200 employees representing a broad range of talent with over 1000 years of experience

[14] Ministry of Foreign Affairs, 2008.

in the nuclear sector. Many of ENEC's team have previously worked in utilities. In setting up its team, ENEC tried to "benchmark" its operations with other nations' programs. It traveled to China and Korea to study their nuclear programs.[15] In October 2010, ENEC became a member of the World Association of Nuclear Operators. To build the workforce it will need to run the UAE's nuclear power plants, ENEC has embarked on a number of education and training initiatives (see section 3 below).

In its operational role, ENEC is responsible for obtaining construction and environmental licensing (from FANR and the Environmental Agency—Abu Dhabi, or EAD, respectively) for Abu Dhabi's four-unit nuclear facility at Braka on the Arabian Gulf. In November 2010, ENEC received two licenses from FANR related to the Braka site: the *"Site Preparation License, UAE Nuclear Power Plants Units 1, 2, 3 and 4"* and the *"Limited Construction License to Manufacture and Assemble Nuclear Safety Related Equipment, UAE Nuclear Power Plants Units 1, 2, 3, and 4"* give the corporation permission to start work on non-plant related construction features of the Braka facility, and mechanical elements of the plants themselves (pressure vessels, pumps, coolant systems etc), respectively. Having spent a year assessing the site and the safety case for the first two nuclear reactors at Braka—a process in which it partnered with KEPCO, the prime contractor for construction of the plants—ENEC submitted its Construction License Application (CLA) for work on the Units 1 and 2 at the Braka site in December 2010. According to ENEC, the CLA process was based on that of KINS in its application for licensing of the Shin Kori units 3 and 4 in Korea. The Shin Kori plant, which comprises the same KEPCO-supplied AP1400 rector designs as those being planned for Braka is regarded as the "reference plant" for the UAE program.

International Advisory Board

The UAE's International Advisory Board (IAB) is led by Dr. Hans Blix, former Director General of the IAEA. The IAB, which has no legally binding powers, issues a semi-annual report on the following issues:

1. Nuclear safety
2. Nuclear security
3. Nuclear nonproliferation
4. Program transparency
5. Program sustainability

The IAB's reports assess the progress the government of the UAE is making toward its goals of implementing a safe, secure, and transparent nuclear power program. The nine-person board offers recommendations to policymakers on ways in which to improve the program. According to the IAB's charter, it has a commitment from the government of the UAE that the latter "will not seek to edit […] consensus IAB views," and that the board's reports will be published free of modification.[16]

Training and education

The UAE's 2008 White Paper stated that "any undertaking by the UAE to develop a nuclear power program would be accompanied by a strategy to strengthen human resources to meet future staffing requirements." The document laid out the need for the development of sufficient resources to regulate, manage, operate, and maintain the safety of nuclear facilities, and the need for a "skilled cadre of nuclear engineers, technicians and regulatory personnel."

The country is taking a multi-pronged approach to the development of human capital related to the civil nuclear sector. In the near term, the UAE Nuclear Energy Scholarship initiative is a

[15] Brookings interviews with ENEC officials, Abu Dhabi October 3-8, 2010.
[16] "First Semi-annual Report," International Advisory Board, 2010.

collaboration between ENEC, FANR, and the Khalifa University of Science, Technology and Research (KUSTAR). The scholarship program is aimed at getting UAE nationals to study nuclear, chemical, and electrical and mechanical engineering at the undergraduate level and nuclear engineering at the graduate level in the UAE itself or at institutions in Korea or the United States. Students that fulfill the entry requirements are provided with full tuition, a stipend, and a performance-based bonus. Khalifa University currently offers a graduate-level program in nuclear engineering, although there is currently no nuclear-related undergraduate degree within the UAE.

To address the demand for skilled nuclear technicians and other plant personnel, the UAE's Institute of Applied Technology is developing a post-secondary vocational training program called a Higher Diploma in Nuclear Technology (HDNT). The HDNT program, which has been developed by IAT in coordination with ENEC and KEPCO, is intended to be the flagship program of Abu Dhabi Polytechnic, a new institution established to train professionals for employment in areas of emerging technologies. Students on the HDNT course are sponsored by ENEC, which guarantees employment to graduates of the program. The program's syllabus, which was developed in close collaboration with KEPCO, combines general academic and technical instruction at the IAT with on-the-job training both in the UAE and at operating reactors overseas. The program is scheduled to begin in the fall of 2011.

Another proposed professional-development program supported by ENEC, FANR and KUSTAR is the Gulf Nuclear Energy Infrastructure Institute (GNEII), a partnership between KUSTAR, Sandia National Laboratories and the Texas Engineering Experiment Station of Texas A&M University System. The initiative, which will be based at Khalifa University in Abu Dhabi, is intended to provide a "regional educational, training and research hub for promoting a nuclear safety, safeguards, and security culture," according to KUSTAR. Courses will seek to train nuclear professionals in the handling of sensitive materials and issues relating to safety and security of nuclear materials with regard to terrorist threats. A memorandum of understanding between the three principal partners was signed in February 2011. The institute is initially open to professionals from three Emirati organizations, but participation will be expanded to professionals from all six Gulf Cooperation Council countries in 2012. The institute is funded by Khalifa University, the U.S. National Nuclear Security Administration, and the U.S. Department of State.[17]

The UAE is also involved in an educational program involving KUSTAR (also involving the IAEA) on an "e-learning Portal." The resource is designed to supplement classroom studies and builds on the precedent of the Asian Network for Education in Nuclear Technology (ANENT), a regional initiative to promote education and human-resource development; strengthen scientific infrastructure; and develop a self-sustaining network of institutions in the Asia Pacific region.[18]

International Agreements

Multilateral Commitments and Memberships

The UAE has entered into a range of international agreements including:

- UN Treaty on Nonproliferation of Nuclear Weapons (1995)

[17] "NNSA Launches Gulf Nuclear Energy Infrastructure Institute to Promote Nuclear Safety and Security," National Nuclear Safety Administration Press Release, February 22, 2011 (http://nnsa.energy.gov/mediaroom/pressreleases/gneii02.22.11).
[18] International Atomic Energy Agency Managing Nuclear Knowledge, IAEA Activities and International Coordination, Asian Network for Education in Nuclear Technology (ANENT), July 2007.

- IAEA Comprehensive Safeguards Agreement (2003)
- IAEA Small Quantities Protocol (2003)
- IAEA Additional Protocol to its Safeguards Agreement (signed 2009, ratified 2010)
- IAEA Convention on the Physical Protection of Nuclear Material (2003, Amendments to the Convention ratified in 2009)
- UN Comprehensive Test Ban Treaty (2000)
- UN International Convention for the Suppression of Acts of Nuclear Terrorism (2005)
- Convention on Early Notification of a Nuclear Accident (1987)
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1987)
- Convention on Nuclear Safety (2009)
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (2009)[19]

U.S. 123 Agreement

Following negotiations between the United States and the UAE in 2008, the UAE government signed a Memorandum of Understanding (MoU) and a proposed bilateral agreement on peaceful nuclear cooperation with the United States on January 15, 2009. A revised version of this agreement, a so-called "123 Agreement" (referring to Section 123 of the U.S. Atomic Energy Act of 1954), was signed by the two countries on May 21, 2009. The U.S. Congress allowed the agreement to go forward and it came into force on December 17, 2009 following the exchange of diplomatic notes from the two countries.

The terms of the UAE's 123 agreement make provision for a "comprehensive framework for peaceful nuclear cooperation…based on a mutual commitment to nuclear nonproliferation."[20] The agreement, which is underpinned by the UAE's stated intention to forgo enrichment and reprocessing, has a term of 30 years and "permits the transfer of technology, material, equipment (including reactors), and components for nuclear research and nuclear power production."

Notable provisions of the agreement include:

- Article 7, which makes the commitment of the UAE to forgo enrichment and reprocessing a legally binding provision between the UAE and the United States.

- Article 13, which makes provision in the case of the UAE's violation of Article 7 for the cessation of nuclear cooperation between the United States and the return of items transferred under the agreement.

- A provision giving the United States the right to require the removal of fissionable material subject to the agreement from the UAE in "exceptional circumstances of concern."

- A provision that the terms afforded to the UAE in the deal will be "no less favorable in scope and effect" than those between the United States and any other non-nuclear-weapon State in the Middle East in future nuclear cooperation agreements.[21] Under the agreement the UAE retains the right to renegotiate the terms of the 123 agreement if the US grants more favorable terms to another country in the Middle East.

The agreement also includes an "agreed minute" that grants the United States prior approval of

[19] International Advisory Board, "Semi-Annual Report."
[20] Press Release, Office of the Press Secretary, The White House, May 21, 2009. (http://www.whitehouse.gov/the_press_office/Message-from-the-President-on-the-US-UAE-Peaceful-Uses-of-Nuclear-Energy-Agreement/.)
[21] Ibid.

any retransfer of irradiated nuclear material to France and the United Kingdom for storage or reprocessing. The minute states that, in the case of such transfers, the material would have to be held within the European Atomic Energy Community and subject to the agreement between the United States and EURATOM.

Other Bilateral Agreements

Nuclear Cooperation Agreements. In addition to the nuclear cooperation agreement with the United States, the UAE has several other cooperation agreements in effect with other countries including:

- France (2008)
- South Korea (2009)
- United Kingdom (2010)
- Japan (signed 2009, implementation pending)

Cooperation with the IAEA. The UAE has a long history of cooperation with the IAEA dating back to 1977 when it began its first technical cooperation agreement. The country has stated that its nuclear power program is based on the principles outlined in the IAEA's *Milestones* document and that the program will conform to the IAEA's standards. The foundation and structure of FANR were explicitly informed by IAEA documents and guidelines.

Having founded its regulator, NEPIO, and nuclear-related academic programs in cooperation with the IAEA, the UAE has continued to work with the agency as it builds out its program. In January 2011, the IAEA sent a delegation to conduct an Integrated Nuclear Infrastructure Review (INIR), a complementary process to the guidelines and standards laid out in the *Milestones* document. The INIR is conducted at the request of a member state and involves an assessment of a country's progress toward the development of a civil nuclear program. The IAEA INIR mission to the UAE in 2011 found that the program was "progressing well." It highlighted several areas of the UAE's program that it considered "good practices for other countries starting nuclear power programs to consider." These included "cooperation without compromising their independence between the regulatory bodies and utility, human resource development, a well-structured management system, and a strong safety culture."[22]

Various UAE ministries and government institutions have also held workshops in Abu Dhabi with representatives from the IAEA including a session on Human Resource Development in March 2010 and a session in March 2011 on safeguards commitments.

Summary and Findings

Aside from Iran, the UAE has made the most progress toward the development of a civil nuclear program in the Middle East to date. The UAE's stated rationale for the program—rapidly increasing electricity demand—is borne out by the country's energy projections, which show an urgent need for increased power-generation capacity. The UAE's program is supported by the country's sovereign wealth, which has enabled it to purchase an initial group of reactors and to engage the services of the world's leading consultants and personnel. However, while the landmark multi-billion dollar deal between the UAE and South Korea may be the most high-profile aspect of the program, the UAE's approach to civil nuclear power has been informed and underpinned by a clear strategy. Through the formulation of a high-level policy document (the White Paper), the UAE communicated its intentions and priorities to the global

[22] "IAEA Reviews Progress of UAE Nuclear Power Programme," International Atomic Energy Agency Staff Report, January 24, 2011 (http://www.iaea.org/newscenter/news/2011/npprogramme.html).

community in a way that sought to allay fears and justify the need for a peaceful nuclear program. Through cooperation with the IAEA, other nuclear-power states, and expatriate consultants, the UAE has engaged the international community in its program from an early stage. The choice of the Korean APR1400 reactor fulfilled the White Paper's commitment to third-generation, once-through reactor technology. While the APR1400 reactor design does not incorporate some of the most advanced safety features available (such as double containment structures and core catchers available on the EPR), it has been approved by the Korean Institute of National Safety (KINS) and is based on a design previously approved by the US Nuclear Regulatory Commission.

The UAE has expressed a willingness to base its nuclear program development around the broad tenets of the IAEA Milestones approach, while attempting to institute its nuclear program according to an accelerated schedule. In addition, the regulator and the operator have worked closely together to identify the human resource development needs that must be met to insure that the reactors will be run in a safe and efficient manner.

The UAE's timetable for implementation of its program is ambitious and unprecedented, with less than ten years between the publication of the policy document and the planned connection of the first reactor to the grid. While this schedule has been the cause of some skepticism (particularly in the early stages of the program's design) and concern (it is faster than the IAEA's suggested average for a country with a "little-developed technical base"), the UAE has demonstrated an understanding of the need for a methodical approach to each of the central aspects of a nuclear program.[23] According to the IAEA, the UAE's development of a regulatory and operational framework for its nuclear program is progressing well and there are several aspects of the UAE's approach to its nuclear program that could serve as a model for other countries looking to implement civil nuclear programs. In its first six-monthly report, the UAE's IAB also delivered a positive assessment of the program's institutional development and integrity, with "strong evidence of commitment to regulatory independence and competence, […] serious commitment to the establishment of a strong safety culture, […] and evidence to the program's commitment to transparency."

In the field of human-resource development, the UAE has shown an awareness of the need for a systematic approach to building indigenous technical capacity for its program. However, the composition of its regulator is an indication that the country will have to rely on expatriate expertise in the short-to-medium term. According to several authorities consulted in the course of this research, the ability of the UAE to build a broad domestic knowledge base will be critical to the success of its nuclear program. There is some concern that an increased reliance on imported expertise will leave the UAE's nuclear program at risk of being unsustainable. The issue of human resources is also one in which the UAE's program may not serve as an applicable model for other states in the region: given the finite amount of global nuclear expertise (particularly in light of the relative stagnation of nuclear training and education in the United States and Europe over the last 20 years), countries looking to develop new nuclear programs will find themselves competing for scarce talent, particularly with regard to operational and regulatory experience. In such an environment, the richer countries able to offer the most attractive employment terms—such as the UAE—will have an advantage over those with fewer resources. For the latter, there may be limited opportunity to import the necessary human capital to get their programs up and running, particularly if many of

[23] "Milestones in the Development of a National Infrastructure for Nuclear Power," International Atomic Energy Agency, 2007.

the leading candidates have already been engaged by well-funded early-movers in the region.

The UAE's nuclear cooperation agreement with the United States was a clear statement that the country was willing to forgo its rights to enrich and reprocess nuclear fuel as the price for convincing the world of its peaceful intentions. The decision by the UAE to enter into the agreement has ramifications for other countries in the region: if the latter wish to engage in nuclear commerce with the United States (and other states whose products and services use U.S. components), they will have to abide, at minimum, by the same conditions as those accepted by the UAE; otherwise, the United States will have to offer any more lenient terms offered to those countries to the UAE. UAE officials maintain that they have absolutely no interest in reprising the terms of the US-UAE agreement and that their program is one that is specifically designed to eliminate all aspects of the front end of the nuclear fuel cycle.

While the UAE has made a definitive statement on its intention to forswear all aspects of enrichment and reprocessing, there remain unanswered questions about other aspects of the fuel cycle. According to the UAE government, the agreement with KEPCO makes provision for "nuclear fuel supply and operation and maintenance support." According to a regulatory filing, KEPCO will supply fuel for the program for the first three years of operations. Beyond that, there is currently no public policy for fuel supply. In March 2011, Australian foreign minister Kevin Rudd said that his country was working toward a bilateral uranium trade deal with the UAE; however at the time of writing, no such agreement had been finalized. In 2008, the UAE announced that it had pledged $10 million toward an international fuel bank initiative comprising a stockpile of low-enriched uranium fuel administered by the IAEA. The IAEA's governing body approved the multilateral fuel-supply facility in December 2010.[24] Whether through bilateral agreements or a multilateral mechanism, the secure supply of fuel will be a priority for the UAE nuclear program.

There is also a need for the UAE, like many other nuclear-power nations, to establish a policy for the long-term storage and disposal of its spent fuel. The Roadmap provides several recommendations for the management of spent fuel, including the negotiations of fuel take back agreements with suppliers and the development of a strategy for ultimate disposition of spent fuel. According to the International Advisory Board's report of late 2010, the UAE government understands that it needs to develop a comprehensive spent fuel policy. The report recommends that the UAE program "accelerate the development of an integrated fuel cycle strategy, including methods for securing long term fuel supplies, as well as arrangements for covering the costs of decommissioning of nuclear facilities and the management of spent fuel and other nuclear waste." At the time of writing, such a strategy had not been made public.

Civil Nuclear Power in Jordan

Energy Context and Origins of the Nuclear Energy Program

Jordan is confronted with serious challenges in its energy sector. Rising energy demand and a lack of domestic resources hinder economic development and growth saddling the country with high energy costs. This situation worsened as oil prices escalated throughout the first decade of the 21st century and has prompted the government to intensify its efforts to diversify the energy economy, especially through the development of domestic energy resources. Demand for energy is rising, exacerbating the country's resource

[24] "Assurance of Nuclear Fuel Supply: Resolution adopted by the Board of Governors on 3 December 2010," International Atomic Energy Agency Board of Governors, GOV/2010/70, December 3, 2010.

constraints and fossil fuel dependence. Jordan's National Master Strategy of Energy (NMSE) projects that primary energy demand will increase between 4.5 percent and 6.2 percent annually between 2007 and 2020, depending on low and high growth-scenario assumptions respectively.[25]

Demand growth in the electricity sector is expected to increase at an annual rate of 7.4 percent from 2007 to 2020. Meeting this demand will require an additional 4,000 MW at a cost of $4.2-$5.2 billion, excluding transmission.[26] The electricity sector accounts for a growing portion of primary energy consumption, rising from 35 percent in 2006 to 45 percent of total energy use in 2009.[27]

The country is highly dependent on imports, which accounted for 96 percent of all energy use in 2007. Moreover, fossil fuels dominate the energy sector, accounting for 98 percent of all energy consumption in 2009. This profile has severe environmental implications, in particular contributing to local pollution and greenhouse-gas emissions. The cost of imported fossil energy has risen dramatically, from USD $1.1 billion 2003 to $3.9 billion in 2008. This import bill accounts for an increasingly large share of GDP: from 11 percent of GDP in 2003 to 20 percent in 2008.[28] The severity of Jordan's dependence in the energy sector has been starkly illustrated in the first half of 2011. The country relies on imports of Egyptian natural gas through the Arab Gas Pipeline for 80 percent of its electricity generation, but this supply has been disrupted as a result of four separate attacks on the pipeline in Egypt.[29] The Ministry of Finance estimates that gas supply disruptions in the first half of 2011 cost Jordan JD 637 million (USD $895 million).[30]

Water scarcity is also a major factor in Jordan's energy future. In the summer, water access is especially scarce, with supplies sometimes available only one day per week, according to the Water Authority of Jordan.[31] With rising energy demand and population growth, as well as limited indigenous water resources, demand for water is rapidly outstripping supply. Currently it is estimated that water demand exceeds supply by 30 percent; if this trend continues, per-capita water supply could decline to levels that categorize Jordan as having an absolute water shortage.[32] To address this situation, one option being discussed on the supply side is building desalination capacity, but such facilities also require large amounts of electricity.

Given its worsening energy security situation, Jordan is seriously considering nuclear power. The Kingdom has an advanced program in place with committed plans and is developing a legal

[25] "Summary: Update Master Strategy of the Energy Sector in Jordan for the Period 2007-2020," National Master Strategy for Energy (NMES), Hashemite Kingdom of Jordan, December 2007. (NMES, December 2007).
[26] Ibid.
[27] "Jordan's Nuclear Energy Program," Presentation by Khaled Touqan, then-Chairman of the Jordan Atomic Energy Commission, to Brookings research team, in Amman, Jordan, February 2011. (JAEC, February 2011).
[28] Ibid.
[29] Ibid.
[30] "The Energy Sector in Jordan," Presentation by the Jordan Electricity Regulatory Commission to the ERC/NARUC Partnership, May 3-7, 2009, in Amman, Jordan. (ERC, May 2009). The current gas supply agreement calls for Egypt to supply 240 million cubic meters of gas per day over a 12-year period, at prices 30 percent below international market value. Egypt is currently trying to re-negotiate this agreement by providing some gas at this original price but pricing the rest at incremental rates. See "Egypt insists on change to gas deal," *Jordan Times*, April 15, 2011.
[31] "Private Sector Participation," Water Authority of Jordan, Hashemite Kingdom of Jordan (http://www.waj.gov.jo/sites/en-us/SitePages/About%20WAJ/Privatization.aspx).
[32] JAEC, February 2011; and Mousa S. Mohsen, "Water Strategies and Potential of Desalination in Jordan," *Desalination*, Volume 203, Issues 1-3, February 2007.

and regulatory infrastructure to support it.[33] In July 2004, King Abdallah II authorized a Royal Commission to review and update the NMSE "with the aim to…improve the level of availability and openness of the energy market…and achieve energy supply security."[34] The Commission modeled a number of scenarios examining the costs and benefits of various electricity sector portfolios, and reached the conclusion that a mechanism should be developed to promote nuclear power as part of the country's overall electricity generation expansion program. On January 19, 2007, the King announced that Jordan was "looking at nuclear power for peaceful and energy purposes."[35] Several days later, the Ministry of Energy announced that a Higher Committee for Nuclear Strategy, chaired by the King, was being formed to examine the requirements for a 600 MW reactor, the principal nuclear scenario examined by the Royal Commission updating the NMSE.

As assessment of the broad feasibility of a civil nuclear energy program progressed, another important development emerged in 2007 that influenced the process: the government announced that uranium had been discovered in central Jordan, and that a further potential for uranium extraction was possible from the country's large phosphate deposits.[36] On August 27, 2007, King Abdallah chaired a meeting of the Higher Committee for Nuclear Strategy during which the Vice President of the Committee, Dr. Khaled Touqan (now Minister of Energy and Mineral Resources), provided a status update on the development of a nuclear energy strategy. Dr. Touqan announced that it was feasible for nuclear energy to account for 30 percent of total energy generated in the Kingdom by 2030, and that Jordan could become a net exporter of energy in that timeframe.[37] The decision to incorporate nuclear energy as part of Jordan's energy mix was formalized with the publication of the updated NMES in December 2007. The strategy calls for six percent of Jordan's energy mix to be met by nuclear power by 2020.

According to the Jordan Atomic Energy Commission (JAEC), the benefits of a civil nuclear energy program for Jordan include:[38]

- Increased energy independence
- Provision of electricity at a reasonable price
- Revenue and grid stability opportunities through exports
- The opportunity to utilize the country's uranium deposits
- The opportunity to develop nuclear capabilities in project development, design, construction, and plant operation
- Infrastructure upgrades, job creation, provision of services, and education of workforce
- A reduction of carbon-dioxide emissions
- Support for major infrastructure projects, such as the Red Sea-Dead Sea Canal project

The Government of Jordan has outlined five key components for its national nuclear energy strategy:[39]

- Generation Policy: nuclear power will meet demand for electricity and desalination through a privatized entity with

[33] As categorized by the World Nuclear Association. See, http://www.world-nuclear.org/info/inf102.html.
[34] NMES, December 2007.
[35] "King Abdullah to Haaretz: Jordan aims to develop nuclear power." *El Haaretz*, January 19, 2007.
[36] "Jordan: Uranium Hotspot," *Industrial Fuels and Power,* January 14, 2010 (http://www.ifandp.com/article/00560.html).
[37] "King urges speeding up nuclear energy programme." *Jordan Times*, August 27, 2007.
[38] "Jordan's Nuclear Power Program," Presentation by Kamal J. Araj, Jordan Atomic Energy Commission, to The First Arab Conference on the Prospects of Nuclear Power for Electricity Generation and Seawater Desalination, June 23-26, in Tunisia. (JAEC, June 2010).
[39] Ibid.

government equity (a public-private partnership model)
- Uranium Exploitation Policy: the government will maximize sovereignty while creating value from the resource base
- Fuel Cycle: the government will seek to negotiate assurances for fuel services including waste disposal
- Preparation: the government will prioritize investment for nuclear-related studies; training and HR; and infrastructure
- Funding: the government will investigate creative financing methods that minimize its resources

Technology and Commercial Model

Jordan's objective is to have a 700-1200 MW generation III or generation III+ reactor operating by 2019.[40] With just 2,400 MW in existing installed capacity, such a reactor would comprise up to half of the country's national electric grid, far more than the ten percent which is the maximum electricity share most experts recommend for one generation facility. To deal with this issue JAEC, the body responsible for development and implementation of the program, has conducted grid capacity studies to assess how to accommodate the planned nuclear power plants. The conclusion of these studies is that, with Jordan's electricity generation capacity expected to grow through the addition of non-nuclear generation—such as natural gas—and through the possible establishment and expansion of interconnections and export agreements with its neighbors, the grid will be large enough to accommodate a nuclear facility.[41] Nevertheless, expanding interconnections and exports will be a major undertaking in a volatile region.

To achieve its goals, JAEC is overseeing the implementation of a two-track strategy involving the selection of an engineering, procurement, and construction (EPC) contractor to provide the reactor technology and construction; and the selection of a strategic partner to establish a joint utility to operate the plant. In January 2010, JAEC sent a questionnaire to nuclear vendors, responses to which were received in March 2010.[42] In May 2010, JAEC shortlisted three firms and technologies for its nuclear program:[43]

- Areva and Mitsubishi Heavy Industries (ATMEA 1)
- AECL Canada (CANDU-6)
- AtomStroyExport (AES-92 VVER-1000)

In January 2011, JAEC submitted a request for proposals (RFP) soliciting bids from the three shortlisted firms.[44] On June 30, 2011, JAEC accepted the technical bids and the winning firm is to be announced in December 2011.[45] A summary of JAEC's main criteria, issues and questions governing the solicitation process is illustrated in **Figure 2-1**. (In the aftermath of Fukushima, JAEC asked the shortlisted firms to include in their proposals details on their respective reactors' ability to withstand a similar seismic event.[46]

In addition to the nuclear vendors for EPC services, Jordan has solicited interest for a strategic partner for the utility operator. In February 2011, it requested bids from GDF Suez of France, Datang of China, Rosatom of Russia, and Kan-

[40] Ibid., and "Country Report: Jordan," *International Atomic Energy Agency,* July 2010 (http://www-pub.iaea.org/MTCD/publications/PDF/CNPP2010_CD/countryprofiles/Jordan/CNPP2010Jordan.htm). (IAEA, July 2010).
[41] Ibid.
[42] JAEC, June 2010.
[43] "Financing to influence choice of nuclear technology," *Jordan Times*, July 29, 2010.
[44] "Nuclear Commission to bring international company on board," *Jordan Times*, February 7, 2011
[45] "Jordan receives nuclear reactor bids," *The Jordan Times*, July 1, 2011.
[46] Ibid.

Figure 2-1: Reactor Vendor Selection Process

General Criteria for Selection of Reactor	Major Issues for Assessment	Overall Evaluation Process
▪ Safety and reliability (GEN III) ▪ Simplicity, standardization & modularization ▪ Waste considerations ▪ Diversion-Resistance ▪ Cost considerations ▪ Fuel cycle considerations ▪ Desalination compatibility ▪ Cooling water requirements ▪ Potential spin-off industry ▪ Size 700-? MWe	▪ Economics and plant size ▪ Operability/Reliability/ Maintainability ▪ Constructability including schedule ▪ Licensability and safety ▪ Project related issues including national participation & infrastructure development ▪ Owner's scope of supply ▪ Supplier and vendor issues including capabilities ▪ Financing options ▪ Sustainability	What are the deliverables to ensure the country is ready? What are the impacts on job creation and technology transfer? What is the approach to resolve our financial constraints? What is the wealth creation to Jordan from Uranium assets? How does the proposal address fuel cycle, including fuel security, costs and waste management? How does the proposed generation technology meet our selection criteria for the reactor? What is the safety record of the operator?

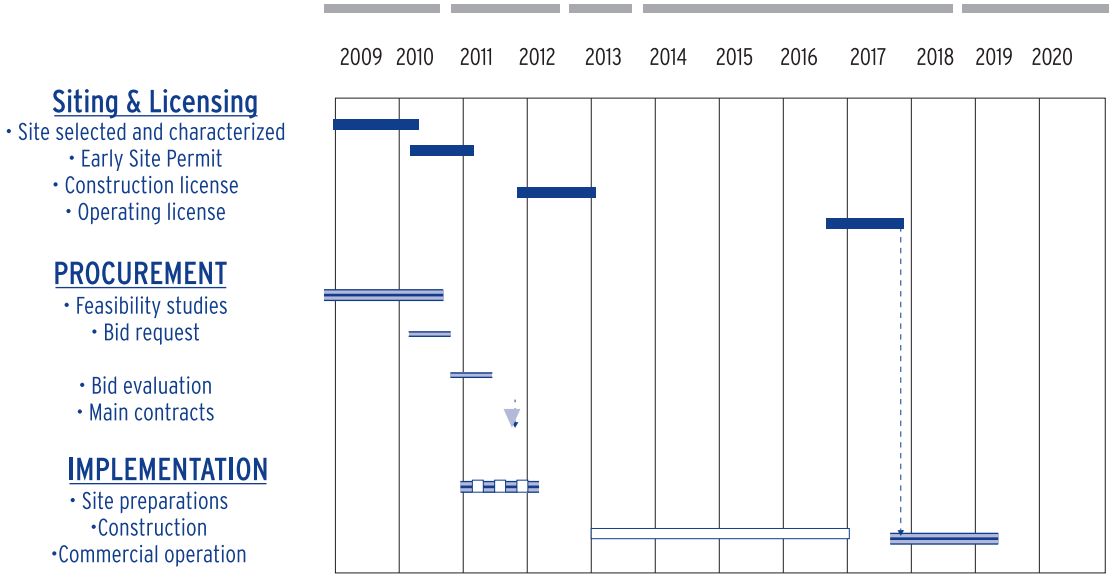
Source: Jordan Atomic Energy Commission

sai Electric Power of Japan.[47] It is not clear if the choice of reactor will affect the choice of strategic partner. Under the business model that JAEC has proposed, the strategic partner and the government will own 50 percent, and the remaining 50 percent will be open to other investors. The operator of the plant will sell electricity to Jordan's National Electric Power Company (NEPCO), which is the transmission asset provider and system operator in Jordan, under a Power Purchase Agreement (PPA).[48] It is envisioned that the financing structure for the project will be a typical limited recourse financing approach, with debt (70 percent) and equity (30 percent) provided from a variety of sources. The Jordanian government will also contribute financing, principally from uranium mining revenues. **Figure 2-2** provides an overview of the timetable for implementing Jordan's first nuclear power plant.

To support the nuclear program's implementation, JAEC retained the services of two international engineering consulting firms. In September 2009, JAEC selected Tractebel of Belgium to do siting and environmental studies for a plant location near Aqaba.[49] Based on initial studies, the site near Aqaba is now viewed as suboptimal, owing to concerns over added costs to accommodate potential seismic activity, distance from the grid, and water requirements. JAEC has identified a new site in

[47] "Jordan reaches out to nuclear plant operators," *Jordan Times*, February 22, 2011.
[48] Ibid and JAEC, February 2011. NEPCO functions as the single buyer in Jordan.
[49] "Tractebel awarded Jordanian contract," *World Nuclear News*, September 14, 2009.

Figure 2-2: Schedule for Nuclear Power Plant



Source: Jordan Atomic Energy Commission

Majdal, 40 kilometers north of Amman that will be at the "center of the grid and electricity load," and will use recycled water from the Khirbet Al Samra water treatment plant.[50] (Jordanian officials travelled to the Palo Verde power plant in Arizona, which uses a similar technology.) In November 2009, JAEC awarded a 2-year pre-construction consulting services contract to WorleyParsons, an Australian consultancy to assist in feasibility and financial assessment, optimization studies, technology assessment, tender preparation and evaluation, and preparation of contractual options.[51]

Exploration and Mining

JAEC indicated in December 2010 that the central region of the country has 70,000 metric tonnes of uranium (tU), and that reserves that could be extracted from phosphate total 140,000 tU countrywide. Uranium exploration in central Jordan is at an advanced stage, with Areva of France becoming a key partner in assessing the country's uranium resources. Following the signing of a nuclear cooperation agreement between Jordan and France in August 2008, the government of Jordan signed an exploration agreement with Areva for exploration in Central Jordan. This agreement created two shareholding companies: Nabatean Energy, a joint venture between JAEC (51 percent) and Areva (49 percent); and Jordanian French Uranium Mining Co (JFMUC), a joint venture between Areva (50 percent) and Jordan Energy Resources, Inc (50 percent).[52] Within a year of the signing of the Exploration Agreement, JFMUC had focused on a 100 square kilometer area within the overall concession, drilling 9,680 samples and finding high grade uranium averaging 400 parts per million (ppm) near surface level.[53] In February 2010, the exploration agreement was upgraded to a mining agreement, granting

[50] "JAEC changes nuclear reactor site," *Jordan Times*, December 10, 2011.
[51] "WorleyParsons awarded Jordanian contract," *World Nuclear News*, November 16, 2009.
[52] JERI is Jordan Energy Resources Inc., the commercial branch of JAEC established in August 2007. See JAEC, February 2011.
[53] "Kingdom's uranium prospects 'promising'," *Jordan Times,* October 21, 2009.

Areva a 25-year concession for a 1,469 square kilometer area.[54] It is expected that uranium production in the central part of the country will become operational in 2013 with a production rate of 2,000 tU annually.[55]

Exploration is also taking place in other parts of the country, although results are not yet confirmed. Rio Tinto recently ceased its exploration activities in Wadi Sahab Abiad in southern Jordan citing lack of commercially viable deposits, although Jordan Energy Resources has taken over operations and maintains that the region merits further study.[56] JAEC has also retained the Chinese firm Sino-Uranium to explore in the Eastern Desert region.[57]

Jordan is currently establishing a "uranium atlas" of the country, and has also discovered some quantities of zirconium and thorium. JAEC has indicated that Jordan's overall strategy is to "secure fuel for our plants" and to use the proceeds from uranium extraction to help fund the development and establishment of its first nuclear power plant.[58]

Institutions and Principal Legal Framework

In July 2007, the existing legal and regulatory framework governing nuclear activities in Jordan was amended and two new laws instituted:[59]

- Nuclear Energy Law No. 42 for the Year 2007 (Law 42/2007), creating the Jordan Atomic Energy Commission (JAEC);
- Nuclear Safety and Security and Radiation Protection Law No. 43 for the Year 2007 (Law 43/2007), creating the Jordan Nuclear Regulatory Commission (JNRC).[60]

This framework separated management and promotion of the nuclear program under the Jordan Atomic Energy Commission from regulatory activities under the Jordan Nuclear Regulatory Commission. Both organizations are under the portfolio of the prime minister, and are governed by a board of directors with broad representation, including from other relevant government agencies.

More specific details on the role and functions of each are presented below.

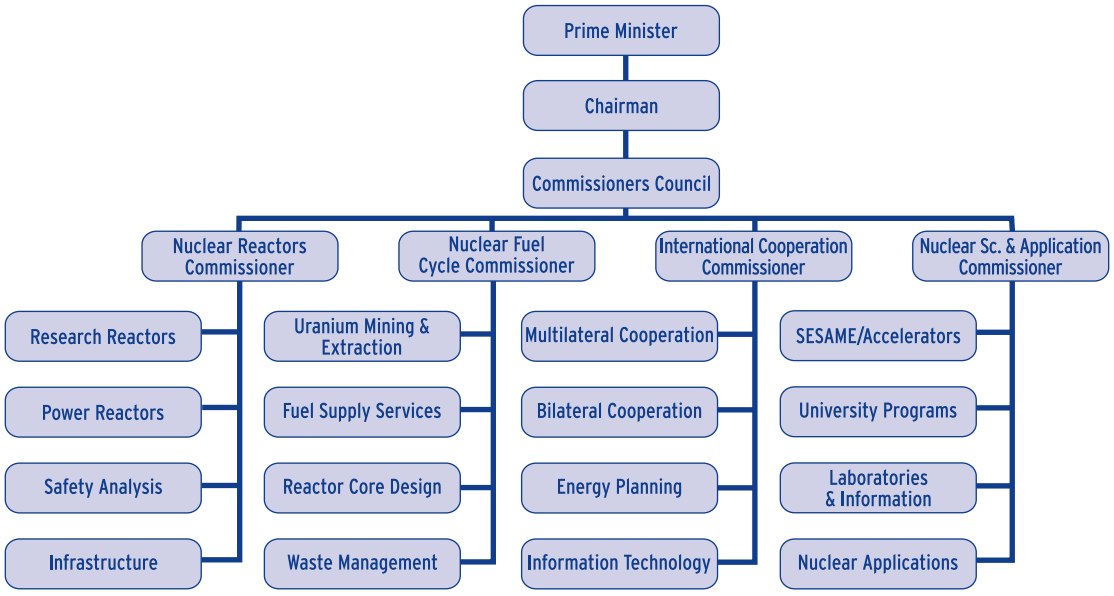
Jordan Atomic Energy Commission

JAEC is responsible for overall nuclear policy and strategy, and managing the development and implementation of the civil nuclear power program. The Commission is currently working in three main areas: exploration and mining; nuclear power projects; and a subcritical assembly and research reactor.

According to Law 42/2007, JAEC is responsible for the management of nuclear materials through the entire fuel cycle. As such, JAEC established a 250 square meter interim storage facility for low level radioactive waste in 2009. The Commission

[54] JAEC, February 2011
[55] "Jordan: Uranium Hotspot" *Industrial Fuels and Power,* January 14, 2010. (http://www.ifandp.com/article/00560.html). By way of comparison, the US produced 1,453 tonnes of uranium in 2009 and the world's largest producer, Kazakhstan, produced 14,000 tonnes in the same year (see World Nuclear Association).
[56] "Mining giant withdraws from uranium prospecting in southern region," *Jordan Times*, April 20, 2011.
[57] "Kingdom's uranium prospects 'promising'," *Jordan Times*, October 21, 2009.
[58] From an interview with JAEC officials, February 2011.
[59] Prior to 2001, nuclear activities were the responsibility of the Nuclear Energy Department within the Ministry of Energy & Mineral Resources (MEMR). In 2001, the Nuclear Energy and Radiation Protection Law (No. 29/2001) established a Jordan National Energy Commission with a mandate for promotion and regulation of nuclear activities. See presentation by Jamal Sharaf, Jordan Nuclear Regulatory Commission, March 2010.
[60] Law 43/2007 initially established the entity as the Radiation and Nuclear Regulatory Commission; but the law was amended in May 2008 to set up the JNRC.

Figure 2-3: JAEC Organizational Chart



Source: Jordan Atomic Energy Commission

is in the process of developing a long-term waste management strategy and is also reviewing for signature the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.[61]

Law 42/2007 also calls for JAEC to promote nuclear power and ensure that civil society is informed of all aspects of the civil nuclear energy program. Specifically, Article 10(a6) states that it is the Commission's responsibility for "issuing leaflets and preparing the necessary media programs to raise public awareness of the importance of the use of nuclear energy and radiation technology and its positive impact on economic and social development plans." As an example of JAEC's public outreach, the commission hosted a National Public Information Seminar on the Facts of Nuclear Power (supported by the IAEA) in December 2010 to discuss Jordan's nuclear energy program. It was attended by NGOs, government agencies, and other organizations. The chairman of JAEC indicated that the Commission intended to make this an annual event. He further stated that JAEC is working on a White Paper describing the nuclear program and its rationale, benefits and challenges, and that it will be made available to the public in 2011.

There has been growing opposition to the nuclear power program in Jordan, especially since the proposed site for the country's first nuclear plant was moved from the Aqaba region to a location northeast of Amman. A local tribe has been very vocal in its criticism and a coalition called Irhamouna has been leading protests and an anti-nuclear campaign.[62] Opposition has been galvanized further by the Fukushima accident, since which there have been several anti-nuclear protests in Amman, including one in front of the Prime Minister's office.

[61] "Country Report: Jordan," International Atomic Energy Agency, July 2010.
[62] "Jordan's anti-nuclear movement gains steam," *Jordan Times*, August 1, 2011.

Jordan Nuclear Regulatory Commission

The Jordan Nuclear Regulatory Commission (JNRC) is the independent government body responsible for regulating all nuclear activity and facilities in Jordan. As stated in JNRC's Strategic Plan 2010-2014, its primary goal is "to regulate the safe use of nuclear materials and technologies and radioactive sources and nuclear installations (in the future) for peaceful purposes to ensure the protection of public health and safety, workers and the environment." JNRC's principal, specific responsibilities are licensing facilities, preparing the legislative framework, and establishing a system for inventory and accounting of nuclear materials.[63]

While Law 43/2007 covers nuclear energy, the JNRC found that it was inadequate in its scope and was more directed toward radiation issues than toward nuclear power. In addition, Article 26 of the Law calls for the drafting of specific regulations to implement the Commission's mandate. As a result JNRC, with the assistance of the IAEA and Worley Parsons, is working on further implementing the legal and regulatory framework. The new draft law was submitted in 2010.[64]

Near-term priorities for JNRC are drafting licenses for the Subcritical Assembly (JSA) and Jordan Research and Training Reactor (JRTR), and regulations for extraction and transport of uranium.[65]

JAEC currently has 171 total staff with the following number of technical personnel by function:[66]

- Nuclear Safety and Security Directorate (10)
- Radiation Protection Directorate (13)
- Supportive Technical Services Directorate (9)
- Border Control Directorate (104)

JNRC has drafted a detailed staff development plan calling for 321 total staff by 2014, designed to coincide with the progress of the nuclear program to ensure that the requisite skills align with the corresponding stages of the program.

Like JAEC, JNRC also has a public awareness mandate: Article 10(a7) of *Law 43/2007* calls for JNRC "to issue leaflets and prepare the necessary media programs to raise public awareness of the importance of radiation protection, and enhance the culture of nuclear safety and security."

Training and Education

Jordan's basic human resources development approach involves the use of both international and domestic mechanisms with an underlying focus on establishing domestic skills for each stage of the nuclear program. Its strategy is based on the recognition that a situation in which Jordanian nationals are "involved in every aspect of a nuclear power plant will take a generation."[67]

JAEC is coordinating an approach to human-resource development that incorporates several core elements, including basic training for new staff (nuclear theory, general plant system, etc.); practical training to improve existing staff's expertise (operation, mechanical, electrical, instruments and control, core and fuel, safety, etc.); and specialized training, including project-management skills training in regulatory compliance.[68] It

[63] According to Jordan Nuclear Regulatory Commission's Strategic Plan.
[64] Ibid.
[65] "JNRC steps up efforts as nuclear program gains steam," *Jordan Times*, March 7, 2011.
[66] According to JNRC's Strategic Plan.
[67] Comment from a JAEC official, quoted in "Education key to Jordan nuclear future – experts." *Jordan Times*, December 17, 2010.
[68] "Human Resource Planning for Jordan's Nuclear Programme," Kamal Araj, Jordan Atomic Energy Commission, Presentation to the International Atomic Energy Agency Technical Meeting on "Workforce Planning to Support New Nuclear Power Programmes," on March 31-April 2, 2010. (JAEC, March 2010).

is doing this through a variety of formal domestic university programs and vocational training programs.

University Programs

In 2007, the Jordan University of Science and Technology (JUST) established a nuclear engineering department with five faculty members. The department seeks to train future reactor operators holding BSc degrees in nuclear engineering and offers a five-year course of study with 160 credit hours. The program currently has 145 students, and the first batch of 19 students will graduate in June 2011. JUST has also signed a number of cooperation agreements with international academic institutions including North Carolina State University, University of Illinois, Ohio State University, and the University of California.[69]

Al Balqa Applied University (BAU) has also launched a Master's of Science (MSc) program in nuclear physics with capacity for around five students per year. In 2009, the program graduated nine students all of whom went to work at JNRC. The program is currently on hold, although it continues to receive considerable interest.[70] The University of Jordan (UJ) has started an MSc in nuclear physics with about ten graduates per year, and is in the process of establishing a curriculum related to nuclear power project management and nuclear safety. Other formal educational initiatives related to nuclear power include training and expert visits with top laboratories, IAEA technical cooperation programs, and external training and scholarships.

Training Reactor and Facilities

Jordan has also developed a strategy of establishing nuclear facilities to support local human resources training and the development of a knowledge infrastructure. To achieve this objective, JAEC has instituted two programs: the building of a subcritical assembly and a Jordan Research and Training Reactor (JRTR), both at JUST. In November 2008, JAEC signed a contract with the China Institute of Atomic Energy for the construction of the JSA, which would allow students to "modify core configurations, work closely with the reactor core, and familiarize themselves with the basic features of the reactor."[71] In December 2009, JAEC awarded a consortium of the Korean Atomic Energy Research Institute (KAERI) and the Daewoo Engineering & Construction a $173 million contract for construction of the 5 MW JRTR at JUST.[72] The JRTR is expected to be commissioned in 2015 and will produce radioisotopes for medicine, agriculture, and industry; provide training facilities; and serve as a Nuclear Science and Technology Center.[73]

In recognition of the current lack of local expertise, Jordan has tried to ensure that external vendors, suppliers and consultants transfer know-how as part of their activities. These efforts include the inclusion of training as part of every contract that JAEC negotiates; the inclusion of project management training as part of the pre-construction consultancy services with WorleyParsons; and the inclusion of nuclear-operator training in the contract for the nuclear power plant.

[69] The NC State collaboration links students with a virtual reactor (1 MW PULSTAR research reactor). "Education key to Jordan nuclear future – experts." *Jordan Times,* December 17, 2010.
[70] Based on interviews with JNRC officials in February 2011.
[71] "Project overview of Jordan's first nuclear facility," Presentation by Dr. Ned Xoubi, JSA, to the CEA Mission on the SR of Subcritical Assemblies, December 5, 2010 in Amman, Jordan.
[72] "Korean consortium for Jordan's first reactor," *World Nuclear News*, December 7, 2009.
[73] JAEC, February 2011.

The government is also establishing a virtual Center of Excellence, designed to bring together major organizations to establish training programs not provided by existing entities. The entities participating are JAEC, UJ, BAU, JUST, the German-Jordanian University, and the Ministries of Labor, Public Sector Development, and Higher Education & Scientific Research.

Regulatory Training

Jordan is also aware that it needs to build regulatory expertise. According to interviews with the Brookings research team, JNRC sees its major challenge as human resources development.[74] At the outset, the Commission sought to recruit new graduates locally, but soon found this was insufficient. JNRC's approach is now to engage all domestic and international assistance possible. Domestically, the Commission is planning to establish a national Technical Support Organization (TSO), which would function as a specialist entity outside JNRC to provide specific technical assistance to the Commission, especially in the realm of nuclear safety. JNRC has also started pilot relationships with other nuclear regulators, including a MoU with the European Union for technical assistance from European regulators.

The JNRC is also participating in an IAEA initiative called the Regulatory Cooperation Forum (RCF)—designed to pool regulatory expertise from existing, mature nuclear power member states, and share that expertise with nascent nuclear regulators in states with no current program. The RCF is intended to avoid overlap that might occur from individual regulatory bodies providing assistance to JNRC. Jordan is the first test case for the Forum and the RCF organized a visit to Jordan in September 2010 to assess the Commission, defining 12 areas of technical assistance needs.

International Agreements and Cooperation

In January 2010, King Abdallah clearly stated Jordan's intention to adhere to all international obligations regarding the peaceful use of nuclear energy stating that, "we are actually looking at nuclear power for peaceful and energy purposes… I personally believe that any country that has a nuclear program should conform to international regulations and should have international regulatory bodies that check to make sure that any nuclear program moves in the right direction."[75]

Jordan is a signatory to numerous international treaties and agreements:

- UN Treaty on Nonproliferation of Nuclear Weapons (1970)
- IAEA Convention on the Physical Protection of Nuclear Material (2009, Amendment accepted 2009)
- IAEA Convention on Early Notification of a Nuclear Accident (1988)
- IAEA Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1998)
- IAEA Convention on Nuclear Safety (2009)
- IAEA Application of Safeguards in Connection with the Treaty on the Nonproliferation of Nuclear Weapons (with protocol) (1978)
- IAEA Additional Protocol to the Agreement between the Hashemite Kingdom of Jordan and the IAEA for the Application (1998)

[74] Interviews conducted with JAEC officials February 2011.
[75] "King Abdullah to Haaretz: Jordan aims to develop nuclear power," *El Haaretz*, January 19, 2010. (http://www.haaretz.com/news/king-abdullah-to-haaretz-jordan-aims-to-develop-nuclear-power-1.210546.

Jordan is not a signatory to the Vienna Convention on Civil Liability for Nuclear Damage, or to the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention. The Government is in the process of reviewing the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

Bilateral Agreements

As part of securing external assistance for the development of its civil nuclear energy program, Jordan has entered into a variety of bilateral nuclear cooperation agreements with many countries:

- France (2008)
- China (2008)
- South Korea (2008)
- Canada (2009)
- Russia (2009)
- United Kingdom (2009)
- Argentina (2009)
- Japan (2010)
- Romania (2011)
- Spain (2011)
- Turkey (2011)

It has ongoing negotiations with the United States, Italy, and the Czech Republic.

Cooperation with the United States. In September 2007, Jordan and the United States signed a MoU for nuclear cooperation, under which funding and technology is being provided for border monitoring related to nuclear materials. Jordan is also a member of Global Nuclear Energy Partnership (GNEP), now the International Framework for Nuclear Energy Cooperation (IFNEC).[76]

Jordan does not have a formal nuclear cooperation agreement with the United States. While talks have been ongoing since 2008, the major issue is the US government's insistence on Jordan signing a "123 Agreement" under which Jordan would be required to forswear pursuit of domestic uranium enrichment. The United States would prefer that states rely on the existing commercial market for fuel cycle services, whereas Jordan does "not agree on applying conditions and restrictions outside of the NPT on a regional basis or a country-by-country basis."[77] More on Jordan's approach is detailed in the Summary and Findings section below.

Cooperation with the IAEA. Jordan became a member state of the IAEA in 1966 and, in addition to being a signatory to numerous IAEA conventions (noted above), has worked closely with the Agency since 1978. After King Abdallah's January 2007 announcement that Jordan was interested in civil nuclear energy, then IAEA Secretary General ElBaradei traveled to Amman to initiate more detailed technical assistance. For example, as part of its feasibility assessment for integrating nuclear power into the national energy mix, Jordan used an IAEA tool called MESSAGE, an optimization model for identifying least cost energy supply strategies.[78] In addition, Jordan has used the IAEA *Milestones* document to guide the overall planning and implementation of its nuclear energy program.[79] In August 2009, the IAEA conducted an Integrated Nuclear Infrastructure Review (INIR) mission to Jordan to assess the overall status of nuclear power

[76] IFNEC "provides a forum for cooperation among participating states to explore mutually beneficial approaches to ensure the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient and meets the highest standards of safety, security and non-proliferation. Participating states would not give up any rights and voluntarily engage to share the effort and gain the benefits of economical, peaceful nuclear energy, from IFNEC's *Statement of Mission* at http://www.ifnec.org/docs/IFNEC_StatementofMission.pdf.

[77] Jay Solomon, "Jordan's Nuclear Ambitions Pose Quandary for U.S.," *Wall Street Journal,* June 12, 2010. The quote is from Dr. Khaled Touqan, former Chairman of JAEC and current Minister of Energy and Mineral Resources.

[78] JAEC, June 2010.

[79] Based on interviews with JAEC officials in Amman, Jordan, February 2011.

infrastructure development and identify additional areas of assistance. As noted, the IAEA is also providing assistance to the JNRC in drafting regulations and changes to existing laws. In September 2010, Jordan gained a seat on the IAEA Board of Governors (for a two-year term).

Summary and Findings

The central factor in Jordan's decision to consider nuclear energy is its unsustainable domestic energy situation, especially in the power sector.[80] With rising demand and few natural resources, Jordan is highly dependent on imports of fossil fuels. This has serious ramifications for energy costs and broader deleterious impacts on the country's economic development and on the environment. Jordan's discovery of large, economically recoverable uranium resources has strengthened its interest in building nuclear power plants; the government views its uranium deposits as a potentially secure, domestic fuel source for its reactors, as well as a revenue source for the formation of a utility operating company for its first nuclear power plant.

Jordan has worked closely with the IAEA, seeking technical assistance for a nuclear energy program and having closely followed the IAEA's recommended framework and guidelines for the establishment of a nuclear infrastructure, *Milestones in the Development of a National Infrastructure for Nuclear Power*. It has conducted studies to assess the feasibility of adding nuclear power to the energy mix, begun the establishment of a legal and regulatory framework, and created two of the three main institutions cited by the IAEA as typically involved in the development of such a program: a government body responsible for the promotion and oversight of the overall program (JAEC), and a separate regulatory body (JNRC). The third institution, the owner-operator of the power plant, has yet to be determined (the procurement for the strategic partner was just initiated in late February 2011).

Jordan has also worked to meet the King's pledge to pursue a peaceful program in accordance with international norms; Amman has signed the Treaty on the Nonproliferation of Nuclear Weapons (NPT), an Additional Protocol, and other numerous international treaties and IAEA agreements. It is also actively working toward becoming a signatory to several other conventions. Jordan also has to date signed eleven nuclear cooperation agreements allowing it to work with, and share the experience of, existing nuclear states and those currently developing a civil nuclear energy program. The agreements also allow for vendors from the partnering countries to participate in the procurement process to develop a nuclear power plant.

To achieve its goal of building a nuclear power plant by 2019, JAEC has developed a two-track strategy incorporating a public-private partnership model. Jordan's approach to other stages of the fuel cycle is still evolving. The Minister of Energy and Mineral Resources, Dr. Khaled Touqan, recently said that Jordan will process its uranium ore to produce uranium ore concentrate (U_3O_8, or yellowcake), and then send it outside the country for enrichment.[81] However, he is not categorically ruling out the development of a domestic enrichment capability, stating, "we have signed international treaties that guarantee our right to enrichment and we will preserve this right under the supervision of the IAEA."[82] Nevertheless, Jordanian officials have also indicated that enrichment does not make economic sense given the limited scale

[80] The Government's energy diversification strategy also includes expanding renewable energy capacity, increasing imports of Iraqi oil, and considering an LNG import terminal in Aqaba.

[81] "Jordan to produce yellowcake by 2020," *Jordan Times*, June 24, 2011.

[82] Ibid. The Minister is speaking in the context of the US 123 Agreement discussions, and referring to Article IV of the NPT which states that, "nothing in [the NPT] shall be interpreted as affecting the inalienable right of all the Parties [to the NPT] to develop research, production and use of nuclear energy for peaceful purposes."

of its targeted nuclear reactor capacity. JAEC has indicated that it could envision Jordan developing a fuel fabrication capacity, perhaps located at the site of the JRTR at JUST. While a long-term waste management strategy is being assessed, officials have indicated that some type of leasing option is being discussed for spent fuel take-back. The near-to mid-term strategy appears to call for uranium ore to be processed into yellowcake in Jordan, enriched and fabricated into fuel outside the country, and for spent fuel to be removed and shipped outside the country under some lease-take-back mechanism.[83]

Jordan's development faces two major challenges: lack of financial resources and insufficient human resource capacity in the areas of expertise required. These factors have been critical in forming the specific pathway to achieve its goals. The government's PPP approach is an attempt to leverage outside funding and expertise and reduce the need for government funds, while maintaining domestic input and control. In addition, as noted, the mining of uranium resources will provide revenues for the government in support of its participation in the utility operating company.

With regards to human resource capacity, Jordan has crafted a multi-faceted approach to training, using many mechanisms both domestically and internationally to develop local capacity, as recommended by the IAEA (and as mentioned in the IAEA's *Milestones* document). The government realizes that it requires outside assistance for its nuclear program and has retained contractors such as WorleyParsons and Tractebel in addition to signing numerous nuclear cooperation agreements (NCAs) and other cooperative agreements. Jordan's international cooperation is complemented by its domestic human-resource development programs. The comprehensiveness of the Jordanian approach to developing local human resources capacity has raised the prospect of using its programs and facilities as a regional center for training. This theme is being discussed, especially around the idea of using the JRTR, once it is operational. Nevertheless, Jordan's technical capacity development strategy still faces challenges. There is a need to ensure that the development of skills keeps pace with the nuclear program itself, and that the requisite skills are available for, and tailored to match, the requirements of each stage of the program. The JNRC is aware of this issue and has drafted a five-year human resources strategy to account for the various stages of establishing a nuclear power program. There may also be a need to ensure that those Jordanians educated and trained in Jordan remain in the country. (There has already been an instance in which a technical expert from JNRC left to work in the nuclear industry of another country in the region.)

Nevertheless, significant obstacles remain. For a small country with a high level of debt and other economic challenges, a nuclear power project represents a significant financial investment. While the Jordanian government has cited the potential of a nuclear power program for job creation, it is not clear whether the domestic human resource capacity exists to meet the program's requirements. Moreover, unlike the UAE, Jordan does not have the financial resources to buy in external expertise on a comprehensive basis.

There are several other important risks and challenges that could pose challenges to Jordan's nuclear plans. First, the government's schedule for bringing the first reactor online by 2019—a timeline of about 12 years from the inception of the program—is very ambitious, and shorter than the IAEA's estimate of an average of 15 years for a country with "little-developed technical base." While it does appear that the program is broadly progressing according to the schedule illustrated in

[83] Based on interviews with government officials in February 2011.

Figure 2-2, the official timeline puts great pressure on a regulatory regime that is still being developed and finalized. Additional regulatory challenges are posed by the limited operational experience with the proposed cooling scheme for a reactor that relies on water supplies from a water treatment plant (an approach used in only one other location in the world);[84] and by the fact that one of Jordan's shortlisted reactor designs—the ATMEA 1—has yet to receive approval by its home regulatory authority.[85] It is also unclear how independent the JNRC is in practice. Its board consists of representatives from several other government agencies, including the JAEC, which is responsible for nuclear policy and the promotion of nuclear power.

Like many other countries in the region Jordan will need to continue to elaborate its longer-term strategy with regard to the nuclear fuel cycle and waste management. This is especially critical for waste management, which is often left inadequately addressed, as it pertains to the back-end of the fuel cycle. Finally, Jordan will need to continue to pay close attention to the area of stakeholder involvement, especially in the aftermath of events at the Fukushima Daiichi plant in Japan. With the nuclear plant located closer to Amman, public concerns will have to be addressed early and in a comprehensive manner.

Civil Nuclear Power in Turkey

Energy Context and Origins of a Nuclear Energy Program

Turkey's primary energy sector is characterized by a heavy reliance on hydrocarbon imports, which have risen in parallel with the country's strong economic growth over the last decade. In 2008, natural gas provided 31 percent of all total primary energy consumption, followed by coal and oil, each of which accounted for 30 percent.[86] (The remainder of Turkey's energy supply is provided by hydropower, geothermal, and combustible renewables and waste.) Imports account for 90 percent of oil consumption, nearly all natural gas consumption, and around 20 percent of total coal consumption.[87] Electricity generation is similarly dominated by fossil fuels, with natural gas providing 49 percent of power in 2008, followed by coal at 28 percent, and oil at 3 percent.[88]

Electricity use in Turkey has more than tripled in the last 20 years, from around 58 TWh in 1990 to 162 TWh in 2008. From 2001 to 2008, the country experienced average annual electricity consumption growth of 8.8 percent.[89] In order to meet the growing demand and to balance its grid, Turkey has become both an importer and exporter of electricity, and carries out electricity trade with most of its neighbors (including Bulgaria, Azerbaijan, Iran, Georgia, Armenia, Syria, Iraq and Greece).[90] An interconnection with Europe through the European Network of Transmission System Operators of Electricity (ENTSO-E) is also being explored.[91]

The vast majority of Turkey's electricity demand has been met with newly built gas-fired generation, which has increased by 48 TWh to 94.4 TWh/year, accounting for 72 percent of incremental generation growth from 2000-2009.[92] Turkey is in much the same situation as Jordan, in

[84] See http://www.pnm.com/systems/pv.htm.
[85] ASN, the French nuclear safety regulator is expected to complete its review of the reactor design in late 2011. See http://www.atmea-sas.com/scripts/ATMEA/publigen/content/templates/Show.asp?P=252&L=EN
[86] "2008 Energy Balance for Turkey," *International Energy Agency,* (http://iea.org/stats/balancetable.asp?COUNTRY_CODE=TR).
[87] "Country Analysis Brief: Turkey," *U.S. Energy Information Administration* (http://www.eia.gov/countries/country-data.cfm?fips=TU).
[88] "Energy Policies of IEA Countries: Turkey 2009 Review," International Energy Agency, 2009. (IEA, 2009).
[89] Ibid.
[90] "Energy Policies of IEA Countries: Turkey 2005 Review," International Energy Agency, 2005.
[91] "Annual Report 2009," European Network of Transmission System Operators of Electricity, 2009.
[92] IEA, 2009.

that its domestic hydrocarbon resources do not come close to meeting its energy needs. In 2008, Turkey produced 42,000 barrels per day (bpd) of oil and about 35 billion cubic feet (bcf) of natural gas. Remaining recoverable reserves of natural gas are estimated at 210 bcf.[93] The country imports more than 98 percent of all the natural gas it consumes.[94] Like other countries in the region, Turkey is looking seriously at nuclear power as a means of reducing its import dependence and meeting its rising energy demand.

Turkey has a long history of attempting to develop nuclear power, and the current revival is the sixth attempt at starting a nuclear power program. The country was one of the first participants in President Dwight Eisenhower's Atoms for Peace Initiative. It launched its first feasibility study for nuclear power in the early 1960s, and opened its first research center, the Cekmece Nuclear Research and Training Center, in 1961.[95] Nuclear power first appeared in Turkish development plans in 1968. In 1983, a 600 MWe reactor, to be built at the Mediterranean site of Akkuyu Bay, did not get beyond the planning stage. Akkuyu was revived and underwent several rounds of bidding in the 1990s before once again being shelved in 2000. These plans failed largely because of financing problems.[96]

In 2004, the government commissioned a study to look into potential sites for a nuclear plant other than Akkuyu. In 2006, the government sent a draft bill for new nuclear projects to parliament, and following a dispute between the president and the parliament, the new bill was passed into law in November 2007 (see section 2 below for more details on the law). The political commitment to having greater nuclear penetration in the generation mix was reiterated in the "Electricity Energy Market and Supply Security Strategy" document issued in May 2009 by the prime minister's office, which set out a goal of five percent nuclear power penetration by 2020.[97] In 2011, Turkey's Energy Ministry Undersecretary Metin Kilci said the country's target was to have "a minimum 20 reactors in operation by 2030."[98]

Technology and Commercial Model

In accordance with Turkey's 2007 Law on Construction and Operation of Nuclear Power Plants and Energy Sale (Law No: 5710), nuclear power plant investment in country may come from the public sector, the private sector, or in the form of a public-private partnership (PPP). Following the promulgation of the law, the Turkish Government held a competition for interested bidders for construction of a plant at the Akkuyu site. Under the terms of the competition, the government was willing to guarantee purchase of electricity from the plant for 15 years (between 2015 and 2030). According to the Turkish Atomic Energy Authority (TAEK), competition was cancelled in late 2009 due to legal issues; the submission of only one bid—from a Russian-led consortium—was likely a contributing factor to the tender's termination.

Given the failure of the private-sector model, recent nuclear efforts have proceeded in the form of intergovernmental agreements (IGAs) between the Turkish government and international partner consortiums, conditional on approval of

[93] Ibid.
[94] Ibid.
[95] M. Kibaroglu, "Turkey's Quest for Peaceful Nuclear Power" *The Nonproliferation Review*, Spring-Summer 1997.
[96] "Nuclear Programmes in the Middle East: In the Shadow of Iran," *International Institute for Strategic Studies,* 2008. (IISS, 2008).
[97] "Electricity Energy Market and Supply Security Strategy," Secretariat of the Higher Board of Planning, Undersecretariat of State Planning Organization, Turkish Prime Ministry, May 21, 2009.
[98] "Turkey Targets 20 Nuclear Reactors by 2030-official," *Reuters*, January 31, 2011.

financial backing from the partner consortium's government.[99] This approach underpinned the recent agreement between Turkey and Russia for the construction of up to four nuclear reactors on the old Akkuyu site. Completed in May 2010, and ratified by the Turkish parliament in July 2010, the Turkish-Russian IGA calls for the formation of a joint stock company (JSC)—to be initially funded entirely by the Russian state nuclear entity Rosatom—which will be responsible for the construction, operation, and decommissioning of the nuclear power plants.[100] Ownership of the JSC is split between three principal Russian entities under Rosatom: Atomstroyexport, the prime contractor, with 33.33 percent ownership; Interrao EES, the entity responsible for the power purchase agreement, with 33.33 percent; and Rosenergoatom, responsible for operations and maintenance, with 31.34 percent.[101] The JSC company, called Akkuyu NGS Elektrik Üretim A.Ş (or Akkuyu Electricity Generation JSC), was incorporated in Turkey in December 2010.

According to the terms of the contract, Turkish and third party investors will have the opportunity to purchase stakes in the JSC, although the Russian participant's ownership stake in may never fall below 51 percent throughout the lifetime of the project. The JSC is to remain the ownership entity for all nuclear plants built under the agreement. Generation and construction licenses for the plants are expected to be in place in 2013, with first concrete scheduled to be poured in August 2013.[102] Commissioning of the first unit is expected to be completed in 2019, with subsequent units coming online over the following three years. The project is expected to have a total capital expenditure of around $20 billion, with an operating life of 60 years. Once the four reactors are built, Turkey and the JSC will operate under a negotiated power purchase agreement (PPA). The IGA calls for the Turkish state-run electricity wholesaler, Turkish Electricity Trading Company (TETAS), to buy 70 percent of the electricity from reactors 1 and 2; and 30 percent of the electricity from units 3 and 4 at an average weighted price of 12.35 US cents per kWh. According to Rosatom, the "remainder of the electricity will be sold in the free market."[103] The term of the PPA is 15 years.

Rosatom will serve as the contractor for the construction of four of its VVER 1200 nuclear reactors.[104] The Turkish government has limited its financial risk significantly by ensuring that Rosatom is responsible for all construction costs. The very favorable terms of this nuclear agreement (from Turkey's perspective) were signed in parallel with a number of other energy partnerships at a meeting between the two countries' heads of state in 2010.[105] The agreements included commitments to partner on several joint oil and gas projects, which would take Turkey's oil and gas dependence on Russia to 70 percent, suggesting a broader economic and strategic motivation for Russia's willingness to enter into such a generous arrangement.

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[99] "Recent Status of Nuclear Program in Turkey," Presentation by Sehat Kose, TAEK, to an IAEA Workshop on the Introduction of Nuclear Power Programmes: Management and Evaluation of a National Nuclear Infrastructure, February 8-11, 2011, in Vienna, Austria. (Kose, February 2011).

[100] "Turkish parliament ratifies Russian-Turkish NPP Agreement," *RIA Novosti*, July 15, 2010 (http://en.rian.ru/business/20100715/159820318.html).

[101] Akkuyu NGS Elektrik Üretim A.Ş, "Implementation of First Nuclear Power Plant Project in Turkey", presentation to the 17th International Energy and Environment Conference and Exhibition, in Istanbul, Turkey, June 2011. (Akkuyu NGS Elektrik Üretim 2011)

[102] Ibid.

[103] According to the Rosatom website, (http://www.rosatom.ru/wps/wcm/connect/rosatom/rosatomsite.eng/investmentstrategy/projects/).

[104] "Building of Turkey's First Nuclear Plant, Sited on a Fault Line, Facing Fresh Questions," *Sabah*, March 26, 2011 (http://english.sabah.com.tr/Economy/2011/03/26/building_of_turkeys_first_nuclear_plant_sited_on_a_fault_line_facing_fresh_questions).

[105] "Russia, Turkey Agree on $25 Billion of Nuclear, Oil Projects," *Bloomberg*, May 12, 2010 (http://www.bloomberg.co.jp/apps/news?pid=90970900&sid=a_qAB5Zv_DR8)

In addition to the commercial arrangements, the Turkey-Russia IGA covers a range of fuel and decommissioning issues. Over the life of the project, the JSC is liable for decommissioning costs and spent fuel disposal costs. The JSC is to pay 0.15¢ per kWh generated into dedicated funds for both spent fuel and radiation-waste management, and for decommissioning. According to the agreement, the enriched uranium for the reactors will be provided on long-term contracts between supplier entities and the JSC. Provisions of the contract allow for a separate agreement allowing any fuel of Russian origin used in the reactors to be returned to Russia for spent-fuel reprocessing. It is not clear whether such an arrangement would permit high-level waste from the reprocessing process to remain in Russia or whether Turkey would be required to repatriate it.

The agreement also includes provisions for local Turkish content and expertise to be used in the construction and operation of the plant, "to the extent possible."[106] In March 2011, Turkish Minister of Energy and Natural Resources Taner Yildiz said that final approval for the Turkish-Russian project would likely take 18 months, and that the country would review its nuclear plans in light of the Fukushima disaster in Japan.[107]

In addition to the Russia IGA, Turkey has also engaged the Japanese firm Toshiba in talks to build a second nuclear reactor facility at Sinop on the Black Sea coast.[108] Toshiba has so far been successful in gaining the required support of government-tied entities for its bid, with the Japan Bank for International Cooperation signing on to help finance the project.[109] However, although Yildiz had previously expressed optimism in concluding negotiations with the Japanese team before the end of 2011, Tokyo Electric Power Corporation (TEPCO), the embattled Japanese utility, has since dropped out of the project in the aftermath of the Fukushima nuclear accident.[110]

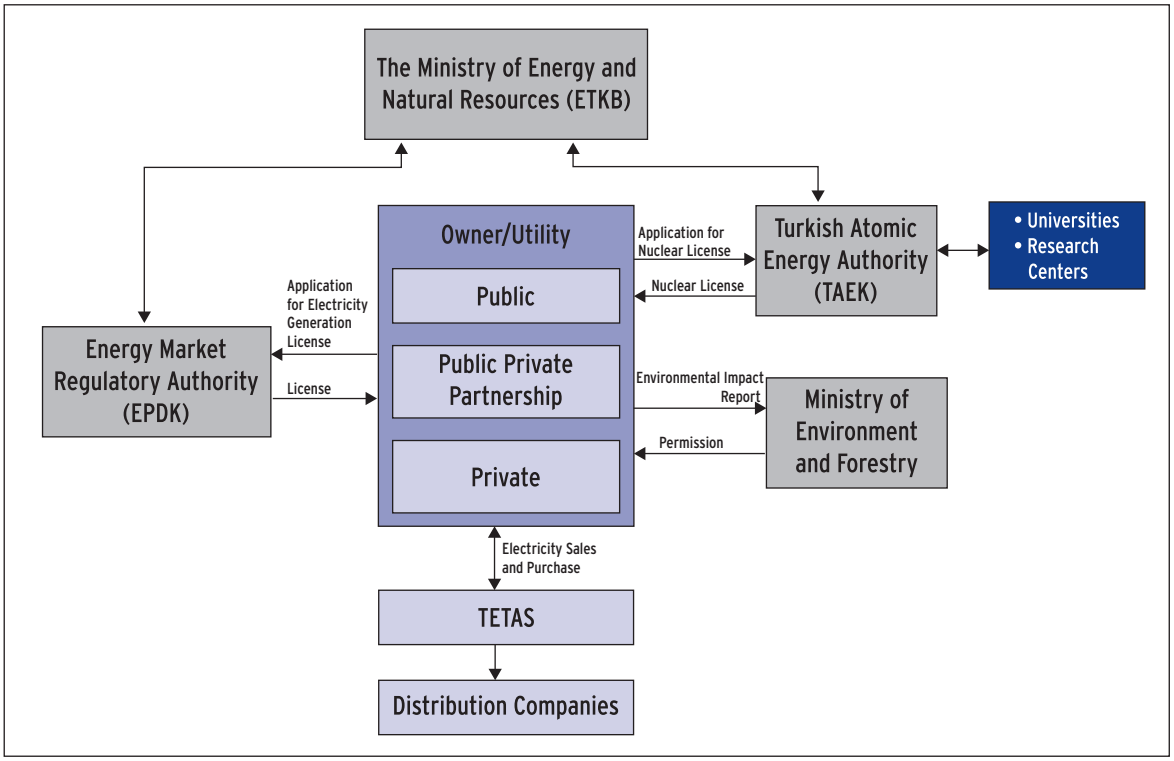
Institutions and Principal Legal Framework

The Ministry of Energy and Natural Resources (MENR) is responsible for all energy policy and planning, and serves as the NEPIO in Turkey. Since 2000, Turkey has undertaken a number of legal steps to lay the groundwork for renewed nuclear power development. In 2001, Law Number 4628, "Electricity Market Law," was approved, opening Turkey's electricity sector to private investment and setting up a market regulatory body with licensing authority.[111] In March 2004, the Turkish Privatization Administration's High Planning Council issued the "Electricity Sector Reform and Privatization Strategy Paper" which has governed the timing of Turkey's electric sector privatization.[112]

While Turkey has numerous nuclear-related laws, the principal law undergirding Turkey's current nuclear efforts is Law Number 5710 of November 2007, "Law on Construction and Operation of Nuclear Power Plants and Energy Sale." The law laid out the "procedures and principles" of nuclear power plant construction and operation

[106] Kose, February 2011.
[107] "Turkey may OK nuclear 18 months after Japan crisis," *Reuters*, March 24, 2011.
[108] Jonathan Soble, "Toshiba upbeat on Turkey nuclear deal," *Financial Times*, February 6, 2011.
[109] "Japan bank to support Toshiba in Turkish nuclear plant bid," *Hürriyet*, March 3, 2011.
[110] "Turkey may OK nuclear 18 months after Japan crisis," *Reuters*, March 24, 2011; and Tsuyoshi Inajima, "Tepco Won't Join Project to Build Turkish Atomic Power Plant," *Bloomberg,* July 27, 2011 (http://www.bloomberg.com/news/2011-07-27/tepco-won-t-join-project-to-build-turkish-atomic-power-plant-1-.html).
[111] Deger Boden Akalin, "Turkey," in *Electricity Regulation in 29 jurisdictions worldwide: 2010,* contributing editor Earle H. O'Donnell.
[112] "Electricity Sector Reform and Privatization Strategy Paper," Privatization Administration, Republic of Turkey Prime Ministry, March 17, 2004 (http://www.oib.gov.tr/program/2004_program/2004_electricity_strategy_paper.htm).

Figure 3-1: The Institutional Structure of Turkey's Civil Nuclear Sector



Source: Turkish Atomic Energy Authority

in Turkey, and connected these principles to the sale of generated electricity.[113] It prioritized private construction of nuclear power plants, while also making provision for public-private partnerships. **Figure 3-1** shows the institutional relationships between the TAEK and other governmental and academic entities.

Turkish Atomic Energy Authority

Turkey has had a nuclear regulatory body since the General Secretariat for Atomic Energy Commission was chartered in 1956. The Secretariat was reorganized into the Turkish Atomic Energy Authority (TAEK) in 1982. Along with its subsidiary research institutions, Çekmece Nuclear Research and Training Center (ÇNAEM) and Sarayköy Nuclear Research and Training Center (SANAEM), TAEK and its predecessor have overseen Turkey's nuclear program for over fifty years.[114] In 2006, Mohammed El Baradei, director general of the IAEA, announced that Turkey had "achieved IAEA Milestones related to establishing a regulatory framework and controlling occupational radiation exposure."[115]

TAEK regulates licensing of all research and training reactors, and is also responsible for all nuclear facilities, including nuclear power plants. TAEK is also responsible for physical security and

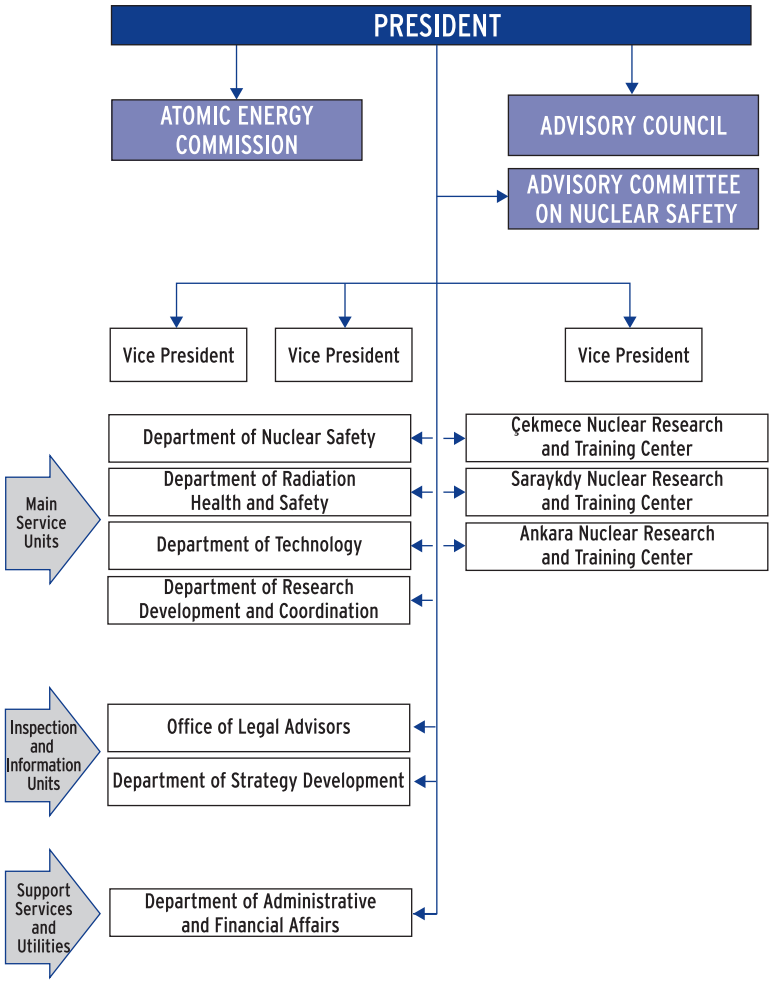
[113] "Recent Status of Nuclear Energy Program in Turkey," Presentation by Anıl B. Bolme, TAEK, to the Workshop on Long-Range Nuclear Energy Programme Planning and Strategy Development, June 14-17, 2010, in Vienna, Austria. (Bolme, June 2010).
[114] From the Turkish Atomic Energy Authority website, (http://www.taek.gov.tr/eng/about-us/history.html).
[115] Mohammed ElBaradei, "Nuclear Power: A Changing Landscape by Director General," Address to the Turkish Atomic Energy Authority, July 7, 2006.

safeguarding of nuclear sites, licensure of importing/exporting nuclear material, transport of nuclear material, and nuclear facility inspection.[116] The Authority receives its working principles, program direction and budget from the Atomic Energy Commission (AEC), which is also the body that approves its regulations. However, the AEC remains under the chairmanship of the president of TAEK, giving rise to the potential for an institutional conflict of interest as TAEK's supervisory body itself falls within the Authority's hierarchy.

As Turkey has not yet moved beyond the planning stage with any commercial reactors, TAEK's main duty is oversight of the country's two civil research reactors, as well as small fuel fabrication and disposal centers (see section 3 for more details).

In 2010, TAEK issued its "Directive on Principles of Licensing of Nuclear Power Plants" in which the prospective owner of a new power plant is required to present TAEK with details of a "reference plant" that can be considered as an example of proposed plant. According to TAEK, if there is no operating version of the plant, the owner may present a plant design that has been granted a construction license or equivalent by a regulatory body based on a thorough review and assessment. In cases where there is some discrepancy between reference design and the proposed plants, the prospective owners are required to provide the TAEK with reference applications that demonstrate the reliability and applicability of the new systems and their technology, and a detailed assessment of the impact of differences on safety and security. Following such submissions and discussion with the prospective owner, TAEK makes the final decision on the acceptability of reference plant and related systems.

Figure 3-2: Organization Structure of the Turkish Atomic Energy Authority



Source: Turkish Atomic Energy Authority

[116] "Nuclear Legislation in OECD Countries: Regulatory and Institutional Framework for Nuclear Activities, Turkey," Organization for Economic Cooperation and Development, 2008. (OECD, 2008).

Training and education

Research Reactors and Facilities

There are two principal research and training centers under the formal aegis of TAEK. The first, the Çekmece Nuclear Research and Training Center (ÇNAEM) was established in 1962 and was the site of Turkey's first research reactor. The 1MWt pool-type reactor, Turkish Reactor 1 (TR-1), reached criticality—the condition of being able to maintain a steady chain reaction and produce a steady output of power—in 1962 and was shut down and decommissioned in 1977. A similar pool-type reactor, the 5 MWt TR-2, was started operation in 1984, and was used for radioisotope production, materials testing and educational purposes. According to a presentation to the IAEA in October 2010, this reactor is still in operation, although in a limited capacity.[117] ÇNAEM is also the site of the country's nuclear fuel pilot plant and low-level waste processing plant.[118] The second is the Sarayköy Nuclear Research and Training Center (SANAEM), which incorporated the former Ankara Nuclear Research and Training center (ANAEM) in 2005 and conducts training of TAEK's technical staff and other governmental organizations.

Turkey also has several formal academic programs dedicated to nuclear technology. Istanbul Technical University (ITU) is the home of the 250-kilowatt training research reactor used to complement the university's nuclear-related research, which encompasses neutron activation analysis, nuclear chemistry, radioisotopes and radiochemistry, radiation measurement, and other applications. Fuel for the reactor is enriched by the United States. (Both the ITU and TR-2 reactors operate under IAEA safeguards.)[119] Hacettepe University in Ankara is the only university in the country that offers a four-year undergraduate degree in the field of nuclear engineering, while Ege University in the city of İzmir hosts departments for Nuclear Energy, Nuclear Technology, and Nuclear Applications at its Institute for Nuclear Sciences, where it offers nuclear-related degrees at the graduate and doctoral levels. Boaziçi University in Istanbul also offers nuclear engineering degrees at the master's and doctoral levels, while Cumhuriyet University conducts experiments in nuclear fuel analysis and fabrication, according to analysis by researchers at King's College London.[120]

According to Akkuyu Electricity Generation JSC, the company responsible for the construction and operation of the Akkuyu nuclear facility, 50 Turkish students will start a training course at the Russian National Research Nuclear University (MIFI) in September 2011 in an effort to provide the facility with key staff.[121]

International Agreements

Turkey has been a member country of the IAEA since 1957, and a party to the Treaty on the Nonproliferation of Nuclear Weapons (NPT) since 1979.[122] Turkey has since signed or ratified numerous international treaties, including:

- UN Treaty on the Nonproliferation of Nuclear Weapons (1979)
- IAEA Comprehensive Safeguards Agreement (1981)
- IAEA Additional Protocol to its Safeguards Agreement (2001)

[117] "Workshop on Research Reactor Coalitions and Networks: Concerted Actions in the Mediterranean Region" Presentation to the IAEA, Vienna, Austria, October 2010.
[118] OECD, 2008.
[119] IISS, 2008.
[120] Lorenz, T. and Kidd, J. "Turkey and Multilateral Nuclear Approaches in the Middle East," *The Nonproliferation Review*, October 11, 2010.
[121] Akkuyu NGS Elektrik Üretim, 2011.
[122] IISS, 2008.

- IAEA Convention on the Physical Protection of Nuclear Material (1986)
- UN Comprehensive Test Ban Treaty (2000)
- Convention on Early Notification of a Nuclear Accident (1990)
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1990)
- Convention on Nuclear Safety (1995)
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (signed 2009, not ratified).[123]

Turkey is also a member of several NPT-related bodies, including the Zangger Committee and the Nuclear Suppliers Group.[124]

Bilateral Agreements

Turkey has bilateral agreements in place with a number of countries, including:

- Canada (1986)
- Argentina (1992)
- South Korea (1999)
- United States (2006)
- Ukraine (2008)
- Russia (2011)
- France (2011)
- Jordan (2011)
- Germany (signed 1988, not ratified)

It also has a technical agreement in place with Ukraine and early notification agreements in place with Bulgaria, Ukraine, Russia, and Romania.

Cooperation with the IAEA. During the policy development and legislative process surrounding a renewal of its nuclear sector, Turkey has worked closely with both the IAEA and the OECD's Nuclear Energy Agency. The Turkish Ambassador to the United Nations, Tomur Bayer, pledged in September 2010 that Turkey was, "resolutely committed to the goal of ensuring safe, secure and peaceful utilization of nuclear energy," and would continue to work closely with the IAEA.[125]

Most recently, a delegation from the OECD's Nuclear Energy Agency met with officials from the Turkish Ministry of Foreign Affairs in Ankara to discuss introduction of nuclear power to Turkey.[126]

Its above commitments to non-proliferation notwithstanding, Turkey was instrumental in 2010 in preventing an agreement within the Nuclear Suppliers Group (NSG) regarding export controls on technologies related to sensitive aspects to the nuclear fuel cycle. The original guidelines, which were published in 1978, required suppliers to exercise "restraint" in exporting sensitive nuclear technologies. At the annual NSG meeting in 2010, Turkey suggested that efforts to clarify "restraint" must be careful not to impose further restrictions on nations beyond the scope of the NPT. Moreover, Turkish officials opposed an additional ruling that would deny exports on the basis of "stability and security of the recipient state." Turkey feared that, because it is a Middle Eastern state, countries would perceive it as lacking "stability and security" and thus be able to invoke this rule.[127]

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[123] From the TAEK website (http://www.taek.gov.tr/eng/international/multilateral-treaties.html).
[124] OECD, 2008.
[125] Tomur Bayer, "Statement to the IAEA," 54th General Conference, September 22, 2010.
[126] "OECD/NEA and Nuclear Energy in Turkey," Turkish Atomic Energy Authority, February 22, 2011 (http://www.taek.gov.tr/eng/haberler/1-latest-news/780-oecdnea-and-nuclear-energy-in-turkey.html).
[127] For more information on Turkey's role in the 2010 NSG Annual Meeting see: Mark Hibbs, "Nuclear Suppliers Group and the IAEA Additional Protocol," *Nuclear Energy Brief,* Carnegie Endowment for International Peace, August 18, 2010. (http://www.carnegieendowment.org/2010/08/18/nuclear-suppliers-group-and-iaea-additional-protocol/ep.)

Summary and Findings

Increases in energy demand, import dependence, and industrial activity are the driving forces behind Turkey's most recent move toward developing a civil nuclear power generation capacity. The Turkish government has integrated nuclear energy into the country's overall energy strategy, as well as electricity sector policy, and has targeted nuclear power to account for five percent of electricity generation by 2020.

Turkey has a long history of interest in nuclear power, which has been included in every five-year development plan since the 1960s. It has developed many decades of experience in the nuclear sector through the operation of research reactors and has a large pool of nuclear professionals and well developed nuclear education programs. The country has an extensive institutional infrastructure and legal framework, with a formal political commitment enshrined in several high-level policies and laws. Its strong nuclear-related academic and research base provide it with an opportunity to build a high-value added services sector around any future civil nuclear program. A NEPIO and a separate—but not fully independent— nuclear regulator (TAEK) are in place, as well as numerous regulations governing the nuclear activities; there is broad technical, institutional, and legislative support for a nuclear energy program.

In accordance with the present regulations Turkey has shifted its plan from a private investment model for nuclear generation to a public-private-partnership model. Under this new framework, the Turkish government is targeting state-to-state cooperation for the construction and operation of nuclear facilities, a model minimizes the Turkish government's financial risk. Turkey has entered into an intergovernmental agreement with the Russian Federation for the construction of up to four nuclear plants at Akkuyu on the Mediterranean. The intergovernmental agreement is in the form of a joint-stock company (JSC), an entity that will be responsible for construction (at Rosatom's cost), and will retain ownership over the reactors. According to the JSC, the Akkuyu project will take the form of a build-own-operate arrangement, with construction to begin in 2013 and commissioning of the first reactor to take place in 2019. Following the agreement with Rosatom, an attempt to engage with a government-backed South Korean consortium has been less successful, and has led Ankara to begin negotiations with Toshiba of Japan.

Turkey has shown itself willing to develop nuclear power within international nonproliferation frameworks to which it is a party, although it has recently opposed reform of certain international safeguards guidelines owing to a concern that it will be negatively affected by them.

Civil Nuclear Power in Egypt

Energy Context and Origins of the Nuclear Energy Program

Egypt's energy and electricity challenges mirror those of its eastern neighbors. Until now the country has been highly dependent on oil and natural gas for energy and electricity consumption. However, growing demand for both oil and gas is constricting domestic supplies which, particularly in the case of natural gas, are also exported. Nearly all of its energy comes from oil (46 percent of its primary energy consumption) and natural gas (49 percent).[128] Hydrocarbons also dominate the electricity sector; natural gas is used to gener-

[128] 2008 data according to the International Energy Agency (www.iea.org).

ate around 69 percent of the nation's electricity, with oil, hydropower and wind accounting for the rest.[129] In 2008, of Egypt's installed capacity of 23.4 gigawatts (GW), 20.3 GW was conventional thermal generation, 2.8 GW hydropower, and 0.3 GW wind power.[130]

This reliance on hydrocarbons is becoming strained. Peak oil production has fallen from 935,000 barrels/day in 1996 to 660,000 barrels/day in 2010, making it slightly lower than domestic consumption (710,000bpd). In a government-endorsed effort to reduce dependency on oil, natural gas is increasingly used in the transportation sector through the diffusion of compressed natural gas (CNG) vehicles. By replacing oil with natural gas in the transportation sector, Egypt is expected to reduce the amount of gas previously marked for export and will have to accelerate its natural gas production to meet its domestic requirements and international obligations.[131]

The rapid increases in domestic gas demand in the electricity and transportation sectors mean that Egypt finds itself facing a growing supply crunch. Moreover, the combination of an aging infrastructure, lack of maintenance and rising consumption has led to blackouts.[132] In response, the Ministry of Energy and Electricity (MOEE) is adopting a multipronged strategy to diversify the nation's energy sector: it is moving to develop the country's wind and solar resources; to build stronger energy cooperation ties with its neighbors in the GCC, Jordan, Syria, and Lebanon; to implement efficiencies throughout the power sector; and to deploy civil nuclear generation capacity.[133] The government has also announced plans to spend $100 billion on the sector over the next ten years. As part of its new strategy, it plans to derive 20 percent of its electricity from renewable sources by 2020.[134] Nuclear energy is also part of Egypt's alternative energy strategy: in 2010, President Hosni Mubarak announced definitively that the country's first nuclear power plant would be built at El-Dabaa, and in June 2010, IAEA Director General Yukio Amano said that the Agency was "very happy to cooperate with Egypt in its project of introducing nuclear power."[135] By 2025, the country planned to have four nuclear power plants online.[136] However, the recent political upheaval in Egypt appears to have once again hamstrung the country's nuclear plans. In the aftermath of the civil unrest and the ouster of President Hosni Mubarak in February 2011, the status of Egypt's civil nuclear plans is unclear; no tenders have been issued to date. According to a statement from the Egyptian cabinet, the uprisings in Egypt "have not had much effect on the nuclear program."[137] However, the macroeconomic impacts of the political turmoil in Egypt are likely to increase the financial challenge of meeting the high capital costs of a fleet of reactors.

While it has no operational power reactors, Egypt has a long history in pursuing a nuclear energy program. Its Atomic Energy Commission (now the Egypt Atomic Energy Authority, or AEA) dates back to 1955.[138] In 1957, it entered into a nuclear

[129] Ibid.
[130] "Country Analysis Brief: Egypt," U.S. Energy Information Administration, (http://www.eia.doe.gov/countries/cab.cfm?fips=EG). (Country Analysis: Egypt, Energy Information Administration).
[131] "Country Analysis: Egypt," Energy Information Administration.
[132] Ibid.
[133] "Electricity Sector in Egypt," Presentation by Dr. Shaher Anis Mahmoud, Egyptian Electricity Holding Company, February 9-11, 2009, to the DSM & EE Workshop in Tripoli, Libya.
[134] "Country Analysis: Egypt," Energy Information Administration.
[135] "UN watchdog backs Egypt nuclear power plant plans," *Reuters,* June 22, 2010.
[136] "Emerging Nuclear Energy Countries," *World Nuclear Association* (http://world-nuclear.org/info/inf102.html).
[137] "Egypt says to press ahead with nuclear tender," *Reuters,* March 9, 2011.
[138] Yair Evron, "The Arab Position in the Nuclear Field: A Study of Policies up to 1967: Cooperation and Conflict, VIII, 1973.

cooperation agreement with the Soviet Union.[140] As part of the agreement, the USSR built ETRR-1, Egypt's first research reactor, a 2MW unit that reached criticality in 1961.[140] In 1963, Alexandria University established a nuclear engineering department.[141] The same year, Egypt attempted—and failed—to purchase a French reactor for power generation.[142] The country put out international tenders for an electricity and desalination facility outside of Alexandria in 1964. Contracts were presented to both Siemens of then-West Germany and Westinghouse of the United States, neither of which came to fruition. The Six Day War of June 1967 ravaged Egypt's economy and put any ambitions for nuclear energy on hold for several years.[143]

In the mid-1970s, interest in a civil nuclear energy program resurfaced as Anwar Sadat, Egypt's President, saw it as vital to rebuilding the country's economy.[144] In 1974 the government tentatively agreed with the USSR to construct a 460 MW reactor. It granted Westinghouse another contract for a plant outside of Alexandria. However, neither plant was built: the latter failed because Egypt and the United States could not agree on a spent fuel storage plan.[145] In 1976 the government established the Nuclear Power Plants Authority (NPPA). A year later the Nuclear Materials Authority (NMA) was formed. In 1978, the government announced that it would have 7200 MW of installed nuclear capacity by 1999.[146] The following year it announced that the coastal town of El-Dabaa had been selected for a new nuclear facility.

Following the spike in international petroleum prices in 1979-1980, President Hosni Mubarak established the Supreme Council on Nuclear Energy in 1981.[147] However, any momentum from this initiative and the bidding round for the El-Dabaa site in 1983 was soon frozen by the Chernobyl accident in 1986.[148] In the 1990s, Egypt widened its search for international partners with Argentina, Canada, and France competing to supply its second research reactor. Argentina won the bid and began construction on the Egyptian Second Research Reactor (ETRR-2, also known as the Multipurpose Nuclear Reactor) in March 1993. Egypt commenced operation of the reactor in 1998 at Inshas, in the Nile Delta north west of Cairo.[149] According to a 1999 AEA document, the 22 MW pool-type reactor is supplied by enriched fuel elements produced by a Fuel Manufacturing Pilot Plant.[150] The Inshas facility also houses a Hot Laboratory and Waste Management Center (HLWMC), which according to the Federation of American Scientists, "includes a small French-supplied hot cell complex for plutonium extraction research."[151]

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[139] "Nuclear Programmes in the Middle East: In the Shadow of Iran," *International Institute for Strategic Studies,* May 2008. (IISS, 2008).
[140] According to the IAEA Research Reactor Database. See, http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1.
[141] "Workforce Planning Vision in Egypt," Presentation by Ahmed Awaise, NPPA, at the IAEA Technical Meeting on Workforce Planning for New Nuclear Power Programmes, March 31-April 2, 2009 in Vienna, Austria.
[142] "Nuclear Energy Prospects in Three Middle East Countries," *Special UX Consulting Report*, May 2009.
[143] IISS, May 2008.
[144] Ibid.
[145] Ibid.
[146] "Emerging Nuclear Energy Countries," World Nuclear Association.
[147] "Status of the Egyptian Project of First Nuclear Power Plant," Presentation by Y.M. Ibrahim, Chairman, NPPA, to The First Arab Conference on Prospects of Nuclear Power for Electricity Generation and Seawater Desalination, June 23-25, 2010, in Hammamet, Tunisia. (Y.M. Ibrahim, June 2010).
[148] "Country Report: Arab Republic of Egypt," *International Atomic Energy Agency,* July 2010 (http://www-pub.iaea.org/MTCD/publications/PDF/CNPP2010_CD/countryprofiles/Egypt/CNPP2010Egypt.htm). (IAEA, July 2010).
[149] Ibid.
[150] W. I. Zidan, "LEU Fuel Element Produced by the Egyptian Fuel Manufacturing Plant" *Advanced methods of process/quality control in nuclear reactor fuel manufacture*, International Atomic Energy Agency, 2000.
[151] E. Solingen, "Nuclear Logics: Contrasting Paths in East Asia and the Middle East," *Princeton University Press*, 2007.

More recently Egypt's nuclear energy program was the subject of some scrutiny from the IAEA. In February 2005, the IAEA completed a report following an investigation found that a number of experiments and research activities related to sensitive aspects of the fuel cycle were not adequately reported and that "failures by Egypt to report nuclear material and facilities to the Agency in a timely manner are a matter of concern." The government, whose research reactors are under IAEA safeguards, responded that the failure to report these sensitive—but not illegal—activities was the result of "a lack of clarity about its obligations under its Safeguards Agreement."[152] According to the IAEA's report, the Egyptian authorities were cooperative and transparent about allowing external investigators, and Egypt avoided a formal rebuke from the Agency for its failure to report.[153] While the IAEA took no further action on the matter, some analysts see the Agency's lack of subsequent safeguards verification and the admission in a subsequent Safeguards Implementation Reports that Egypt's State System of Accounting for and Control of Nuclear Material admitted that it did not have the authority to exercise control of nuclear material in the state as cause for concern.[154]

Egypt recently has resumed its interest in civil nuclear power. Spurred to action by the country's deteriorating electric power supply-demand balance, the country's desire to conserve domestic resources, and high international prices for oil and gas, the government announced its intention to re-launch its nuclear power program.[155] The effort was led by a Presidential Initiative of September 2006, which articulated a new national energy strategy based on the following principles:

- Guaranteeing the rights of future generations to Egypt's petroleum and natural gas resources;
- Facilitating the utilization of renewable resources;
- Facilitating the peaceful uses of nuclear energy.[156]

Also in 2006, the government announced international tenders for a 1,000 MW nuclear power plant at El-Dabaa, the consummation of a cooperation agreement with China, and the creation of a State System of Accounts for Controlling Nuclear Materials (SSAC).[157] In 2007, Egypt's nuclear energy ambitions were broadened through the announcement of a policy to start a reactor-construction program to alleviate the growing shortage of electricity throughout the economy. As part of the announcement, the government sought institutional and legislative reform, and took measures to build a more robust, independent regulator.[158] In 2008, Egypt signed a nuclear cooperation agreement with Russia, announced that it would select the winner of the contract for the construction of its first nuclear power plant, and awarded a contract to Bechtel, a U.S. engineering firm, for the selection of the reactor technology, the siting of the first plant, the training of operating personnel, and the provision of technical support services for 20 years. In May 2009, the agreement with Bechtel was transferred to WorleyParsons, an Australian engineering firm. At the time, the MOEE announced that at least one nuclear

[152] "Implementation of the NPT Safeguards Agreement in the Arab Republic of Egypt: Report by the Director General," IAEA Board of Governors, February 14, 2005. GOV/2005/9. pg. 5.
[153] Ibid., and Greg Webb, "Case closed on Egyptian nuclear research," *Global Security Newswire,* March 4, 2005.
[154] Goldschmidt, P. "The IAEA Reports on Egypt: Reluctantly?", Survival: Global Politics and Strategy, vol. 51, no. 1, February-March 2009.
[155] "Status of the Egyptian Project of First Nuclear Power Plant," Presentation by Y.M. Ibrahim, Chairman, NPPA, to The First Arab Conference on Prospects of Nuclear Power for Electricity Generation and Seawater Desalination, June 23-25, 2010, Hammamet, Tunisia.
[156] Ibid.
[157] "Emerging Nuclear Energy Countries," World Nuclear Association.
[158] IAEA, July 2010.

generation facility would be constructed by 2017 and be fully interconnected to the grid by 2019.[159]

According to Hassan Younis, the country's energy and electricity minister, the government was preparing to issue a tender for the construction of the new plant by the end of January 2011. On January 16, two of Egypt's leading infrastructure companies—Orascom Construction Industries and Arab Contractors—announced the formation of a partnership and stated they were in active negotiations with international nuclear vendors to bid on the project. Other interested bidders were said to include France, the United States, China, Russia and Japan.[160] As mentioned earlier, the revolution in Egypt has since put such plans in limbo. Moreover, the accident at the Fukushima nuclear power plant may add to Egypt's nuclear energy concerns. In late March 2011, the government asked the IAEA to review the technical specifications of its proposed nuclear plant in the wake of the nuclear disaster at the Fukushima plant.

Technology and Commercial Model

At the time of writing, few details have been made available regarding the commercial arrangements for Egypt's civil nuclear program. According to a 2009 presentation by the Director General of Nuclear Fuel Affairs and Economics at NPPA, the original tender for consulting services called for:

- "Sites selection and evaluation; updating El-Dabaa site studies; pre-contract activities including Technology Assessment, Quality Assurance Program, Preparation of Contract, Training and Technology Transfer to NPPA personnel and Financial Assessment" and
- "Consultation Services for Project implementation (optional) including construction management, field engineering, start-up and commissioning services. The Tenderer shall not be the same entity as or a related entity of the supplier of Nuclear Power Plants Systems."[161]

According to the NPPA, Egypt has opted for a "turnkey contract approach" for its first nuclear power plant project, and is pursuing an open-fuel cycle approach. NPPA has also emphasized its preference for the civil nuclear program to be part of a national industrial strategy to modernize Egyptian industry and scientific research through local participation in every plant. As part of its requirements, WorleyParsons is required to assess these concerns when devising a plan for procurement, component suppliers, and other services.[162]

According to a leaked diplomatic cable in February 2011, Dr. Ramses Khalil, WorleyParsons' Regional Power Manager for Egypt and Africa told US representatives to expect "significant U.S. content in the project, including U.S. engineers employed to build local capacity and transfer technology to the Egyptian side."[163] According to the cable, WorleyParsons planned to bring nuclear engineers from the United States and Bulgaria to work with and instruct their Egyptian counterparts. In addition to the United States, Russia, France, and China also indicated interest in becoming involved in the nuclear project.[164]

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[159] "Emerging Nuclear Energy Countries," World Nuclear Association.
[160] "Egyptian joint venture eyes nuclear contracts," *World Nuclear News,* January 17, 2011 (http://www.world-nuclear-news.org/CEgyptian_joint_venture_eyes_nuclear_contracts-1701114.html).
[161] "Egyptian Nuclear Program," presentation to the IAEA, by Asmaa Salah-Eldin Abdel-Salam, General Director of Nuclear Fuel Affairs & Economics, Nuclear Power Plants Authority, in Vienna, Austria, February 2009.
[162] Ibid.
[163] Quoted in the *Daily Telegraph*, "Contract Signed for Egypt's First Nuclear Plant," February 15, 2011.
[164] Ibid.

Like the UAE, Egypt has signed a nuclear cooperation agreement with the United States. However the 1981 agreement did not include a pledge by Egypt to forswear sensitive aspects of the nuclear fuel cycle such as enrichment and reprocessing. Indeed, the Egyptian nuclear establishment recently underscored its insistence on keeping open its options under Article IV of the NPT. In its General Statement to the Second Preparatory Committee, the Egyptian delegation stated the position that Egypt "rejects any attempts to impose additional obligations on non-nuclear weapon states" in compliance with their commitments under the NPT, and reaffirmed the position that "Non-Nuclear Weapons States Party to the Treaty have a right to the full enjoyment of the benefits of peaceful uses of nuclear energy pursuant to Article IV of the NPT."[165] Egypt's decision on how far it exercises its rights under the article will have implications both for its domestic energy program and for regional security.

Institutions and Principal Legal Framework

With a long history of nuclear energy ambitions, Egypt has developed a rudimentary legal foundation for a nuclear program. For instance, Presidential Decree No. 288 of 1957 established what is now the Egypt Atomic Energy Authority (AEA); Law No. 59 of 1960 allowed for the use of and protection against the use of ionizing radiation; Law No. 13 of 1976 established the Nuclear Power Plant Authority (NPPA); and the 2006 Presidential Decree No. 152 established the State System of Accounting for and Control of Nuclear Material (SSAC).[166]

In recent years, Egypt has worked to enhance the institutional and legal framework of its nuclear sector by drafting a new nuclear law that more clearly defines the role of each institution as well as the institutional relationships and authorities among the requisite entities; creating a nuclear regulator that is independent of other nuclear authorities; and enhancing cooperation with the IAEA through training courses, workshops, and other missions.[167] According to the AEA, the process for designing this new law included an analysis of legislation in other countries, examination of the IAEA *Milestones* and other documents, and consideration of amendments suggested by both the IAEA and domestic experts on particular provisions in the draft law.[168]

Egyptian Atomic Energy Authority/ Nuclear and Radiation Control Authority

The principal entity for nuclear research has historically been the Egyptian Atomic Energy Authority (AEA). On March 29, 2010, Law No. 7 of 2010, The Law on Regulating Nuclear and Radiation Activities (LRNRA), was ratified by then-President Hosni Mubarak, after having been approved by Parliament.[169] The law established the Nuclear and Radiation Control Authority (NRCA), a legally independent institution.[170] Under the law, all functions and employees of the AEA will be transferred to the NRCA.

Originally established by Presidential Decree No. 288 of 1957 as the Atomic Energy Establishment, the AEA was authorized to take all proper

[165] General Statement of Egypt to the Second Preparatory Committee of the NPT Review Conference, April 28, 2008.
[166] IAEA, July 2010.
[167] Ibid.
[168] Y.M. Ibrahim, June 2010.
[169] There have been some concerns about the law and the new institution. In leaked diplomatic cables, in December 2009, NPPA Chairman Yassin Ibrahim expressed concern that the new law did not address the issue of nuclear liability in accordance with international norms or pay enough attention to nuclear safety. Chairman Ibrahim stated that he was concerned that, in the draft law, precise institutional relationships are "unclear," that the legislative review of the bill was not transparent or thorough in its emphasis on nuclear safety, and that too many critical provisions in the draft law are unclear.
[170] "The Egyptian Nuclear Power Program," Presentation by Mostafa El-Asiry, NPPA, to the 2nd Meeting of the Arab-Japan Economic Forum, December 11-12, 2010, Tunis, Tunisia. (Mostafa El-Asiry, December 2010).

security actions to protect the public against the danger of radiation. This was followed in 1960 by Law No. 59 which authorized the use of ionizing radiation and protection against radiation. The AEA was also tasked with the regulation of open isotopes and reactors and the granting of licenses to regulate them. The AEA manages four research centers and two research reactors; the first reactor (2MW) was built in 1961 and the second (22MW) in 1998. The AEA works closely with a number of universities in conducting its research (see section on Education and Training below).

The AEA's safety rules, on which nuclear regulations, safety criteria, codes, rules and standards are based, are those of the IAEA Nuclear Safety Standards (NUSS) and are used as a frame of reference for the review and assessment of all reports on safety for all nuclear power plants built in Egypt.[171] The AEA also allows the regulator to accept the safety criteria, codes, rules and standards used in the vendor country, to the extent that they are not at variance with NUSS evaluation criteria. Any additional plants or modifications to existing plants must also either comply with NUSS criteria or those of a vendor country that has experience with changes in design of a similar facility. Finally, Egypt will not accept a plant from any vendor unless the plant is also licensable in the vendor's country. The AEA has five steps in the licensing process: site approval, issuance of a construction permit, obtaining a fuel loading and commissioning permit, obtaining an operating license, and acquisition of a decommissioning license.[172]

Nuclear Power Plants Authority

The Nuclear Power Plants Authority (NPPA) was established by Law No. 13 of 1976 and amended by Law No. 18 of 1984. NPPA's authority has also been clarified under a variety of other related legislation. NPPA is overseen by the MOEE and has four principal functions: it conducts feasibility studies for nuclear power plants; designs bid specifications and evaluation criteria; supervises project implementation; and oversees operations and maintenance of the plant over its operating life. The NPPA is the only governmental entity that has the right to build and operate nuclear power plants. It works in close cooperation with private sector entities and scientific institutes by having key people participate in every nuclear plant as a means of expanding technological know-how throughout the economy. Often working in close collaboration with consultants hired by the government, NPPA has the authority to choose which suppliers are best qualified to supply critical components and services required to build the plants. NPPA also has the requisite authority to determine which materials and services are best purchased abroad and which can be procured locally. The NPPA has the right to include the sourcing of any materials and services in a bid specification. NPPA has stated that it intends to pursue an open fuel cycle and will adopt high level waste fuel management at the reactor site while additional criteria for low and mid-level waste will be delineated in the new Nuclear Law.[173]

Supreme Council on the Peaceful Uses of Nuclear Energy

In 2007, the Supreme Council on the Peaceful Uses of Nuclear Energy was reshuffled to report directly to the president and was designated as the country's Nuclear Energy Implementation Organization (NEPIO) with the mandate to provide stringent management and coordination oversight of all nuclear power projects.[174] All relevant ministries participate on the Supreme Council.

[171] Ibid.
[172] Ibid.
[173] IAEA, July 2010.
[174] Mostafa El-Asiry, December 2010, and IAEA, July 2010.

National Center for Nuclear Safety and Radiation Control

Under Decree No. 15 of August 1982, the Chairman of the AEA formed a Nuclear Regulatory and Safety Committee. The committee was modified in a reorganization of the AEA in 1991, and became the National Center for Nuclear Safety and Radiation Control (NCNSRC) with responsibility to serve as the regulatory authority for nuclear matters on behalf of the AEA. The NCNSRC comprises a reviewing and assessment unit, a regulatory inspection and enforcement unit, and a series of divisions and departments responsible for the following:

- Nuclear laws and licensing
- Safeguards and physical protection
- Quality assurance
- Radiological safety
- Siting and environmental issues
- Radiation protection
- Engineering safety
- Operations
- Fuel cycle safety[175]

The NCNSRC has the authority to conduct licensing hearings, thereby regulating nuclear power plant design, siting, construction, operations and decommissioning.[176] In practice, however, the NCNSRC makes recommendations on the above matters that are then submitted to AEA's Board of Directors for approval. During the licensing process the Environmental Affairs Agency, under the Ministry of the Environment, has oversight of the environmental aspects of any nuclear power plants.[177]

Finally there is a Higher Council of Nuclear Energy Use which was established by Presidential Decree No.784 of 1975 and amended by Law No.248 of 1978. Its job is to rule on critical nuclear policy issues.

Training and Education

There are two public universities (Alexandra and Cairo) and one private one (the Egyptian-Russian University) that award nuclear-related degrees in Egypt. Several scientific institutes, including the Academy of Scientific Research and Technology (ASRT), the National Research Center, the National Center for Radiation Research and Technology (NCRRT), and the Mubarak City for Scientific Research and Technology Applications (MUSCAT), work in several technologies applicable to the nuclear industry.[178]

Egypt wants to develop qualified nuclear instructors in its universities and scientific institutions and to attract qualified personnel for its regulatory body over the next several years. Building on this base, Egypt plans over the next 3-5 years to train people in Egypt and to send Egyptians abroad to acquire all the requisite skills needed for a successful nuclear power program. According to NCNSRC, once this goal is achieved, Egypt will continue expanding its training programs to put the industry on a long-term sustainable basis.[179]

Given its long-standing involvement in nuclear research, Egypt has a skilled cadre of engineers and scientists familiar with nuclear technology. However, it lacks people with experience in construction, operation and maintenance of a nuclear

[175] "National Strategy for Nuclear Power Programme Infrastructure and Status of Implementation," Presentation by Abdel Hamid Nada, National Center for Nuclear Safety and Radiation Control (NCNSRC), to the IAEA, TM/WS on Topical Issues on Infrastructure Development: Managing the Development of a National Infrastructure for Nuclear Power, February 2010.
[176] IAEA, July 2010.
[177] Ibid.
[178] Ibid.
[179] Ibid.

power plant, as well regulatory capacity. The government is seeking international assistance to bolster its capacity and has signed a number of training agreements with the IAEA and other countries, including China, Argentina, France, the Republic of Korea, Russia, the United States, Canada, Germany, and France.[180]

International Cooperation Agreements

Multilateral Commitments and Agreements

Egypt has entered into a number of multilateral agreements, including:

- UN Treaty on the Nonproliferation of Nuclear Weapons (NPT) (1981)
- IAEA Comprehensive Safeguards Agreement (1982)
- UN Convention on the Suppression of Acts of Nuclear Terrorism (2005)*
- IAEA Convention on Early Notification of a Nuclear Accident (1988)
- IAEA Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1988)
- IAEA Convention on Nuclear Safety (1994)*

*signed, not in force

However, there remain a number of international agreements that Egypt has not signed that are important for an internationally-supported nuclear energy program. For instance, Egypt still has to sign an Additional Protocol to the Comprehensive Safeguards Agreement, the Convention on the Physical Protection of Nuclear Material, the Joint Convention on the Safety of Spent Fuel Management, and the Convention on Supplementary Compensation for Nuclear Damage.

Bilateral Cooperation and Agreements

Egypt has a long and active history in bilateral cooperation in the nuclear energy sphere, dating back to a 1961 cooperation agreement with the Norwegian Atomic Energy Institute. Egypt also has bilateral agreements in place with:

- India (1962)
- Yugoslavia (1963)
- France (1981)
- United States (1981)
- Germany (1982)
- Canada (1982)
- South Korea (1986)
- Australia (1988)
- USSR (1989)
- China (2002)
- Russia (2008)

Cooperation with the United States – Similar to that of the UAE's more recent nuclear cooperation agreement, Egypt's agreement with the United States under section 123 of the U.S. Atomic Energy Act has a provision whereby the "terms and conditions [of the agreement] shall be no less favorable in scope and effect than those which may be accorded by the United States to any other non-nuclear weapon state in the Middle East in a peaceful nuclear cooperation agreement." As the UAE's agreement with the United States is more stringent than the one between Egypt and the United States, there has been no amendment necessary to the original scope of the agreement.[181]

Cooperation with the IAEA – Having been a member of the IAEA since 1957, Egypt has a long history of technical cooperation with the international nuclear energy organization, having collaborated with the agency on over 160 occasions. Much of the technical cooperation that is specific

[180] Ibid.
[181] Christopher M. Blanchard and Paul K. Kerr, "The United Arab Emirates nuclear Program and Proposed U.S. Nuclear Cooperation,"*Congressional Research Service,* December 29, 2009.

to nuclear energy development dates back to the 1970s and early 1980s, when Egypt's atomic energy interests were peaking. During that time, Cairo sought assistance in a variety of civil nuclear power-related areas including fuel cladding, fabrication, project management, and technician training. More recently, Egypt cooperated with the IAEA on "human resource development for nuclear power project preparation and project management," on the development of a simulator of a nuclear desalination plant, on a safety and environmental impact assessment for a nuclear power plant at El Dabaa, on preparations of bid invitations for a nuclear power plant, and on nuclear power for electricity generation. It has also received technical assistance from the IAEA in uranium exploration and analysis, milling techniques, and nuclear safety.[182]

Summary and Findings

Egypt's growing reliance on imported energy sources, coupled with its increasing electricity demand from population growth, urbanization and industrialization are driving its pursuit of nuclear power generation capacity. The country also sees the development of a civil nuclear power sector as a means of creating a domestic industrial capacity in a high-technology sector. Egypt has a long history of pursuing a civil nuclear power capacity and has an established institutional and academic base for civil nuclear power development. However, until recently, its progress toward the installation of a full-scale nuclear reactor has been intermittent and unsuccessful. The 2006 Presidential Initiative breathed new life in Egypt's nuclear-energy plans. Over the past five years, the country has restructured its institutional base, and has engaged international consultants in the process of establishing a suitable technology and commercial model for its nuclear power program.

Egypt's legal framework has been revised to accommodate the most recent push toward nuclear power development. Its long-awaited nuclear law, produced with input from the IAEA and others in the international community, was passed in early 2010 and addressed all aspects of plant licensing, safety and security, civil liability, spent fuel management, and the creation of a new regulatory body. Egypt's domestic educational capacity in the nuclear sector is befitting of country with its long-standing interest in nuclear power. Several of its institutions offer formal qualifications in nuclear-related subjects. It also has a skilled cadre of nuclear engineers, although it lacks the construction and operational experience required for a full-scale nuclear power program.

Details of Egypt's commercial arrangements remain scant. Official accounts suggest that the country was on the verge of offering a tender for its nuclear power plant at El-Dabaa in January 2011. Despite official assertions that the political unrest in Egypt in March 2011 would have little effect on the country's nuclear development plans, at the time of writing, there have been no public details made of the tender. Even in the relative political stability of the Mubarak era, Egypt struggled to put in place the necessary policy and operational infrastructure for a civil nuclear power program. Given the uncertainties of the new political and economic circumstances, energy planners in Cairo will face a challenge in capturing the momentum and building on the progress of previous years.

[182] For more information on Egypt's technical cooperation history with the IAEA, see http://tc.iaea.org/tcweb/tcprogramme/projectsbycountry/query/default.asp.

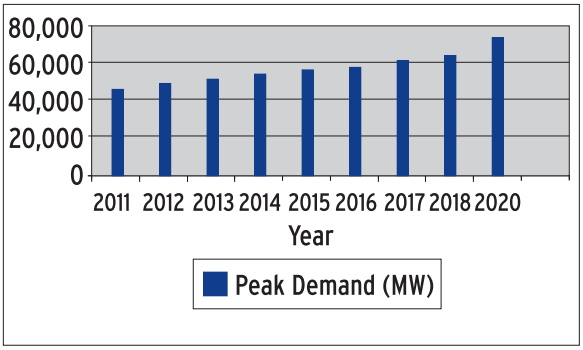
Civil Nuclear Power in Saudi Arabia

Energy Context and Origins of a Nuclear Energy Program

As the world's second largest producer of oil and its tenth largest producer of natural gas, the Kingdom of Saudi Arabia has long been dependent on hydrocarbons for domestic energy supply and economic growth. In 2008, 62 percent of the country's total primary energy consumption was from oil, with the remaining 38 percent from natural gas. In the same year, 57 percent of all electricity generation was from oil, with the remaining 43 percent generated by natural gas.[183]

Buoyed by rising oil prices and increasing industrial investment, the Saudi Arabian economy is expected to grow at around 4.5 percent per year to 2015.[184] This economic growth, coupled with a rapid population expansion, has led to a precipitous increase in energy, electricity, and water demand. In 2005, the International Energy Agency predicted that Saudi Arabia's electricity demand would increase by about 4 percent per year to 2030, doubling the Kingdom's electricity demand by 2035.[185] The Saudi Electric Company (SEC), the major national electric utility, is more bullish in its projection: SEC forecasts that total load capacity will reach over 65,000 MW by 2018 and over 75,000 MW by 2020, up from an estimated 44,000 MW in 2010 (see **Figure 5-1**).[186] Although Saudi Arabia is better endowed with oil and natural gas resources than many of its neighbors, its reliance on finite hydrocarbon resources to meet burgeoning demand for electricity and water comes at increasingly high economic and environmental costs. As Dr. Hashim Yamani, President of the King Abdullah Center for Atomic and Renewable Energy (KA-CARE) notes, "oil exports and economic growth will be constrained if there is no mix of alternative energy. We won't be able to leverage prices of oil to build our institutions."[187]

Figure 5-1: Projected Growth in Saudi Arabia's Electricity Demand



Source: Saudi Electric Company

With such considerations in mind, Riyadh has expressed recently its renewed interest in civil nuclear power generation, which—similar to the UAE—is seen as a means of diversifying the Kingdom's existing electricity supply mix and freeing up oil and natural gas for export rather than consuming them in domestic power generation. Saudi Arabia's ambitions for civil nuclear power are based, at least in part, also on the ancillary industrial and research opportunities afforded by a civil nuclear reactor program and the prestige that accrues to a nation having such a technological capability.

Saudi Arabia's interest in nuclear energy has tracked major fluctuations in the oil market over the past three decades. In 1978, when the Kingdom initiated a technical cooperation study with the IAEA, the global appetite for nuclear energy was nearing its peak. The oil price shocks of 1973-

[183] International Energy Agency, (www.iea.org).
[184] According to the International Monetary Fund's World Economic Outlook Database, October 2010 (www.imf.org).
[185] *World Energy Outlook 2005: Middle East and North Africa Insights,* (Paris: International Energy Agency, 2005).
[186] "Annual Report 2009," Saudi Electric Company.
[187] Abeer Allam, "Saudi to develop solar and nuclear power," *Financial Times*, January 24, 2011.

1974 and 1979 increased interest in nuclear energy, as countries looked to mitigate their dependence on oil imports for electricity generation.[188] Riyadh was a part of this movement towards nuclear energy. The high price of oil, which the government exported in abundance, brought windfall revenues and encouraged investments in alternative energy sources. The country was also interested in nuclear energy's potential for water desalination and it saw nuclear energy as a potential boon for employment, economic growth and diversification, and technological and infrastructure development.[189] The 1978 technical cooperation agreement with the IAEA sought the development of a nuclear energy plan for the region, specifically identifying the "establishment of training and research institutions with regard to the introduction of nuclear power in the country."[190] In 1979, the Kingdom announced a plan to set up a nuclear energy center as a first step to developing a nuclear industry.[191]

The global deployment of nuclear energy stalled in the late-1980s and 1990s, in part because of a return to pre-1979 oil prices and the Chernobyl nuclear disaster in 1986. Some events, however, suggest that Saudi Arabia maintained an ongoing interest in nuclear power. In 1988, the Atomic Energy Research Institute (AERI) was established within the King Abdulaziz City for Science and Technology (KACST), the national center for applied science and technology research and development. Also in the late 1980s, scientists examined industrial sites in Jeddah and Dhahran as potential locations for a nuclear power plant.[192] During the early 1990s, King Abdulaziz University collaborated with AERI in examining various nuclear energy technology components, including centrifugal pumps and concrete shielding for nuclear reactors.[193]

In 2003, a study by King Saud University determined that CANDU reactors, the Canadian-originated pressurized heavy water reactor (PHWR), would be the most appropriate for the desalination and electrification of the country. However, in February 2004, the deputy director of AERI announced that Saudi Arabia had no plans to develop nuclear energy or to become a nuclear power.[194]

Recently, there are signs of a more consistent policy on nuclear energy. Saudi Arabia provided the initial impetus for the region to embrace the global talk of a nuclear energy rebirth.[195] The Kingdom is perceived as the "prime motivator" of the December 2006 Gulf Cooperation Council (GCC) announcement announcing the launch of a "joint program in nuclear technology for peaceful purposes according to international standards

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[188] Joseph A. Yager, "The Energy Battles of 1979," *Energy Policy in Perspective: Today's problems, yesterday's solutions,* Washington, DC: The Brookings Institution, 1981.

[189] Wyn Q. Bowen and Joanna Kidd, "The Nuclear Capabilities and Ambitions of Iran's Neighbors," *Getting Ready for a Nuclear Iran,* Carlisle, PA: Strategic Studies Institute, 2005. Also, from an interview with Dr. Chen Kane, Senior Research Associate, James Martin Center for Nonproliferation Studies.

[190] IAEA Technical Cooperation Project Datasheet, Project Number SAU/0/002, "Nuclear Energy Planning." (http://www-tc.iaea.org/tcweb/projectinfo/projectinfo_body.asp).

[191] "Saudi Arabia Is Reported to Plan Establishment of a Nuclear Center," *The New York Times,* April 8, 1979.

[192] Ibrahim Ismail Kutbi, "A Pragmatic Pairwise Group-Decision for Selection of Sites for nuclear Power Plants," *Nuclear Engineering and Design,* Vol. 100. 1987; and, F.M. Husein, M.A. Obeid, and K.S. El-Malahy, "Site Selection of a Dual Purpose Nuclear Power Plant in Saudi Arabia," *Nuclear Technology,* Vol. 79, No. 3.

[193] "Nuclear Programmes in the Middle East: In the Shadow of Iran," *International Institute for Strategic Studies,* May 2008.

[194] Ibid. These are not the only instances of Saudi Arabia's on-and-off interest in nuclear energy. For a more detailed background on Saudi Arabia's nuclear ambitions until 2008, see "Nuclear Programmes in the Middle East," *IISS;* and Bowen and Kidd, "The Nuclear Capabilities and Ambitions of Iran's Neighbors."

[195] James M. Acton and Wyn Q. Bowen, "Atoms for Peace in the Middle East: The Technical and Regulatory Requirements," Working Paper Series, *Nonproliferation Policy Education Center,* September 2008.

and arrangements."[196] In 2007 and 2008, Saudi Arabia received offers of technical assistance from Russia and France. In May 2008, Saudi Arabia and the United States signed a Memorandum of Understanding (MoU) on Civil Nuclear Energy Cooperation.[197] (There is more discussion of these and other forms of international cooperation, including Saudi Arabia's technical cooperation with the IAEA, in Section 5.4.)

The Kingdom's nuclear ambitions took several steps forward in 2010. In April 2010, the Kingdom announced Royal Decree 35/A, which included a plan to establish the King Abdullah City for Atomic and Renewable Energy (KA-CARE) in Riyadh to house the country's nuclear reactors and to be the country's representative to the IAEA. Royal Decree 36/A appointed Dr. Yamani, formerly the Minister for Industry and Electricity and the Minister for Commerce and Industry, as President of the KA-CARE. Two months later, Saudi Arabia announced the decision to commission Pöyry, a Finnish energy and engineering consultancy, to draft for KA-CARE a "national vision and high-level strategy in the area of nuclear and renewable energy applications…and help define KA-CARE's strategy, operating model, key short and longer term priorities, and the immediate initiatives and action plan."[198]

Technology and Commercial Model

The IAEA recommends that no single nuclear reactor should account for more than 5 to 10 percent of a country's total grid capacity. Unlike for some smaller states in the region, this is not of a concern for Saudi Arabia. In 2009, the country's installed generation capacity was over 45,000 MW: large enough to absorb even the largest nuclear power plants. This is important because Saudi Arabia will require significant capacity additions to meet its large and growing electricity and desalination needs.

Parts of the country still suffer from occasional power shortages, but this appears to be due to a lack of capacity and not because of transmission failures.[199] Ultimately, the electricity sector's past shortcomings are resulting in a major investment effort to develop the country's electricity infrastructure. According to some reports, the Kingdom has allocated $111 billion towards new capacity generation.[200]

As already noted, upon its founding in 2010, the Riyadh-based KA-CARE was determined to be the location of the country's first nuclear power plants.[201] However, there have recently been internal debates whether Riyadh is the most appropriate location for nuclear power plants. Some opponents to housing nuclear power plants in Saudi's landlocked capital city argue that nuclear reactors are best situated next to bodies of water; the Fukushima accident has also highlighted the potential dangers of building reactors close to densely populated urban centers. Previous reports have recommended three cities that would be technically able to host a nuclear power plant: Jeddah, Dhahran, and Rabigh City.[202] All of these cities

[196] Ibid., and William J. Broad and David E. Sanger, "With an eye on Iran, rivals also want nuclear power," *New York Times,* April 15, 2007.
[197] "U.S.-Saudi Arabia Memorandum of Understanding on Nuclear Energy Cooperation," U.S. Department of State, May 16, 2008. (U.S. Department of State, May 2008).
[198] "Poyry awarded nuclear and renewable energy strategy project in Saudi Arabia," Poyry PLC Press Release, June 10, 2010 (http://www.poyry.com/Press_and_Stock_releases/1422909.html).
[199] James M. Acton and Wyn Q. Bowen, "Atoms for Peace in the Middle East: The Technical and Regulatory Requirements," Working Paper Series, *Nonproliferation Policy Education Center,* September 2008.
[200] "Power in the GCC," *KippReport,* February 8, 2010.
[201] "Nuclear Dangers, Nuclear Realities," The Stimson Center Workshop Report, April 11-12, 2010, Riyadh, Saudi Arabia.
[202] In addition to recommendations in the 1980s for Jeddah and Dhahran, Rabigh City was recommended in a 2005 report by researchers at King Abdulaziz University and the King Abdullah Center for Science and Technology (KACST). See: M.S. Aljohani, A.F. Abdul-Fattah, and A.I. Almarshad, "Siting of nuclear desalination plants in Saudi Arabia: a seismic study," *International Journal of Nuclear Desalination,* Vol. 1, No. 4 (May 2005).

are very close to water (Jeddah and Rabigh City are on the Red Sea and Dhahran is on the Persian Gulf).

As the largest economy and the largest consumer of electricity on the Arabian Peninsula, a potential Saudi Arabian civil nuclear program has attracted great interest among commercial nuclear vendors around the world.[203] The business model and operational details of a potential Saudi civil nuclear program have not yet been made public.

The United States has also shown commercial support for Saudi Arabia's nuclear energy ambitions. In July 2010, three leading nuclear companies—Shaw Group, Toshiba and Exelon—agreed to pursue joint contracts for the design, engineering, construction and operation of new nuclear power plants in Saudi Arabia. Under the terms of the "teaming agreement," the group would jointly develop Toshiba's Advanced Boiling Water Reactor (ABWR).[204] In December 2010, U.S. Deputy Secretary of Commerce Francisco Sanchez visited KA-CARE and announced that "[the Saudis] seem to be very committed to having civil nuclear as part of what generates energy for them and to do it relatively quickly, like within the next 10 years," adding that U.S. suppliers would be appealing to Saudi officials.[205]

In June 2011, a senior official at KA-CARE announced that the Kingdom was planning to spend over $100 billion on 16 reactors, with the first two planned for completion within 10 years.[206] This followed a previous announcement at the Saudi Solar Forum in early April 2011, when Khalid Al Sulaiman, vice president for renewable energy at KA-CARE, said that investments in nuclear and renewable energy would be part of a $100 billion effort on the part of the Saudi government to curb dependence on oil and boost domestic electricity capacity. The government still needs to approve any plan before it becomes policy.[207]

With regard to the fuel cycle, Saudi Arabia stated in its May 2008 MoU with the United States its "intent to rely on international markets for nuclear fuel and not to pursue sensitive nuclear technologies."[208] Whether the Kingdom is willing to comply with terms on sensitive aspects of the fuel cycle similar to those agreed between the United Arab Emirates and the United States in their landmark 2009 nuclear cooperation agreement will be one of the most important considerations, both for Saudi energy planners and the international community.

Saudi Arabia has repeatedly stated that nuclear energy is an economic interest of the country and that any program it pursues will be transparent and compliant with international standards. Prince Saud al-Faisal, Saudi Arabia's Foreign Minister, said in 2006, "this is not a secret and we are doing this out in the open. Our aim is to obtain the technology for peaceful purposes, no more, no less."[209] In 2007, he reiterated this sentiment, stating that any nuclear energy program would be developed "under strict controls

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[203] In addition to recommendations in the 1980s for Jeddah and Dhahran, Rabigh City was recommended in a 2005 report by researchers at King Abdulaziz University and the King Abdullah Center for Science and Technology (KACST). See: M.S. Aljohani, A.F. Abdul-Fattah, and A.I. Almarshad, "Siting of nuclear desalination plants in Saudi Arabia: a seismic study," *International Journal of Nuclear Desalination,* Vol. 1, No. 4 (May 2005).

[204] "Shaw, Toshiba, and Exelon Sign Teaming Agreement for Nuclear Projects in Saudi Arabia," Shaw Group Press Release, July 12, 2010 (http://ir.shawgrp.com/phoenix.zhtml?c=61066&p=irol-newsArticle_print&ID=1446255&highlight).

[205] "Saudi Arabia expected to be generating N-power in 10 years," *Saudi Economic Survey,* December 19, 2010.

[206] "Saudi plans to build 16 nuclear reactors by 2030," *Retuers*, June 1, 2011.

[207] Mourad Haroutunian and Anthony DiPaola, "Saudi Arabia Looks to Solar, Nuclear Power to Reduce Its Oil Use by Half," *Bloomberg BusinessWeek,* April 3, 2010.

[208] U.S. Department of State, May 2008.

[209] "Nuclear Energy an option for Gulf states," *World Nuclear News,* April 11, 2007 (http://www.world-nuclear-news.org/newsarticle.aspx?id=13210).

and with peaceful intentions, to be an example for any country seeking to adopt the technology without any intention to join the nuclear arms race."[210] Saudi Arabia has been a strong supporter of making the Middle East a nuclear weapons-free zone, following the examples of Africa, Latin America, and Southeast Asia. Recent comments by Prince Turki al-Faisal, the former Saudi ambassador to the United States and a former head of intelligence, suggested that the Kingdom might pursue nuclear weapons in the event of Iran gaining a nuclear weapons capability.[211] While statements of this nature should be treated seriously, a 20-year public pursuit of a civil nuclear program on the scale indicated above is unlikely to be the means by which Saudi Arabia prepares a strategic response to a potentially nuclear Iran.

Institutions and Legal Framework

King Abdullah Center for Atomic and Renewable Energy

The King Abdullah Center for Atomic and Renewable Energy (KA-CARE) was established by Royal Decree A/35 in April 2010. Under the oversight of a 13 member Supreme Council, KA-CARE's key objectives are to:

- "Propose national policies on nuclear and renewable energy, set the necessary implementation plans and strategies, and draft the relevant rules and regulations;
- Implement scientific research programmes and encourage research projects in the private sector and universities;
- Grant scholarships and implement training programmes in the Kingdom to develop domestic expertise in the field of nuclear and renewable energy;
- Act as the regulatory body for the nuclear and renewable energy industries (see section 5.5 for more analysis of the dual role of KA-CARE);
- Act as the competent agency responsible for treaties on nuclear energy signed by the Kingdom, including representing the Kingdom before the IAEA and other relevant international organizations."[212]

As evident from these objectives, KA-CARE most likely will operate as a stand-alone, vertically integrated institution. (It is also expected to have an investment fund, similar to Abu Dhabi's Masdar Clean Tech Fund, which will invest both nationally and internationally in companies that are deemed to be of interest.) All nuclear power related organizations prior to KA-CARE's formation, including AERI, will be housed within KA-CARE. While the Kingdom has designated KA-CARE as the primary national institution for nuclear energy, it is still unclear whether the organization will be involved in reactor construction. The relationship between SEC and external nuclear power developers is also unclear; although it appears that the SEC will evaluate various models pursued by other nations. Under the Decree establishing the center, KA-CARE will have an independent budget estimated at $133 million. In order to encourage investment in the program, it will be exempt from tax and custom duties on equipment and machines that it imports for scientific activities.

[210] See, "Nuclear disarmament tops agenda in disarmament commission, but speakers call for halt to illicit arms trade, creation of nuclear weapon-free Middle East," *Disarmament Commission 2010 Substantive Session, 305th & 306th Meetings,* General Assembly DC/3216.

[211] In a speech in late June 2011 in the United Kingdom, Prince Turki al-Faisal stated that Iran developing a nuclear weapon would compel Saudi Arabia "to pursue policies which could lead to untold and possibly dramatic consequences." However, he went on to state that for the moment, "sanctions against Iran are working." (Jason Burke, "Saudi Arabia worries about stability, security and Iran," *The Guardian (UK),* June 29, 2011.)

[212] "Nuclear Power in the Middle East and North Africa," Freshfields Bruckhaus Deringer LLP, January 2011.

KA-CARE's activities have so far focused almost exclusively on renewable energy. The Saudi government has prioritized solar energy over nuclear energy for electricity generation, partly due to lower upfront costs and partly due to national goals. However, there is an understanding in the government that solar energy will not be sufficient to provide the base-load power generation the country requires while reducing the opportunity cost of burning fossil fuels in power generation. Further increases in the price of crude oil may further encourage the nuclear-energy wing of KA-CARE.

Atomic Energy Research Institute

The Atomic Energy Research Institute (AERI), created in 1988 within KACST, was established "to employ and develop nuclear technology as to serve agricultural, industrial, health, research, economic, security and preventive development in KSA, taking into consideration the protection of human life and the environment from ionizing radiation." It had a broad mandate that included the creation of a regulatory framework for the various applications of nuclear technologies relevant to Saudi Arabia, encompassing technical capacity development, and international cooperation.[213] It is expected that AERI's responsibilities will be rolled into KA-CARE.[214]

Other Institutions

By all available accounts, KA-CARE has been given a broad mandate that includes nearly all aspects of nuclear energy development, from research and training to regulation and international representation. As a result, the responsibility of other potentially relevant institutions in a Saudi nuclear energy program is still uncertain. However, given their roles in the current electricity sector, the following institutions may contribute to a nuclear energy program:

- The Ministry of Water and Electricity is the cabinet-level ministry charged with the development of water supplies and electricity;
- The Electricity and Co-generation Regulatory Authority (ECRA) acts as the electricity regulator and sets prices, though under government supervision and control;
- The Saudi Electric Company is the largest generator of electricity in Saudi Arabia; at the end of 2009, it accounted for 85 percent of all generating capacity in Saudi Arabia.[215]

Since its establishment, KA-CARE has done little in the form of legal and regulatory development, other than the determination that, in addition to its other mandates, KA-CARE would also house the country's nuclear regulator.

Training and Education

In other industries, such as hydrocarbon production, Saudi Arabia has proven unwilling to rely entirely on expatriate expertise and technical capacity. The country has instead demonstrated an interest in leveraging foreign expertise for knowledge development towards the ultimate goal of full program control, as illustrated by the development of Saudi Aramco and Saudi Basic Industries Corporation (SABIC). While this sometimes leads to slow commercial and industrial progress, Saudi Arabia has shown itself willing to persevere with this strategy with respect to its nuclear sector. It seeks to build a self-sufficient nuclear energy program by investing considerable resources into domestic capacity development. It will also tap

[213] From the King Abdullah City for Science and Technology website (http://www.kacst.edu.sa/en/about/institutes/Pages/ae.aspx).
[214] "Nuclear Power in the Middle East and North Africa," Freshfields Bruckhaus Deringer LLP, January 2011.
[215] "Country Overview: Saudi Arabia," *Power Engineering International,* March 2011.

into international technical cooperation agreements to solicit the training and development experience of more experienced nations.[216]

According to the IAEA, Saudi Arabia does not have a research reactor. It cannot therefore provide its nuclear engineers-in-training with hands-on experience in operating a nuclear reactor.[217] However, the Kingdom has taken other measures—albeit quite modest ones—to improve local technical capacity. First, owing to its long history in other forms of theoretical nuclear research, some Saudi scientists and engineers have some experience with specific aspects of operating a nuclear power plant. For instance, King Abdulaziz University has spent many years researching nuclear energy matters and has a number of relevant research ventures, including software that simulates a nuclear power plant, a nuclear desalination planning study, and a study on radioactive waste management in Saudi Arabia.[218]

Second, many Saudi institutions have developed specific training programs and certifications that will help support a national nuclear energy program, particularly in the area of nuclear security. Graduate schools across the country carry basic nuclear energy security courses, particularly as it pertains to nuclear medicine, agriculture, power, and water. Most notably, KACST has laboratory simulators that run various nuclear applications.

International Agreements

Multilateral Commitments and Memberships

Saudi Arabia has entered into a number of international agreements, including:

- UN Treaty on the Nonproliferation of Nuclear Weapons (NPT) (1988)
- IAEA Comprehensive Safeguards Agreement (2009)
- IAEA Convention on Physical Protection of Nuclear Material (2009)
- UN Convention on the Suppression of Acts of Nuclear Terrorism (2007)*
- IAEA Convention on Early Notification of a Nuclear Accident (1987)
- IAEA Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1989)
- IAEA Convention on Nuclear Safety (2010)

* Saudi Arabia signed the Convention on the Suppression of Acts of Nuclear Terrorism, but also declared to the United Nations that it does not consider itself bound by Article 23, Paragraph 1 of the Convention. (The stipulation in question details the process for dispute resolution under the convention.)[219]

There are also a number of agreements that the Kingdom has not yet signed, some of which are important institutional steps required for building an internationally-recognized nuclear energy program. These include the conclusion of an Additional Protocol to the Comprehensive Safeguards Agreement, the Joint Convention on the Safety of Spent Fuel Management, and the three liability conventions: the Vienna Convention on Civil Liability for Nuclear Damage; the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention; and the Convention on Supplementary Compensation for Nuclear Damage.

[216] From an interview with Giacomo Lucciani, Senior Advisor, Gulf Research Center in Geneva, Switzerland.
[217] Acton and Bowen, "Atoms for Peace in the Middle East: The Technical and Regulatory Requirements."
[218] For more information see the Saudi Research Database, www.srbd.org.
[219] Article 23, Paragraph states: "Any dispute between two or more States Parties concerning the interpretation or application of this Convention which cannot be settled through negotiation within a reasonable time shall, at the request of one of them, be submitted to arbitration. If, within six months of the date of the request for arbitration, the parties are unable to agree on the organization of the arbitration, any one of those parties may refer the dispute to the International Court of Justice, by application, in conformity with the Statute of the Court." ("International Convention for the Suppression of Acts of Nuclear Terrorism," Resolution adopted by the General Assembly, 59/290. United Nations General Assembly, April 15, 2005. Document #: A/RES/59/290.)

Bilateral Agreements

In February 2011, Saudi Arabia signed a nuclear cooperation agreement with France to "enhance cooperation in the fields of production, use, and transfer of knowledge of peaceful uses of nuclear energy."[220] It is the Kingdom's first official nuclear energy cooperation agreement. In recent months, Saudi Arabia has gathered momentum towards bilateral cooperation with a number of other countries. In January 2011, Japan's Minister for Economy, Trade, and Industry offered Japanese aid both in technical capacity building and training, and in developing the rules and regulations that are necessary for a nuclear energy program.[221] Toward the end of 2010, Saudi Arabia and Russia furthered their dialogue on nuclear energy that started in 2007: in October 2010, the Saudi Cabinet agreed to a draft cooperation agreement with Russia, and negotiations towards a final agreement continued in December 2010.[222] In June 2011, the Saudi government entered into a nuclear cooperation agreement with Argentina.[223]

Cooperation with the IAEA – Other than its 1978 technical cooperation agreement with the IAEA that sought to establish training and research institutions for the development of nuclear energy, most of Saudi Arabia's early interactions with the IAEA focused on the agricultural and medical applications of atomic energy. Technical cooperation with the IAEA on nuclear power increased in the late 1990s into the 2000s. The Kingdom cooperated with the IAEA on "training in nuclear science and engineering" in 1995 and on "human resource development and technical support" in 1997 and in 2001. In 2003, it began cooperation with the IAEA on a still-active project on human resource development and nuclear technology support.[224]

Cooperation with the United States – Saudi Arabia and the United States signed a "Memorandum of Understanding on Nuclear Energy Cooperation" in 2008. The agreement, which is not legally binding, committed the two governments to "establish a comprehensive framework for cooperation in the development of environmentally sustainable, safe, and secure civil nuclear energy through a series of complementary agreements."[225] The agreement made provision for US assistance to Saudi Arabia on the development of nuclear technology for medicine, industry, and power generation; and on the development of "human and infrastructure resources." The text of the agreement made explicit reference to Saudi Arabia's intent to "rely on international markets for nuclear fuel and to not pursue sensitive nuclear technologies."

Summary and Findings

Saudi Arabia has shown an increasingly proactive interest in the potential for nuclear power in recent years. Population and economic growth have increased electricity demand, which is now projected to roughly double over the next two decades. During a period of high oil and gas prices, diverting these resources to meet growing electricity demand comes with high economic opportunity and environmental costs. With its ability to supply base-load, zero-carbon electricity, nuclear energy is being reconsidered by the Kingdom's energy planners as a potential source of electricity generation.

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[220] "Saudi Arabia, France sign nuclear agreement," *Saudi Economic Survey,* March 4, 2011.
[221] "Japan offers help for Saudi Arabian nuclear power project," *BBC Monitoring Asia Pacific,* January 8, 2011.
[222] "Saudi & Russia in talks to sign nuke deal: report," *Al-Arabiya,* December 28, 2010.
[223] "Saudi, Argentina sign nuclear cooperation deal," *The Daily Star (Lebanon),* June 28, 2011.
[224] For more information on all of Saudi Arabia's technical cooperation projects with the IAEA, see http://tc.iaea.org/tcweb/tcprogramme/projectsbycountry/query/default.asp.
[225] United States Department of State, Office of the Spokesman, "U.S.-Saudi Arabia Memorandum of Understanding on Nuclear Energy Cooperation," May 16, 2008.

Since 2006, when the GCC overtly declared interest in nuclear energy, Saudi Arabia has made gradual progress toward a domestic nuclear program. The establishment of KA-CARE as a well-funded, centralized entity is the most prominent step in that regard. The Kingdom is also engaging the international community: it has established cooperation with a number of countries—including a technical cooperation agreement with France—and it has agreed to several international conventions and treaties. Together, these steps suggest that it is building the foundation for a sustainable nuclear energy program.

There is still much to do before Saudi Arabia can be considered to have launched a formal nuclear power program. The government has yet to make public a long-term strategy for the development of its nuclear sector. Regulations and legislation that would control and ensure a safe program are limited. Despite some experience in nuclear technology for agriculture and medicine applications, indigenous technical capacity for nuclear energy applications is still limited. Saudi Arabia's history in other areas of industrial development suggests that it may follow a slower path to a nuclear energy program based on an initial stimulus of international expertise to help with domestic institutional development rather than on importing international expertise wholesale. Moreover, it appears that the Kingdom currently prioritizes renewable energy development to nuclear energy, as most of the progress at KA-CARE has been in solar and wind power technologies.

As the Kingdom develops a clearer plan for nuclear energy, it will need to make three critical considerations. The first is regarding the independence of its regulator, which will be under increased international scrutiny in the wake of the Fukushima accident where it appears that a lack of independent oversight was partly to blame for the crisis. At this early stage it appears that a Saudi nuclear regulator will be housed with KA-CARE, which is contrary to international best-practice where the nuclear regulator is independent and insulated from nuclear operators, the government, and industry. Second, the country will need to develop a commercial model both for soliciting reactor bids and selecting a reactor and for developing an owner/operator structure and implementing power purchase agreements.

A third major consideration for the government of Saudi Arabia will be its policy on the sensitive aspects of the nuclear fuel cycle. Given the terms of the U.S. agreement with the UAE, the Saudi government will have to make a decision on whether to formalize the commitment made in its MoU with the United States on sensitive aspects of the fuel cycle in a nuclear cooperation agreement. A decision to do so will enable U.S. suppliers and suppliers using licensed U.S. technology to engage in nuclear-power related commerce with Saudi Arabia. However, reluctance on the part of Saudi Arabia to follow the UAE model will restrict its options with regard to nuclear vendors and will have potential implications on the approach to civil nuclear power development in other countries throughout the region.

Civil Nuclear Power in Kuwait

Energy context and Origins of the Nuclear Energy Program

Kuwait is one of the world's largest oil producers, with exports of around 2.5 million barrels per day (bpd) and proven reserves of just over 100 billion barrels.[226] As in the case of many countries in the GCC, Kuwait has witnessed a rapid increase in both electricity and water demand in recent years,

[226] Oil and Gas Journal 2010, quoted by U.S. Energy Information Administration, Country Analysis Brief: Kuwait (http://www.eia.doe.gov/cabs/Kuwait/Oil.html).

a trend that is expected to accelerate between now and 2030. According to the Kuwait government, the country is allocating an increasing proportion of its oil and gas production to the generation of electricity and water desalination: in 2010, between 11 and 15 percent of oil production (around 350,000 bpd) was allocated to producing power and potable water.[227] Kuwait is seeking to increase its production of natural gas, which is a critical input to the country's electricity generation and petrochemical facilities. However, current gas production is limited to small volumes of associated gas (gas that is extracted while drilling for oil), leading Kuwait to be a net gas importer in the form of LNG cargoes.

Like other countries in the region, Kuwait is examining the potential for civil nuclear power to enable it to supplant its increasing use of oil in its power-generation sector. It also sees nuclear power as a means of economic diversification through the development of indigenous non-hydrocarbon related industries and a base of technical services. While Kuwait explored the possibility of a nuclear program in the 1970s, it did not get beyond the stage of establishing a nuclear energy committee and issuing a request for proposal (RFP). Starting in 2009, the country began proactively renewing its interest in the development of nuclear power. In 2009, the Kuwait National Nuclear Energy Committee (KNNEC) was founded by decree (see Section 3 below for more information). According to Ahmed Bishara, the Secretary General of KNNEC, Kuwait planned to have up to four 1-gigawatt reactors operational by 2022.[228] However, according to government officials, KNNEC was abruptly closed down in the summer of 2011 by the Kuwait Parliament. In July 2011, newspaper reports suggested that the Kuwaiti cabinet had taken a decision to disband KNNEC, transferring the committee's responsibilities to the Kuwait Institute for Scientific Research, "in a bid by the government to adopt a more cautious approach to utilizing nuclear power for research and medical purposes."[229] According to officials interviewed in the course of this research, the accident in Fukushima was instrumental in the government's decision to reconsider its nuclear power plans.

Developing a "Roadmap"

Before its closure, KNNEC was developing a four-phase plan for the development of nuclear power in the country based on the IAEA's *Milestones in the Development of a National Infrastructure for Nuclear Power* document.[230] According to KNNEC, the country had completed several aspects of the "pre-project" phase, including a long-term energy plan, a preliminary economic feasibility study on civil nuclear power, and a site identification-and-selection study. The Committee collaborated with the IAEA on both the long-term energy study and the preliminary economic feasibility study, which also involved an international consulting firm. With regard to site selection, the Committee had identified three potential sites on the Arabian Gulf: Bubyan Island, Failaka Island, and Southern Shore. According to KNNEC, other Phase 1 activities—including the preparation of a legal framework, the drafting of a comprehensive nuclear law, and preliminary efforts at manpower development—had also been set in motion. In early 2011, Kuwait began the process of issuing an RFP for the second phase of its nuclear development program.

[227] "Roadmap to Development of Kuwait's Nuclear Infrastructure," presentation by A. Shihad Eldin of KNNEC to the IAEA, February 2011 in Vienna, Austria. (Eldin, February 2011).
[228] Tsuyoshi Inajima and Yuji Okada. "Kuwait Plans to Build Four Nuclear Reactors as It Seeks Alternative to Oil," *Bloomberg*, September 9, 2010.
[229] Kuwait Times, "Kuwait no longer interested in pursuing nuclear energy," July 11, 2011.
[230] (Eldin, February 2011).

Institutions and Principal Legal Framework

Kuwait's limited regulatory framework addresses the treatment of nuclear materials, including export controls. The Decree Law 131 of 1977 states that "no radiation device or radioactive substance may be imported, exported, manufactured, possessed, bought, sold, transported or disposed of without a license obtained for the purpose from the Ministry of Public Health."[231] According to its IAEA-based roadmap, as described in the above section, KNNEC is currently working with the IAEA and the Kuwait's Council of Ministers on the preparation of a legal framework and a Draft Comprehensive Nuclear Law.[232]

Kuwait National Nuclear Energy Committee

The Kuwait National Nuclear Energy Committee (KNNEC), also called the National Committee for the Peaceful Use of Nuclear Energy, was established by decree 43 of 2009 on March 10, 2009. The Committee's role is to "[e]xplore and prepare for the introduction of safe and secure peaceful nuclear power program."[233] According to KNNEC, its mission involved the development of policies, technical studies, manpower requirements, and international partnerships necessary to support a domestic nuclear program.

Training and Education

As part of its manpower development initiative, Kuwait is intending to underwrite 20 scholarships to the United States for the study of nuclear power-related subjects. In 2010, the National Committee for the Peaceful Use of Nuclear Energy signed a cooperation agreement with the Kuwait Institute for Scientific Research (KISR) through which the latter agreed to provide "technical, legal, administrative, and financial support" to the committee. The agreement also made provision for the committee to train KISR's workforce.[234]

International Agreements

Multilateral Commitments and Memberships

Kuwait has signed a number of international treaties and agreements. It is a signatory to the following:

- UN Treaty on the Nonproliferation of Nuclear Weapons (1989)
- IAEA Comprehensive Safeguards Agreement (2002)
- IAEA Additional Protocol to its Safeguards Agreement (2003)
- IAEA Convention on the Physical Protection of Nuclear Material (2004)
- UN Comprehensive Test Ban Treaty (2003)
- UN International Convention for the Suppression of Acts of Nuclear Terrorism (2005)
- Convention on Early Notification of a Nuclear Accident (2003)
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (2003)
- Convention on Nuclear Safety (2006)

Bilateral Agreements

It has also signed a series of bilateral agreements in the past two years including:

[231] "Decree - Law 131 of 1977 on the Control of the Use of Ionizing Radiation and Protection from the Hazards," Kuwait Ministry of Health, November 27, 1977.
[232] Shihad Eldin, (KNNEC, February 2011).
[233] Ibid.
[234] From the Kuwait Institute for Scientific Research, November 7, 2010 (http://www.kisr.edu.kw/Default.aspx?pageid=12&nid=1).

- Nuclear Cooperation Agreement (NCA) with France (January 2010)
- Memorandum of Cooperation (MoC) with Jordan (March 2010)
- Memorandum of Cooperation (MoC) with United States Department of Energy (June 2010)
- Memorandum of Cooperation (MoC) with Japan (September 2010)
- Memorandum of Understanding (MoU) with Russia (September 2010)
- Memorandum of Understanding (MoU) with the United Kingdom (February 2011)

Other bilateral agreements under discussion include a memorandum of understanding (MOU) with South Korea, a memorandum of cooperation with the UAE, and a nuclear cooperation agreement (NCA) with Russia. In December 2010, Kuwait's sovereign wealth fund, the Kuwait Investment Authority agreed to take a €600 million ($1.17 billion) equity stake in Areva, the French nuclear conglomerate.[235]

Cooperation with the IAEA – Kuwait has participated in a number of technical cooperation projects with the IAEA, including studies on radiation metrology, ground-water hydrology, environmental exposure, and emergency response. Kuwait signed its first Country Program Framework with the IAEA in 2009 to lay the foundation for medium-term planning between the country and the Agency. According to the IAEA, the agency and Kuwait have prioritized a number of future technical cooperation ventures including:

- The introduction of nuclear power;
- Nuclear safety and security;
- Radiation protection related regulatory activities;
- Nuclear applications in health care with a focus on quality assurance;
- Nuclear applications in industry with a focus on radiotracer techniques;
- Environmental protection;
- Sustainable food and water resources;
- Technical capacity building;
- Training and development for human resources;

Summary and Findings

Prior to the Fukushima accident, Kuwait had made progress toward the development of a civil nuclear power program. Following the formation of the KNNEC, it initiated a request for proposal for a high-level roadmap for the development of its civil nuclear power sector based on the IAEA's *Milestones* approach, made progress in short-listing potential sites for its reactors, and had set a date of 2022 for its first reactors to come online. However, the accident in northern Japan led to a reexamination of the role and timetable for nuclear power in the country's future. With the disbanding of KNNEC, the country looks to have made a decision to indefinitely delay development of a civil nuclear power program.

Civil Nuclear Power in Bahrain, Qatar and Oman

The Gulf States of Bahrain, Qatar, and Oman have all expressed interest in developing civil nuclear power programs. Along with Saudi Arabia, the United Arab Emirates, and Kuwait, all three countries are members of the Gulf Cooperation Council (GCC). Like the larger countries in the region, all three of the smaller Gulf States are concerned about soaring electricity demand and increasing diversion of oil and gas exports into domestic power generation. The recent interest of the three

[235] "Capital Increase of Areva," Press Release, December 11, 2010 (http://www.areva.com/EN/news-8650/capital-increase-of-areva.html0.

states in nuclear power can be traced to the final communiqué of the 2006 GCC Summit in Riyadh, Saudi Arabia, which announced that the GCC Supreme Council had commissioned a "joint study by the GCC member countries to forge a joint program in the field of nuclear technology for peaceful purposes according to international criteria and systems."[236] In 2007, at the request of the GCC, the IAEA conducted a "pre-feasibility" study on the inclusion of nuclear power in the region's electricity generation and desalination sectors. All three countries are involved with the IAEA's technical cooperation project RAS/4/030, which aims to "establish and operate a Regional Nuclear Centre for Capacity Building, Training and Research in the Gulf Cooperation Council (GCC) countries including a new research reactor and an accelerator as main facilities; and to improve and further develop technical and safety infrastructure in the GCC countries in order to match the dimensions of the regional nuclear programme."[237] Given their small populations and the limited size of their electricity grids, Qatar, Bahrain, and Oman have less capacity to support domestic nuclear power programs than Saudi Arabia or the United Arab Emirates. However, they have all, to varying degrees, made progress in recent years toward the articulation of a strategy for nuclear power development.

Bahrain

While Bahrain is a minor oil producing country in comparison with some of its neighbors, its economy depends heavily on hydrocarbon production and exports. Petroleum products account for almost 60 percent of national exports and 70 percent of government revenues. Most of Bahrain's domestic energy consumption is met with natural gas. As of January 2011, the country had 3.25 trillion cubic feet of gas reserves and 125 million barrels of proven oil reserves.[238] Total production of oil liquids was an estimated 46,000 bbl/d in 2010, while total consumption for the same year reached 45,000 bbl/d. Although oil production has remained steady during the past decade, an increase in domestic consumption resulted in a reduction of exports as of 2005. It is likely that exports will continue to decrease as Bahrain's economy evolves and energy consumption continues to grow in petrochemical and aluminum production.[239]

Bahrain's electricity sector is also reliant on hydrocarbons; in 2009, the country generated 11.2 billion kilowatt-hours of electricity, the majority from natural gas-fired generation and the remainder from oil. Electricity generation has increased by an estimated 9 percent per year over the past five years; and Bahrain's Electricity and Water Authority (EWA) expects the same level of growth for the next ten years. In order to meet rising demand, independent power projects (IPPs) and the privatization of some state-owned assets have been encouraged. Bahrain's first IPP power station (the Al Ezzel plant) started to operate in 2006, producing about a third of the country's total generating capacity in 2009.[240]

Nuclear-Sector Developments

Bahrain's interest in nuclear energy came to prominence in 2006, when its ambassador to Washington met with representatives of the United States Department of Energy's Global Nuclear Energy Partnership about the prospects for U.S. technological cooperation.

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[236] "GCC Summit Issues Final Communique." Ministry of Foreign Affairs, The Kingdom of Saudi Arabia, December 18, 2006.
[237] "Developing a Regional Nuclear Training Centre for Capacity Building and Research," International Atomic Energy Agency (http://tc.iaea.org/tcweb/projectinfo/projectinfo_body.asp).
[238] "Country Analysis Brief: Bahrain," U.S. Energy Information Administration (http://www.eia.doe.gov/countries/cab.cfm?fips=BA).
[239] Ibid.
[240] Ibid.

In 2008, Bahrain signed a memorandum of understanding (MoU) with the United States on nuclear cooperation in which it "affirmed its intention to forgo sensitive fuel cycle technologies and rely on existing international markets for nuclear fuel."[241] The following year it joined the IAEA and brought into force a comprehensive safeguards agreement. Also in 2009, the government of Bahrain formulated a national committee for the peaceful use of nuclear energy. According to a 2010 presentation to the Arab Atomic Energy Agency by the head of Bahrain's Environment Control Directorate, Mr. Mizra Salman Khalaf, the committee is charged with doing "all that is necessary to develop nuclear power generating capacity in the Kingdom of Bahrain by following recommendations of the IAEA."[242]

The Office of the Prime Minister has also appointed a technical team to advise the national committee on participation with GCC-wide expert groups, IAEA regional projects, and in the Arab Network of Nuclear Regulators. According to Mr. Khalaf, the technical team is also charged with several aspects of developing Bahrain's national nuclear program including:

- The adoption of an "International Legal Regime";
- The drafting of a National Nuclear Law;
- The drafting and review request for a site feasibility study;
- The preparation of a budget for a National Nuclear Program;
- Efforts to raise public awareness about nuclear power; and
- The development of human resources.[243]

The most recent information on Bahrain's plans for nuclear power sector development came in a leaked diplomatic cable from the U.S. embassy in Manama. According to the cable, in January 2010 Bahraini officials met with a team from the U.S. State Department's Bureau of International Security and Non-Proliferation for a briefing on Bahrain's plans for the introduction of civil nuclear power generation.[244] According to the cable, the Bahraini delegation laid out details on several aspects of the country's plans for civil nuclear energy, including the information that Bahrain had hired a consultant to study nuclear power; that the government was moving to put into place the legal and policy framework required to meet the international standards required for a peaceful nuclear power program; and that the government of Bahrain understood and was committed to dealing with all the issues that arise from a long-term civil nuclear program.

According to the cable, the Bahraini government official stated that Freshfields Bruckhaus Derringer had been retained as a legal advisor for the nuclear program's development. Bahrain was also in the process of tendering a bid for an energy consultant, a solicitation that was answered by 15 companies to provide assistance, according to the cable. The Bahraini officials quoted by the U.S. embassy acknowledged that it was possible that Bahrain had no good site for a plant, and that making a site evaluation would be the top priority of the eventual winner of the tender.

The cable also made clear several other Bahraini policy positions including:

[241] "Bahrain Promises Nuclear Energy Cooperation with United States," Embassy of the Kingdom of Bahrain in Washington, DC, April 23, 2008 (http://www.bahrainembassy.org/index.cfm?fuseaction=document.home&id=228). (Embassy of the Kingdom of Bahrain, 2008).
[242] Mirza Salman Khalaf, "The Status Of The Nuclear Power Project/Programme In The Kingdom Of Bahrain," Presentation to The First Arab Conference on the Prospects of Nuclear Power for Electricity Generation and Seawater Desalination, June 23-25, 2010, Hammamet, Tunisia.
[243] Ibid.
[244] "Bahrain Outlines Initial Preparations for Nuclear Power Program," *The Daily Telegraph*, February 18, 2011.

- Bahrain is proceeding to establish a framework to support nuclear power, even if no feasible site is found, as there is a belief that Bahrain might be able to import nuclear power from elsewhere within the GCC area. (The officials said that, while Bahrain would be open to the possibility of a shared GCC reactor, they believed that civil nuclear power was an option Bahrain should explore domestically.)
- The Bahraini government has no interest in acquiring either enrichment or reprocessing technology and is opposed to Iran or any other country in the region doing so.
- Bahrain is in the process of identifying and signing all relevant conventions and treaties dealing with nuclear energy.
- Bahrain hopes to sign the Additional Protocol with the IAEA within the coming months, although ratification may take longer.
- The government knows it must establish a regulatory agency for a long term nuclear program and is in active discussion about how to do this as well as to familiarize itself with what is required in terms of professional and financial resources.
- The country possesses very little nuclear expertise and would welcome any and all help the United States can provide, as well as advice on the critical plans for a detailed implementation roadmap.

Bahrain signed the NPT in 1968 and joined the IAEA in 2009. It has recently become party to a number of international treaties including:

- Convention on Nuclear Safety (2010)
- Agreement between the Kingdom of Bahrain and the International Atomic Energy Agency for the Application of Safeguards in connection with the Treaty on the Nonproliferation of Nuclear Weapons (2009)
- Convention on the Physical Protection of Nuclear Material (2010)

Qatar

Qatar currently holds the world's third largest natural gas reserves and is the world's the largest supplier of liquefied natural gas (LNG). In 2009, Qatar exported 1,800 billion cubic feet (bcf) of LNG. Qatar's natural gas reserves totaled 896 trillion cubic feet (Tcf) as of January 1, 2011, giving the country almost 14 percent of the world's proven natural gas reserves, the majority located in the offshore North Field. Natural gas production totaled 3,154 billion cubic feet bcf in 2009, while domestic consumption for the same year totaled an estimated 745 Bcf.[245] According to estimates from Qatar National Bank, the oil and gas sectors provided over half of Qatar's total GDP in 2010. While Qatar's rapidly increasing transportation sector is driving up oil demand, all electricity capacity in the country is gas-fired. Rapid growth in energy consumption has been driven by Qatar's accelerating economic growth.[246]

As of 2011, Qatar has 25.4 billion barrels of proven oil reserves; and in 2009, it was the sixteenth largest crude oil exporter in the world. In 2009, crude oil production was estimated at 1.2 million barrels per day (bpd). Estimates for 2010 show an estimated production of 1.4 million bpd. Domestic oil consumption tripled between 2000 and 2009, to an estimated total of 147,000 bpd. According to FACTS Global Energy forecasts, due to Qatar's growing economy, oil consumption is expected to increase by about five percent between 2010 and 2015.[247]

[245] Country Analysis Brief: Qatar," U.S. Energy Information Administration, (http://www.eia.doe.gov/countries/cab.cfm?fips=QA).
[246] Ibid.
[247] Ibid.

Nuclear-Sector Developments

With a population of less than 2 million people and a grid capacity of around five gigawatts (GW), Qatar faces significant issues of scale when considering a nuclear power program.[248] It is not surprising, therefore, that the most significant development to date with regard to Qatari nuclear energy ambitions came in the context of an electricity transmission and distribution agreement. In January 2008, the government of Qatar signed both a 470 million-euro ($700 million) deal with French nuclear conglomerate Areva as well as a memorandum of understanding with Électricité de France "to engage discussions on cooperation in the areas of nuclear power production and renewable energy generation."[249] In 2008, the Qatari government announced that an investigation into the viability of nuclear power had shown that there was not a strong case for proceeding.

Qatar currently has limited institutional and technical capacity with regard to nuclear power. Its "Decree number 31" establishes standards for radiation emissions from various industries to limit the environmental impact, and it has developed a national emergency plan to respond effectively to any nuclear emergency. However, it has no dedicated legal framework for nuclear power development and has not made public any strategy for its development.

Qatar's most notable involvement with civil nuclear power is likely to be through affiliations and partnerships in the education sector. According to Sandia National Labs, the GNEII program (see section 1.3) will be open to professionals from Qatar by 2012.[250] According to a 2009 presentation to the IAEA by Ilham Al-Qaradawi, professor of physics at Qatar University, the country is also planning to develop a Qatar Nuclear Research Center (QNRC), a regional educational establishment related to the development of nuclear-related technologies. At the time of writing, there have been no further public statements regarding the center. Mr. Al-Qaradawi's presentation states that Qatar has also established cooperative ties with several other universities and institutions with regard to the development of nuclear power, including Imperial College of the United Kingdom, the Korean Atomic Energy Research Institution (KAERI), the Australian Nuclear Science and Technology Organization (ANSTO), and the World Nuclear University (WNU).

Qatar became a member of the IAEA in 1976, and is party to a number of international agreements including:

- UN Treaty on the Nonproliferation of Nuclear Weapons (1989)
- Convention on the Physical Protection of Nuclear Material (2004)
- Convention on Early Notification of a Nuclear Accident (2005)
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (2005)
- Application of Safeguards in Connection with the Treaty on the Nonproliferation of Nuclear Weapons (2009)

In addition to the agreement with the two French companies in 2008, Qatar signed a "practical cooperation arrangement" with the IAEA in 2006, aimed at assistance in developing its nuclear security regime, and a memorandum of cooperation with Russia's Rosatom in 2010.

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[248] "The Report: Qatar 2010," *Oxford Business Group*, 2010.
[249] "France's Areva, EDF in nuclear agreements with Qatar," *Reuters*, January 14, 2008.
[250] Sandia National Laboratory, "Sandia seeds culture of nuclear energy safety and security", March 7, 2011, (https://share.sandia.gov/news/resources/news_releases/gneii/)

Oman

Like many of its neighbors, Oman is dependent on hydrocarbons both as a source of income and for power generation. With estimated total proven reserves of 5.5 billion barrels (mainly found in the north and central onshore areas of the country), it possesses the largest oil reserves of any non-OPEC country within the Middle East.[251]

Oman's oil production has increased by an estimated 20 percent since 2007, and the country produced 860,000 bpd in 2010. The country is a significant producer of natural gas, producing an estimated 875 bcf in 2010. Both oil and natural gas consumption have also increased significantly in recent years: the former stood at an estimated 115,000 bpd in 2009 while the latter was 520 bcf, up over 100 percent from a decade earlier. Oman possesses considerable natural gas reserves, totaling an estimated 30 trillion cubic feet (Tcf) as of January 1, 2011. However, increases in domestic electricity demand and gas reinjection for enhanced oil recovery (EOR) are increasing gas demand and imposing a relative constraint on supply; Oman imports 200 million cubic feet (Mcf) per day via the Dolphin pipeline to meet its growing electricity needs. The Ministry of Oil is planning to increase reserves by a trillion cubic feet per year for the next 20 years by employing techniques similar to EOR, which is used to stimulate oil production.[252]

As with other countries in the GCC, electricity demand in Oman is projected to increase rapidly in the coming years. According to Omar Abdallah of the Oman Electricity Transmission Company, the country's peak electricity demand in 2009 was 3,546 MW, an increase of 13 percent over the previous year. Peak demand is expected to grow from 4,304 MW in 2011 to 5,411 MW in 2014. Within the GCC, Oman has been in the forefront of privatization of its electric power sector. The opening of the power sector to competitive bidding has enabled the country to scale up capacity to meet rising demand. Much of the projected increase in electricity demand is due to an increase in the demand for desalinated water. The Oman Power and Water Procurement Company (OPWPC) has embarked on the development of a series of new independent water and power plants (IWPPs) to meet the demand. The country also has significant renewable resource potential.[253]

Nuclear-Sector Developments

Oman reportedly established its Civilian Nuclear Energy Agency in 2008, and signed on to the Global Nuclear Energy Partnership (GNEP), a U.S.-led technology and policy initiative on the management of sensitive aspects of the nuclear fuel cycle, the same year. The country joined the IAEA in 2009, and has asked the Agency to advise it on the design and implementation of both a medium and long term technical assistance cooperation plan, and for assistance on the establishment of a national radiation security system based on IAEA criteria. In 2009, Oman and Russia signed a nuclear cooperation agreement.

Summary and Findings

In March 2010, at an International Conference on civil nuclear energy in Paris, Sayyid Badr bin Hamad al Busiady, the Secretary General of the Omani Ministry of Foreign Affairs and the Chairman of the Steering Committee for Peaceful Nuclear Technology, noted Oman's need to learn more about using nuclear energy in power generation, the need for human resource development to

[251] "Country Analysis Brief: Oman," U.S. Energy Information Administration, (http://www.eia.doe.gov/countries/cab.cfm?fips=MU).
[252] Ibid.
[253] Omar Abdallah, "Performance of Oman Transmission System with Distributed Generation," Institute of Electrical and Electronics Engineers, 2010.

sustain a nuclear reactor program and the difficulties in financing a nuclear power plant, designing and constructing nuclear installations, and establishing the legal framework.

Oman is not alone in its inexperience with nuclear energy. Compared with their larger neighbors in the region, Bahrain and Qatar have also made only limited progress with regard to the development of domestic institutional, regulatory, and technical capacity with regard to civil nuclear power. Indeed, given its small size, it is not even clear if the latter is interested in pursuing its own civil nuclear power program. The three states also have relatively few international commitments in place: Bahrain and Oman have joined the IAEA only in the past two years; neither Qatar nor Oman is a signatory to the Additional Protocol to the NPT; and Bahrain is yet to bring into force the Comprehensive Safeguards Agreement.

Given the small sizes of their electrical grids, the installation of gigawatt-scale nuclear power plants in the smaller Gulf states poses significant logistical challenges. (While small modular reactors may play a role in these countries at some point in the future, there is no short or medium term prospect for them.) The role of nuclear power in each of the countries is, therefore, perhaps most realistically viewed from the perspective of their participation in the GCC-wide grid project currently underway.

In 2009, the first phase of the grid was completed with the connection of Saudi Arabia to Kuwait, Bahrain and Qatar. The second stage of the project involving the connection of UAE and Oman was agreed in 2010. The final stage, which will link the two sections together, is expected to be complete in 2011. If completed as forecast, the integration of the electrical networks of all the GCC states will reduce the need for each country to have its own large reserve of electricity capacity, leading to improvements in supply security while introducing greater efficiencies throughout the interconnected network.

In addition to the potential for allowing smaller states to tap into nuclear generation in the region, a GCC-wide grid also has the potential to serve as a bridge to much larger regional grids such as EGLST (Egypt, Jordan, Iraq, Lebanon, Syria and Turkey) and to Europe through ENTSO-E. In this scenario, large-scale nuclear plants serving the pool could be built in a number of locations serving either the GCC grid alone or as generation assets for a larger entity.

Part 2: Conclusions and Recommendations

The research team's objectives in this study were to examine the approaches to civil nuclear power development by countries in the Middle East; to highlight similarities and differences between them; and to identify opportunities to address common challenges. This section draws upon the detailed country analysis in Section I and on the proceedings of an April 2011 roundtable discussion in Abu Dhabi with leading nuclear energy government and regulatory stakeholders from across the region. It provides conclusions on the various countries' drivers for nuclear power; initial steps taken toward the adoption of nuclear power; legal and institutional frameworks; technology and commercial models; human resources development; and international agreements. Based on these conclusions, it offers several recommendations for the safe and responsible development of civil nuclear power programs in the Middle East.

Conclusions[254]

Although two countries in this review, Egypt and Turkey, have had a civil nuclear energy program for decades, none of the countries examined currently has a commercial nuclear reactor connected to the electricity grid. Egypt, Turkey, Jordan and the UAE have started or restarted efforts toward the implementation of a nuclear program in the past several years, and are at an advanced stage of planning or developing a nuclear energy infrastructure. The remainder of the countries are at various stages of considering nuclear power or initiating a program. **Figure 8-1** summarizes the status of nuclear power development in each country.

Figure 8-1: Status of Nuclear Power in the Middle East

STAGE OF DEVELOPMENT	COUNTRIES
Ground broken on reactor site	UAE
Contracts for NPP signed, legal and regulatory infrastructure well-developed	Turkey
Committed plans, NPP procurement process initiated, legal and regulatory infrastructure developing	Jordan
Well-developed plans and legal & regulatory infrastructure, but commitment pending	Egypt
Developing Plans	Bahrain, Saudi Arabia
Considered civil nuclear power as an option but no immediate prospects for development	Kuwait, Oman, Qatar

Source: World Nuclear Association and Brookings; only includes those countries in the Brookings analysis.

[254] Appendix 1 tabulates the status of each country analyzed in a range of development areas.

Drivers and Initial Steps

The countries examined in this research share common motivations for interest in commercial nuclear power. In most of the countries, electricity demand, spurred by economic expansion, increasing industrialization and urbanization, low electricity prices and population growth, is expected to increase by at least six percent per year to 2020. Some countries face annual growth rates exceeding 10 percent. Water scarcity is also contributing to growing electricity consumption as plans are drawn up for increased reliance on energy-intensive desalination facilities. Most of the countries in this review are currently highly dependent on natural gas and petroleum products in power generation; many also rely on imports of natural gas. Even in the case of countries that have adequate domestic natural gas and oil resources, an overreliance on fossil fuels in power generation has raised concerns about the long-term economic and environmental costs. Nuclear power is therefore one option to increase energy security through diversification; reduce the opportunity cost of using valuable hydrocarbons domestically instead of selling them on global markets; and lower the environmental impact of their economic development.[255]

In designing their nuclear-program development plans, all countries examined demonstrated a reliance on external assistance and guidance. The IAEA has played a significant role in providing programmatic guidance and technical assistance, and many of the countries in the region have used the agency's *Milestones in the Development of a National Infrastructure for Nuclear Power* (*Milestones*) document in developing their programs. However, while most countries draw from the *Milestones* document in their program designs, many do not follow the specific recommendations laid down in the document.

For example, on the issue of "national positions", the *Milestones* document recommends that countries demonstrate their understanding of the commitments involved in a nuclear program *before* arriving at a national position on nuclear power development, and that they produce "a comprehensive study of the issues and conditions necessary for the successful implementation of nuclear power" before considering specific nuclear power plant projects.[256] The UAE's White Paper addresses many (although not all) of the policy considerations that the IAEA recommends in advance of a country's formal commitment to nuclear power. However, while the development plans of other countries—including Egypt, Turkey, and Jordan—often incorporate many of the targets laid out by the IAEA *Milestones* document, their commitments to nuclear power have been made without the publication of a similar comprehensive policy document in the public domain.

In other cases countries are have shown a willingness to proceed with plans that are at odds with recommendations in the *Milestones* document. For example, several countries including the UAE have expressed plans to implement their nuclear power program ahead of the IAEA's recommended timeline. The *Milestones* document also clearly explains the need for states to consider issues related to nuclear waste and funding of back end fuel cycle obligations early in the planning; however, as the analysis in Section I shows, these issues have largely been left unaddressed (see Recommendations section below for more on this subject). While variations between states on the approach to civil nuclear power are inevitable, there is a strong case to be made that a core set

[255] Some countries also view nuclear energy as a hedge against the possibility of an international climate agreement on pricing carbon or mitigating carbon emissions.

[256] "Milestones in the Development of a National Infrastructure for Nuclear Power," International Atomic Energy Agency, 2007. pp 11-14

of principles and practices should be at the heart of a safe, secure, and sustainable program. (See the Recommendations section for more on this issue.)

Several analysts have interpreted the decision by countries in the Middle East to pursue nuclear energy development as partially motivated by strategic considerations in response to Iran's nuclear activities.[257] Others suggest that the drive to develop civil nuclear energy is motivated by considerations of prestige, as countries in the region strive to attain the technological status of industrialized nations. Such motivations are dismissed by the government officials in the region interviewed for this research, who cite the high financial barriers and other attendant challenges, such as technical and regulatory capacity development and complex international cooperation agreements, as evidence that such programs could not be undertaken without a clear economic rationale. The charge that the recent wave of interest in nuclear power in the countries of the Middle East is motivated by Iran's actions to develop nuclear technology is also countered by officials who point to the simultaneous interest in civil nuclear power development among other rapidly developing regions of the world.

The inherently dual-use nature of nuclear technology and the volatile political situation in the Middle East mean that it is impossible to discount or disregard the potential for a strategic component to the civil nuclear plans of some countries in the region. However, there are actions that can be taken by states in the region to demonstrate their commitments to peaceful uses of nuclear power. The UAE's willingness to formalize a commitment to forswear involvement in sensitive fuel cycle technologies is one such approach; others include an accession to international conventions on non-proliferation and the institution of mechanisms for transparency and regulatory independence (see the Recommendations section below for more on these measures).

Legal and Institutional Framework

Several countries in the analysis have promulgated laws, regulations, and standards pertaining to the nuclear sector; some have established nuclear-specific institutions. The most important institutional entities identified by the IAEA in its *Milestones* document are: a National Energy Program Implementation Organization (NEPIO), an agency responsible for managing and promoting the nuclear program; an independent nuclear regulator; and the owner/operator of the nuclear power plant.

Several countries in the analysis have established a NEPIO and a regulator. Only two—Turkey and the UAE—have reached the stage of establishing an owner/operator (discussed below). The UAE and Jordan have created regulatory bodies separate from their NEPIOs; in contrast, the NEPIOs in Saudi Arabia (KA-CARE) and Egypt (AEA) also function, or plan on functioning, as the regulator; Turkey's NEPIO, the Ministry of Energy and Natural Resources, is also the administrative body that has responsibility for TAEK, the country's regulator. Many of the countries in the region are still trying to find an appropriate model and mandate for a nuclear regulator, particularly with regard to enforcement mechanisms in the event of a breach of safety or security rules.

Among the countries studied, the UAE is employing several notable measures that may have applicability to other countries in the region. It has initiated the use of Technical Support Organizations (TSOs) to augment the activities of its regulator, especially in the field of nuclear safety, and it has established an International Advisory Board

[257] See (IISS, 2008) and Friedrich Steinhausler, "Infrastructure Security and Nuclear Power," *Strategic Insights*, Volume VIII, Issue 5, December 2009.

(IAB) to monitor the progress and performance of nuclear power infrastructure development, and provide recommendations to policy makers.

Technology and Commercial Model

Nuclear power plant development – Given the lack of domestic operational experience with commercial nuclear power plants, as well the substantial financial requirements involved in setting up a nuclear program, the countries identified as being furthest along in their nuclear programs are pursuing or considering some form of public-private partnership (PPP) in order to draw upon external expertise and capital.

The three countries in the review that are the furthest along in developing a civil nuclear program are all implementing a PPP model that either initially (Jordan) or eventually (Turkey, UAE) establishes a joint venture with government sharing some degree of equity ownership in the utility/operator. For the construction of the nuclear power plants themselves, all three countries are using a "turnkey" approach comprising a single bundled contract between the customer (government) and a nuclear plant vendor (or a consortium led by a vendor), covering engineering, procurement and construction services (EPC) for the entire plant. A turnkey approach allows for the quickest construction of a nuclear reactor and its connection to the grid (as well as a way to engage outside expertise) and is therefore a preferred model for countries facing severe electricity shortages. While some government officials expressed concern at the level of control a turnkey project might cede to external parties, countries retain the option of operating the plants themselves following construction, providing they can develop sufficient technical capacity (see Human Resources Development section below).

There is variation between countries within the PPP framework. The UAE and Turkey are employing a form of a *Build-Own-Operate* (BOO) concession model, in which an outside developer or investor constructs and operates the nuclear power plant, allowing the host governments to harness external financial capital and expertise. The UAE and Turkey have selected partners that, either through a consortium (KEPCO in the case of the UAE) or one entity (Rosatom in the case of Turkey), will not only provide bundled EPC services for construction of the nuclear facilities, but will also provide the fuel, operate the plant and, in the case of Turkey, provide some services for spent fuel management. In both countries, the host governments have the intention (UAE) or option (Turkey) of retaining significant equity stakes in the nuclear operating company. While this gives the government an incentive and a means to ensure the optimal operation of the companies, it also poses a potential conflict of interest with the government as both owner/operator and regulator. Both countries are partnering with government-run or government backed partners, in contrast to the more traditional private-sector counterparties seen in many BOO arrangements.[258]

Jordan's commercial arrangements differ in structure from those of the UAE and Turkey. The Jordan Atomic Energy Commission is using a two-track approach: one procurement process to select a vendor for the EPC services to build the nuclear power plant, and another to select a utility operator. For the latter, Jordan is planning to form a *Joint Venture* utility operating company owned by the government's NEPIO and an external partner to sell electricity to the power sector's single buyer under a power-purchase agreement. The government views the two-track approach as a way to achieve the most competitive terms for

[258] Government-backed vendors are not uncommon in the nuclear industry, but the scale of state support for the KEPCO bid and Turkey's stated preference for government-backed partner suggest a shift in favor of state-backed vendors.

international expertise and financial resources. The joint venture model involves a greater degree of up-front investment from the Jordanian government (some of which will be provided from the country's uranium mining activities), but it does allow greater involvement of the Jordanian nuclear establishment from the outset of the program. As with the UAE and Turkey, Jordan's joint venture model also comes with the challenge of ensuring effective government regulation of a state-owned and operated program.[259]

Given the high capital cost requirements of and the risks involved in nuclear power development, governments in the region have shown a desire to secure state-backed financial guarantees from international vendors. In each of the PPPs outlined above, the contractor is expected to provide substantial financing for the project. In the cases of Turkey and the UAE, the vendors chosen to develop the programs are government-backed companies that provide additional assurances of long-term technical and financial support. Jordan is in the process of inviting bids from four potential strategic partners, three of which are state-backed operators.

There is also notable variation between the three countries on the selection process for nuclear vendors. Jordan is using a typical competitive procurement process involving the issuance of a request for proposals, specifications, bidding process, and contract negotiation. The UAE employed a "competitive dialogue" process, a series of interactions with potential bidders in which the government conveyed the requirements, criteria and goals of the nuclear program via an initial policy document. Turkey has explicitly requested a government-backed contractor in order to minimize its own government's financial exposure—a strategy that has resulted in a predominantly government-to-government dialogue process to determine the selected contractor. In all three cases, each country has also insisted on vendor-supported training and knowledge transfer as criteria in the selection process.

Fuel Cycle Management – Most countries in this review have not determined a specific policy for fuel provision, spent fuel storage, or waste disposal. The exceptions are again Turkey and the UAE. Turkey's approach calls for Rosatom, its chosen vendor, to be responsible for procuring fuel for the reactors, and allows for Russian origin fuel to be reprocessed in Russia. The UAE's agreement with the United States permits it—with prior US approval—to send spent fuel to France or the United Kingdom for storage or reprocessing on the condition that the material is held within the EURATOM area, and that no separated plutonium be returned to the UAE. The UAE has not indicated whether it will pursue this option; however, even if it does so, it will still have to address the issue of the management of the high-level waste from the reprocessing process that the UK and France are unlikely to keep. The nature of the UAE's nuclear cooperation agreement with the United States in which it agrees not to pursue enrichment or to reprocess spent fuel is unique; although the nature of the agreement—which states that the agreement will be "no less favorable in scope or effect" than any subsequent agreements between the U.S. and other Middle East aspirant nuclear energy states—may have an impact on the decisions of other nations in the region when it comes to cooperation with U.S. reactor vendors. Two other countries have signaled their intentions not to develop indigenous enrichment or reprocessing capabilities: in its March 2008 Memorandum of Understanding (MoU) with the United States, Bahrain "affirmed its intention to forgo sensitive fuel cycle technologies"; and in its May 2008 MoU with the United States, Saudi Arabia stated its intent "to rely on international markets for nuclear

[259] "Public-Private Partnership Handbook," Asian Development Bank, 2008.

fuel and not to pursue sensitive nuclear technologies."[260] Beyond these (non-legally binding) declarations, no other country in our review has stated or determined a formal policy for dealing with sensitive aspects of the fuel cycle. On the issue of waste disposal, none of the countries examined has established a strategy for long-term storage of spent fuel or waste-disposal.

Human Resources Development

The countries in this review have widely varying levels of expertise, but are pursuing similar strategies with regard to human resource development. Each recognizes the need for reliance on international assistance in various forms in the near term; and the need for a long-term plan which ensures that indigenous technical and institutional capacity is developed. Each country in the analysis is using international assistance through combinations of consulting companies providing support through multi-year contracts; vendor-related assistance; bilateral agreements with other governments and institutions; and through multilateral arrangements with the IAEA, the EU or other international and regional entities. The UAE, for example has used expatriate advisors in senior staff positions in both its NEPIO and its regulator.

Several nuclear officials interviewed in the course of the research expressed serious concern that such dependence on expatriate technicians and consultants may prove to be unsustainable. Specifically, there may be a "knowledge risk" in which a cadre of older, expatriate advisors concludes its tenure before adequately transferring knowledge to the domestic workforce. This situation may be exacerbated as the centers of established nuclear power—Europe, Japan and North America—experience a retirement cliff of nuclear engineers, leaving them with a deficit of technical capacity for their domestic programs.

Most countries in the analysis have initiated university degree programs related to nuclear physics, engineering or other related disciplines, and have established scholarship plans both domestically and abroad. As detailed above, governments are also requiring external nuclear vendors to support and implement training and other knowledge programs as part of their services. Several countries in the review are also relying on research reactor programs for indigenous training. Turkey and Egypt have long-standing research reactor programs that have enabled practical operational training for decades, while Jordan has taken concrete steps to construct a research reactor with the express purpose of training future personnel for the industry. While research reactors provide enhanced opportunities for training, several government representatives acknowledged that the economic costs and time investment required to develop and operate such reactors have to be weighed against the short-term imperative of building power reactors to serve electricity demand.

International Agreements

All countries in this analysis are signatories of the NPT. Many have signed and ratified some of the major international conventions and agreements including the Comprehensive Safeguards Agreement. However, there are some notable omissions: five of the nine countries in the analysis, including Egypt and Saudi Arabia, are not signatories to the IAEA Additional Protocol, and the UAE is the only country to have signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. None of the countries—including the UAE—has signed any of the three principal international liability conventions: the Vienna Convention on Civil Liability for Nuclear Damage; the Joint Protocol Relating to the Application of the Vienna

[260] Embassy of the Kingdom of Bahrain, 2008; U.S. Department of State, May 2008.

Convention and the Paris Convention; or the Convention on Supplementary Compensation for Nuclear Damage.

As noted above, each of the countries in the region has engaged with the IAEA in the development of its civil nuclear program. There is, however, some disagreement among officials with regard to the appropriate role of the IAEA in providing countries with assistance. There was particular disagreement between those who saw the IAEA's role as a provider of tangible assistance and those who saw its appropriate role as simply an aggregator of best practice.

According to several government representatives, the countries of the GCC countries are in the process of a setting up a group to look at institutional aspects of civil nuclear development. The initiative follows an agreement at the December 2006 Riyadh Summit, in which the GCC governments agreed to investigate a regional approach to the role of nuclear power in meeting their common energy challenges. While interest in civil nuclear power has waned in some industrialized countries in the wake of the 2008 financial crisis and the Fukushima disaster, the GCC continues to investigate options for regional cooperation in the following areas: "legal issues and liability; nuclear regulation; site assessment; training, R&D, safety culture and human resource capacity building; fuel security and supply; nuclear waste management; and emergency response."[261]

Recommendations

Although they share some common characteristics and challenges, the countries in this analysis are each approaching the development of civil nuclear power from different economic, political, and geographic perspectives. Despite this state-to-state variation, it is possible to identify certain tenets that have applicability across countries, as well as certain practices that reinforce the goals of safety and non-proliferation.

1. Newcomer nuclear power countries should consider articulating plans for civil nuclear power in the form of policy statements, and as part of a broader energy plan.

As demonstrated by the experience of the UAE, the development and dissemination of a clearly articulated vision for a civil nuclear power program is an effective means of communicating intentions both to domestic constituents and to the international community. By outlining its motivations and operational strategy, the government of the UAE provided a framework with which to understand its nuclear program. Other countries in the region—particularly those without a history of civil nuclear power development—have the opportunity to use similar policy statements to set their civil nuclear programs in context and to address questions related to safety, security, technology, and institutional structure from the program's outset. Where possible, the nuclear policy document should be framed in the context of a broader national energy strategy in order to maximize coordination within the energy sector. Countries should also to the greatest extent possible provide a clear indication of the domestic and international mechanisms by which they will achieve its commitments to safety and security in their civil nuclear program.

2. Nuclear regulators should maintain administrative and operational independence from plant operators.

As the *Milestones* document notes, "safety and credibility are best served by a complete separation of the regulatory body from the promotional

[261] "Lightbridge, Exelon to advise Gulf States," *World Nuclear News*, December 2, 2010.

and implementing organizations and the political process."[262] As they begin to implement their nuclear power programs, countries in the Middle East should ensure the establishment of a competent nuclear regulator independent from the government and the nuclear operator. In all cases, the regulators should be led by employees with demonstrated experience and expertise. The regulatory authorities should also be given clear enforcement authority. To ensure the highest standards of compliance and transparency, newcomer nuclear energy states in the Middle East should consider implementation of a mechanism for international oversight and peer review. They should also look into the prospect of a regional advisory board that could serve as a means of overseeing and sharing lessons among states as they implement their respective programs.

3. Countries should put in place a long-term human resource development program to ensure the sustainability of their nuclear power programs.

One of the biggest challenges that aspirant nuclear energy countries in the Middle East face is lack of indigenous knowledge and professional expertise on nuclear issues. Since it requires ten to fifteen years for nuclear operators to function at their full professional ability, human resource development is a critical consideration. With the exception of Egypt and Turkey, which have had nuclear programs in place for many decades and have substantial domestic professional expertise, the countries in our review are starting with very limited capacity. As a result, they are pursuing a variety of mechanisms to develop local expertise while also bringing in foreign advisors.

The aspirant nuclear power states in the Middle East should work to put in place a long-term incentive structure to ensure that the requisite expertise is maintained as they build indigenous capacity. For those countries with limited existing professional expertise, expatriate professionals can be retained as staff for newly established entities such as the NEPIO and the regulator. Expatriates should be required as part of their terms of reference to provide on-the-job training for the national staff working alongside them. The countries should simultaneously focus on training a domestic workforce with the skills necessary to keep pace with the evolution of the nuclear program through its various stages of construction and operation. One means of achieving the necessary training would be the foundation of a regional center of excellence, which could train nuclear technicians and engineers from around the region. The center could be based on the model of the Gulf Nuclear Energy Infrastructure Institute, which combines resources from existing nuclear energy states and regional educational establishments.

4. Plans for spent-fuel storage and waste disposal should be considered at the outset of a nuclear program.

The implementation of a civil nuclear power program is a long-term undertaking and one that should involve from the outset a clear strategy for the management, storage, and disposal of spent nuclear fuel and nuclear waste. None of the countries in this review has formulated such a strategy. While designing their civil nuclear programs, countries in the Middle East should make spent-fuel and waste-disposal planning a central part of their development agendas. The countries should collaborate to look at all available options, including the feasibility of a regional storage facility.[263]

5. Vendor selection should be based on a set of clear, transparent criteria to insure that it is removed from political interference.

[262] *Milestones in the Development of National Infrastructure for Nuclear Power,* (Vienna: International Atomic Energy Agency, 2007).

[263] The second year of this project will examine the prospects for civilian nuclear energy cooperation between the aspirant nuclear energy states of the Middle East.

As outlined in Section I, there are a variety of commercial models in place between aspirant nuclear energy states in the Middle East and international vendors. It is not the objective of this study to provide a critique of the various models. However, it is clear from interviews with government officials in the region that the selection process for a nuclear vendor is often subject to political motivations, sometimes at the expense of the technical or economic merits of a bid. In order to minimize the extent to which political interests prevail in the vendor-selection process, states should devise a transparent set of qualification standards for an open, competitive tender process.

6. Countries with serious civil nuclear power plans should sign and ratify all of the principal international safety, security and liability conventions.[264]

Engagement with the international community is essential in the development of a safe, secure, and transparent nuclear program. Accession and adherence to the Additional Protocol is an important signal that a state is willing to pursue a policy of transparency intentions in the use of nuclear technology, and should be a priority for any non-signatory countries in the Middle East developing plans for civil nuclear power programs. None of the countries in this review is party to any of the three principal international liability conventions for nuclear power. Countries in the region implementing, or considering the implementation of, nuclear power should ratify all relevant international nuclear liability conventions and should implement a clear domestic liability regime in national legislation at the planning stage. This should include a clear delineation of a nuclear operator's liability in the event of an accident.

7. Countries should integrate meaningful domestic stakeholder engagement into the nuclear power-program development process.

In its *Milestones* document, the IAEA states that "the establishment of a dialogue among all stakeholders should be seen as an essential part of any complete nuclear program.", defining stakeholders as both those involved in the decision-making process, and those affected by the outcome of the project.[265] Several countries in our review have taken steps to address this requirement. Countries, however, will need to continue to pay close attention to this important area, especially in the aftermath of the accident at the Fukushima Daiichi plant in Japan in March 2011. Transparency and public information are integral to the development of a nuclear power program. Stakeholder engagement should go beyond the provision of information from the government to domestic constituencies; it should involve a two-way exchange in which the views and concerns of populations can be communicated to policy makers.

[264] Appendix 1 provides an overview of the status of countries under review with regard to a selection of international conventions .
[265] "Stakeholder Involvement in Nuclear Issues," International Atomic Energy Agency, 2006. p17

Appendix 1

	Bahrain	Egypt	Jordan	Kuwait	Oman	Qatar	Saudi Arabia	Turkey	UAE
DRIVERS									
Electricity demand	✓	✓	✓	✓	✓	✓	✓	✓	✓
Desalination needs	✓	✓	✓	✓	✓	✓	✓		✓
Uranium reserves (reasonably assured)			✓					✓	
Large commercial fossil energy resources	✓	✓		✓	✓	✓	✓		✓
Large fossil energy use in power (a)	✓	✓	✓	✓	✓	✓	✓	✓	✓
INITIAL STEPS									
Energy strategy / nuclear feasibility review	(b)	✓	✓	(b)	(b)	(b)	(b)	✓	✓
Nuclear policy / strategy / statement		✓	✓	✓			(c)	✓	✓
LEGAL & INSTITUTIONAL FRAMEWORK									
Nuclear Energy Program Implementation Organization (NEPIO)		AEA -NPPA	JAEC	KNNEC			KA-CARE	MENR	ENEC
Nuclear Regulator		AEA	JNRC				KA-CARE	TAEK	FANR
Nuclear Power Plant (NPP) owner/operator								Rosatom	KEPCO
Nuclear energy laws: advanced		✓	✓					✓	✓
Nuclear energy laws: none / limited / in planning	✓			✓	✓	✓	✓		
FUEL CYCLE APPROACH									
NPP technology								VVER-1200	APR 1400
NPP ownership/operation			JV					BOO to JV	BOO to JV
Power Purchase Agreement (PPA) to be used			✓					✓	
Front-end: provided internationally (c)								✓	✓
Front-end: provided domestically			(d)						
Back-end: Spent fuel policy indicated								✓ (e)	
Back-end: Waste disposal policy indicated									
HUMAN RESOURCES DEVELOPMENT									
University-level degrees / nuclear research		✓	✓			✓	✓	✓	✓
Research reactor		✓	(f)					✓	
Substantial international cooperation / scholarships		✓	✓			✓	✓	✓	✓
Substantial existing base of professional scientists (g)		✓					✓	✓	
Vendor-sponsored training (incl. planned)			✓					✓	✓

	Bahrain	Egypt	Jordan	Kuwait	Oman	Qatar	Saudi Arabia	Turkey	UAE
SELECTED INTERNATIONAL CONVENTIONS (h)									
Treaty on the Non-proliferation of Nuclear Weapons	✓	✓	✓	✓	✓	✓	✓	✓	✓
Comprehensive Safeguards Agreement (INFCIRC/153)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Additional Protocol pursuant to INFCIRC/540		✓	✓					✓	✓
Convention on Early Notification of a Nuclear Accident (INFCIRC/335)		✓	✓	✓	✓	✓	✓	✓	✓
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336)		✓	✓	✓	✓	✓	✓	✓	✓
Convention on Nuclear Safety (INFCIRC/449)	✓	✓	✓	✓			✓	✓	✓
Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)			(i)					(i)	✓
Convention on the Physical Protection of Nuclear Material (INFCIR/274)	✓		✓	✓	✓	✓	✓	✓	✓
US 123 Agreement	(j)	✓					(j)	✓	✓
Vienna Convention on Civil Liability for Nuclear Damage (INFCIRC/500)		✓					✓		
Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (INFCIRC/402)		✓						✓	

(a) Defined as ≥ 50 percent of total fuel mix in electricity

(b) IAEA review conducted for GCC (the UAE was included, but the Emirates also conducted their own national energy study); Lightbridge and Exelon currently conducting additional assessment for GCC countries.

(c) Front end refers to uranium exploration, mining, milling; conversion; enrichment; and fuel fabrication. Back-end refers to spent fuel storage and waste disposal.

(d) Jordan will likely undertake only uranium exploration, mining and milling domestically.

(e) Turkey's cooperation agreement with Russia's Rosatom makes provision for spent fuel take-back from Russian-sourced nuclear fuel.

(f) Under development

(g) See Lindsey Windsor and Carol Kessler, "Technical and Political Assessment of Peaceful Nuclear Power Program Prospects in North Africa and the Middle East," Pacific Northwest Center for Global Security, September 2007, p. 8.

(h) Sources: see Ibid, Appendices A-O; and IAEA.

(i) Review in process in Jordan; ratification process ongoing in Turkey

(j) MoU with United States in which the government has affirmed it will not pursue sensitive fuel cycle technologies. The MoU is not legally binding.

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