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Human Resource Development in New Nuclear Energy States: Case Studies from the Middle East

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Executive Summary

The Middle East is likely to play host to the first newcomer civil nuclear energy states of the 21st century. The release of the United Arab Emirates' white paper outlining its peaceful nuclear power strategy in 2008 was followed by the purchase of four nuclear power reactors in 2009, all of which are projected to be operational by 2020. Jordan has completed the first stage of a tender for its nuclear energy program and intends to have at least one reactor connected to the grid by 2020. After many stalled plans to establish a civil nuclear program, Turkey has finalized an agreement with the Russian Federation for the provision of four reactors, also scheduled to begin deployment by the end of the decade. The introduction of civil nuclear power in the region is driven by a set of common motivations: economic growth combined with increasingly expensive fossil fuel-based power generation and growing concern over carbon emissions and other pollution have led each of the three countries to see nuclear energy as a secure carbon-free source of power generation.

After a long hiatus, the likely entry of several new states into the global nuclear power sector presents a number of unprecedented challenges. While the introduction of a new generation of reactor technologies makes nuclear power a potentially safer and more proliferation resistant option than ever before, the catastrophic accident at Japan's Fukushima Daiichi plant in 2011 demonstrates the consequences of technical and human failures in the sector. The ongoing diplomatic impasse over Iran's suspected nuclear weapons program demonstrates the perils of the dual-use nature of nuclear technology in general and the heightened sensitivity around nuclear proliferation in the Middle East in particular. To meet these challenges, it is essential that new nuclear energy states develop the institutional and human capacity to run their programs competently and sustainably. Against this backdrop, this paper assesses human resource development (HRD) in the United Arab Emirates (UAE), Jordan, and Turkey against these two criteria. Its findings, presented as individual case studies, are based on in-depth interviews with officials and representatives from the countries under review and representatives from external international organizations, as well as the output from a roundtable discussion hosted by Brookings in Abu Dhabi in May 2012 .

With widely varying economic, political, and social contexts, each of the three countries under review has different HRD requirements and objectives. A comparative analysis of each country according to a standardized set of metrics is therefore impractical. However, while each country has unique challenges related to its individual circumstances, it is also possible to identify areas of relative success and concern with regard to leading HRD practices.

With a high level of sovereign wealth, and a well-formulated, well-articulated strategy for the implementation of civil nuclear power, the UAE has the most comprehensive approach to HRD among the countries under review. Both its nuclear regulator and its nuclear energy implementation organization have detailed, institutionalized approaches to HRD, and the establishment of a graduate program for nuclear engineers as well as a vocational program for nuclear technicians demonstrates a multi-faceted education and training strategy. The principal challenges for the UAE relate to its ability to reconcile the extensive needs of its civil nuclear program, which is being implemented according to an aggressive timetable and based on a reactor technology that currently has no operational history, and the objectives of recruiting the requisite number of qualified nationals into training programs and professional positions. The need to maintain quality control in its educational programs may run counter to the necessity of recruiting and retaining the number of students necessary to provide the future nuclear-related workforce. Moreover, the drive toward achieving minimum levels of national participation in the nuclear-energy workforce, if indiscriminately enforced, may have negative consequences for competency in the sector.

Jordan faces more challenges than the UAE with regard to preparedness for a civil nuclear program. While the country has a large educated population—with thousands of graduates in technical disciplines graduating every year—the country has far fewer financial resources. As a result, Jordan can neither afford the same level of direct investment in its nuclear power assets nor the same level of support for educational and governmental institutions with a role in nuclear-sector HRD as that found in the UAE.

However, Jordan's challenges go beyond those related to financial considerations. Some of the biggest obstacles with regard to its nuclear program are the result of a lack of public-sector coordination and communication. With no overarching strategy for the implementation of its nuclear program, Jordan's policy makers have come under increasing pressure from the public to justify the need for it. Failure by the government to address these concerns through adequate stakeholder engagement has led the public to further question the economic rationale and the legitimacy of the program, and to reluctance on the part of some officials to support it. With decreasing political—and therefore financial—support, concerns about the program have multiplied. The consequences of this negative spiral for HRD are particularly clear as interest among potential students in nuclear-related degree programs has diminished. Jordan's case demonstrates the critical importance of stakeholder engagement in building the public support and the human capacity to enable the deployment of nuclear power.

Turkey has far more experience with nuclear science than either the UAE or Jordan. While the country has struggled to develop commercial-level nuclear power, its nuclear-related education programs have been established for decades. An industrialized nation of 75 million people, Turkey also has a broad base of human capital on which to draw, including a large, well-educated cadre of engineers. Turkey's HRD-related challenges in the sector therefore relate less to the country's capacity and more to the nature of the agreement it has struck with its Russian partners, which will finance, build, own, and operate its first nuclear power plant. While the commercial terms of this deal are very attractive from Turkey's perspective, the technical complexity of the project, which is using a Russian reactor technology currently not deployed anywhere in the world, is potential cause for concern. With no operational experience of commercial-scale nuclear power, the host country may be vulnerable to a situation of information asymmetry in which the Turkish regulator may not have sufficient expertise and capacity to competently oversee an experienced Russian project company in the construction and operation of a new design of Russian reactor. The ability of the Turkish nuclear sector to build the necessary pipeline of nuclear capacity and industry culture to become an "intelligent customer" of nuclear technology may be further impeded by the nature of the HRD agreement it has with its Russian partners, through which Turkish nuclear engineers are trained in Russia rather than at home.

Based on the conclusions from the three country case studies, the paper offers a series of recommendations on competence and sustainability-related HRD risks for the three reviewed countries and emerging market nations looking to enter the civil nuclear sector.

These recommendations are:

- HRD should be a central part of a new nuclear energy state's strategy
- HRD programs should place a large emphasis on safety culture
- Quality control initiatives should include merit-based recruitment, international benchmarking and vendor involvement
- Stakeholder engagement should be a core element of new nuclear energy programs' HRD strategies
- HRD strategies should be designed around the operational needs of the nuclear industry rather than around high-profile academic programs
- New nuclear energy states adopting new reactor technologies should allocate additional HRD time and resources to become an "intelligent customer"
- National quota policies should be flexible to the needs of new nuclear programs
- Regional cooperation should not be relied upon as the primary or major source for HRD in the nuclear sector

Introduction

In 2011 the Brookings Energy Security Initiative published "Models For Aspirant Nuclear Energy Nations in the Middle East," a comparative analysis of nine countries in the region in good standing with the International Atomic Energy Agency (IAEA) that had demonstrated interest in civil nuclear power programs.[1] The study assessed the political, economic, financial, and technical status of the civil nuclear energy plans in the United Arab Emirates, Jordan, Turkey, Egypt, Saudi Arabia, Kuwait, Bahrain, Qatar, Oman and Bahrain. Of these countries, three—the UAE, Jordan, and Turkey—were seen to be the most likely to move ahead with a nuclear power program in the medium term.[2]

One of the principal findings of the 2011 study was that building and maintaining the necessary human capacity to run both nuclear programs and public sector nuclear-related institutions is a critical component in the development of safe, secure and sustainable civil nuclear programs in the Middle East. The study found that countries in the region have widely varying levels of expertise and that each country recognizes the need for reliance on international assistance in various forms in the near term. It concluded that dependence on expatriate technicians and consultants may prove to be unsustainable, and outlined the prospect of "knowledge risk" through which a cadre of older, expatriate advisors concludes its tenure before adequately transferring knowledge to the domestic workforce.

The study recommended that the aspirant nuclear power states in the Middle East 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, it recommended that expatriate professionals be retained as staff for newly established entities, and that such expatriates should provide on-the-job training for the national staff working alongside them. It further recommended the countries in the region simultaneously focus on training a domestic workforce with the requisite skills necessary to keep pace with the evolution of the nuclear program through its various stages of construction and operation. Finally, the report suggested that one potential means of achieving the necessary training may be the establishment of a regional center of excellence to train nuclear technicians and engineers from around the region.

[1] "Models for Aspirant Civil Nuclear Energy Nations in the Middle East," Brookings Institution, September 27, 2011 (Brookings 2011).
[2] Each country has expressed an intention to have grid-connected nuclear power in the next ten years.

The issue of HRD has taken on more significance in the wake of the catastrophic accident at the Fukushima Daiichi plant in Japan in March 2011. In June 2011 the IAEA promulgated an Action Plan on Nuclear Safety in response to the accident. One of the explicit recommendations of the IAEA plan was the need among Member States embarking on a nuclear power program to "strengthen, develop, maintain and implement their capacity building programs, including education, training and exercises at the national, regional and international levels; [and] to continuously ensure sufficient and competent human resources necessary to assume their responsibility for safe, responsible and sustainable use of nuclear technologies."[3]

This paper builds on the conclusions and recommendations of the 2011 Brookings paper and the IAEA recommendations. It focuses on the issue of HRD through case studies of the three countries in the region with medium-term prospects for a nuclear power program: the UAE, Jordan, and Turkey. These three countries demonstrate a variety of starting conditions likely to be encountered by other emerging market countries looking to implement nuclear power. Their experiences and challenges can therefore be seen to hold valuable lessons for other aspirant nuclear energy states both in the Middle East and around the world.

Based on in-depth interviews with officials and representatives from the countries under review and representatives from external international organizations as well as the output from a roundtable discussion in May 2012 held in Abu Dhabi, the study outlines the existing institutional capacity and strategies for the development of nuclear professionals in each of the three countries. It provides an overview of their major human resource challenges against a defined set of parameters and concludes with a series of recommendations for addressing these challenges.

[3] "IAEA Action Plan on Nuclear Safety," International Atomic Energy Agency, September 2011, p.5.

Definitions and Analytical Framework

Definition of Human Resource Development

The IAEA's "Milestones in the Development of a National Infrastructure for Nuclear Power" ("Milestones") document identifies HRD as one of the 19 "key infrastructure issues" that countries should address when embarking on the development of a new civil nuclear power program. However, HRD is not a standalone consideration; most of the other 18 critical infrastructure issues —from establishment of a regulatory framework to emergency planning and waste management—are underpinned by the need for competent human capital.[4]

The field of HRD encompasses a wide range of issues, ranging from recruitment to retirement planning.[5] Given the focus of this study on new commercial nuclear power states, the areas of HRD that are most relevant are:

- Workforce planning
- Training and Education
- Recruitment
- Stakeholder Engagement

Workforce planning

The primary consideration in workforce planning is an assessment of the present and future competency requirements relative to available skills. To build the necessary level of human capacity to construct, operate, maintain and regulate a nuclear power program, countries require a coherent, integrated assessment of the number of personnel and skill sets required for each of the program's functional areas. Workforce planning is a vital process in ensuring that specific institutions have the capacity to carry out the wider national objectives of the civil nuclear power program. The IAEA recommends that newcomer countries conduct workforce planning assessments for each of the three primary organizations involved in the establishment of new nuclear programs—the nuclear energy program implementation organization (NEPIO); the regulator; and the operating organization—at each of the three milestone phases (feasibility; site investigation and bid preparations; design, construction, and commissioning).

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

[5] According to the IAEA, the nine principal areas of HRD are: workforce planning, training and education, recruitment, remuneration, succession planning, performance management, career management, and retirement. From "Workforce Planning for New Nuclear Power Programmes," International Atomic Energy Agency, February 2011.

Training and Education

Once the workforce planning process is complete, new nuclear energy states are faced with the challenge of addressing competency gaps. This is done primarily through building up the academic and vocational infrastructure for providing a pipeline of skilled workers domestically, or through recruitment of candidates from the domestic or international labor pool. For countries with no experience in commercial-scale nuclear power, there is likely to be a limited existing academic base in the requisite nuclear fields. Consequently, countries looking to develop indigenous capacity face the significant challenge of establishing and staffing universities, colleges, and other training facilities at great administrative and financial expense. Such institution building is also time-consuming. According to the IAEA, some specialists in the nuclear field require 5-10 years of training and experience. The time required for new domestic educational facilities to provide such training will be longer as the institutions themselves will need to be established first. Such specialists, however, make up only a minority of the necessary workforce. By some calculations, only 20 to 35 percent of the workforce required for a civil nuclear energy program need to be educated to a college-degree level, and of this number, only 20 percent need to have a background in nuclear engineering.[6] When building up the educational infrastructure to support a civil nuclear energy program, the operational requirements of the program, including the number of people and level of training required, should be a primary consideration.

Recruitment

Recruitment is an essential aspect of HRD strategy implementation both for candidates looking to enter training and education programs, and for professional positions. Recruitment involves more than interviews and the formal hiring process for nuclear professionals. As the main implementation process for the workforce plan, it should be a rigorous merit-based process. However, it should be informed by—and linked to —the broader goals of the nuclear program, including those of culture, professional values, and attitude, as well as the gap analysis resulting from the workforce planning exercise. Recruitment is also closely linked to stakeholder engagement: if the risks, benefits, and goals of the civil nuclear program are not communicated adequately, there is the potential for recruitment—at both the academic and professional levels—to be negatively affected.

Stakeholder Engagement

The IAEA emphasizes that it is of the "utmost importance to provide opportunities for stakeholder involvement and to look for new ways to obtain stakeholder input" and recommends that "all countries create instruments that enhance stakeholder involvement" with regard to the development of new nuclear power projects.[7] While the IAEA defines stakeholder engagement as a separate key issue area in "Milestones," this study includes it as an issue that falls squarely within the category of HRD. The extent to which governments and public sector institutions in the nuclear sector communicate and consult with other stakeholders—non-governmental organizations, consumer groups, the media, and the general public—has a strong impact on the development of the necessary human capacity to make the program viable. The nuclear sector will only attract high-quality students if young people see the sector as a route to a rewarding career—both in monetary terms as well as satisfaction in making a contribution to

[6] Presentation by Lee Peddicord, director of Nuclear Power Institute and professor of nuclear engineering at Texas A&M University, to IAEA General Conference, Vienna, Austria, September 2012.
[7] "Stakeholder Involvement in Nuclear Issues," International Atomic Energy Agency, 2006, p. 13.

society and national growth. Failure to engage in a dialogue with civil society can result in doubt over the government's commitment or capabilities to manage the program, leading to a lack of certainty on the part of potential recruits.

Framework for Analysis

This study assumes that a successful HRD strategy must rest on two central pillars: competence and sustainability.

Competence is the ability of the host country to be an "intelligent customer" and a qualified overseer of a civil nuclear power program. Competence can be seen as ensuring that the right people are in the right place at the right time. The challenges to the development of a competent domestic nuclear workforce include the establishment and maintenance of the highest professional standards. At the most fundamental level, competence requires that individuals involved in the construction and operation of a nuclear power program have the necessary training, skills, and experience to ensure ongoing safety and security. Competence also applies to the institutions that have responsibility for the licensing, regulation and oversight of the nuclear program. The need for regulatory competence is particularly important in newcomer civil nuclear nations, which are likely to rely heavily on external expertise in the initial stages of the development of their programs. While in many cases a third party may be the primary entity involved in the construction and operation of a new plant, the IAEA makes clear that the responsibility for safety of a nuclear program "cannot be delegated to another country or organization."[8] As the representatives of the sovereign host country, regulators need to be able to evaluate all aspects of a new nuclear power program with regard to domestic laws and international best practice.

Competence goes beyond the ability of individuals to perform their responsibilities. It also comprises a culture of safety and security that pervades the entire nuclear sector at all levels of the workforce. Indeed, the IAEA makes clear that development of a competent nuclear workforce has to involve cultural as well as technical education. There are various approaches to safety culture: in some countries there are dedicated university courses on safety culture, while in others it is the purview of individual institutions. Culture is also an issue when integrating expatriates: some regulators have induction programs where expatriates gain an insight into the workplace dynamics of the host country.

Sustainability refers to the extent to which a country possesses the long-term human capacity required to operate, maintain, and regulate its civil nuclear power assets.

One of the principal concerns with regard to sustainability is an overreliance on external expertise. Such reliance during the early stages of a nuclear power program is not in itself a reason for concern. In instances where nuclear power is being developed according to an accelerated schedule, there is an obvious need for a substantial amount of qualified, experienced human capital to ensure the safe and secure establishment of the program; indeed the IAEA recommends newcomer countries *should* rely on international expertise and support organizations in establishing the necessary domestic institutional infrastructure, and that newcomer countries may incur "unacceptable risks" in terms of time and costs if they try to build a national capability from scratch.[9]

However, in the longer term, overreliance by newcomer countries—especially those looking to develop significant nuclear energy programs—on external expertise leaves such countries susceptible

[8] Ibid p. 7.
[9] Ibid, pp.5-8.

to sustainability risk for a variety of reasons. With a large number of mid-and senior level nuclear professionals set to retire globally over the next decade, and several newcomer countries competing for scarce human capital, the challenge to attract and retain external expertise is likely to increase over time.

Given the short-term nature of many of the employment contracts offered by emerging nuclear-energy countries, particularly in the Middle East, the unsustainability of the workforce has the potential to be exacerbated by a lack of long-term job security for expatriate employees, who may be more likely to seek alternative employment at frequent intervals. Finally, in the event of a crisis—whether economic, political, or environmental—the ability of expatriates, who often lack ultimate authority, to respond effectively, and their willingness to remain in-country in the aftermath may be subject to question. One of the principal ways to ensure sustainability is through the development of a pipeline of indigenous professionals, which in turn requires a sound educational infrastructure and strategy for human resource development.

A large part of the sustainability of a nuclear program is the extent to which it enjoys institutional and public support. The principal consideration in achieving such support is through its stakeholder engagement, an increasingly important aspect of the development and implementation of a civil nuclear power program. In addition to the primary government entities, a range of other stakeholders, including the media, NGOs, the general public, opinion leaders, and national and local government officials, have a role in the program's success and sustainability.

Stakeholder involvement is an integral component of HRD for two major reasons: to give legitimacy in the eyes of the public to the nuclear program itself, and thus to ensure it gains the requisite level of support from policy makers, private industry, and civil society; and to lay the foundations for the future workforce by educating the next generation about the opportunities for a career in the nuclear sector. Failure to execute a clear stakeholder engagement strategy can lead to stakeholder risk, in which resistance to nuclear power in general and reduced interest on the part of would-be nuclear professionals threatens the viability and sustainability of the program.

United Arab Emirates

Nuclear Power Program Status

Of the three countries under review, the UAE has made the most progress to date toward the development of a civil nuclear power capacity. Following the release of its policy paper in 2008, the country established a legal framework and institutional basis for the program with the formation of the Emirates Nuclear Energy Corporation (ENEC) and the Federal Authority for Nuclear Regulation (FANR).[10]

After a "competitive dialogue" with a series of prospective vendors, the UAE agreed to purchase four nuclear reactors from a Korean consortium led by the Korean Electric Power Company (KEPCO) in 2009. The agreement made provision for the construction and initial operation of four APR1400 nuclear reactors with a combined power generation capacity of 5600MW. The agreement between the UAE and KEPCO made provision for associated fuel supply, maintenance, and training and education for Emirati nuclear professionals.

According to the UAE's national strategy, the first of the country's nuclear reactors is scheduled to be operational in 2017, with all four reactors scheduled to be online by 2020—a timeframe that is highly ambitious for a new nuclear energy state. In November 2010, ENEC, the entity that is responsible for the ownership, construction and deployment of the country's nuclear power plants, received licenses from FANR for site preparation and limited construction for non-plant elements at the site of the nuclear power plant in Barakah, in western UAE. This was followed in July 2012 by environmental approval for the Barakah site as well as the awarding of full construction licenses for the first two reactors. ENEC has since started construction on the first of four nuclear reactors.

National Strategy for Human Resources Development

The UAE's 2008 policy 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."[11]

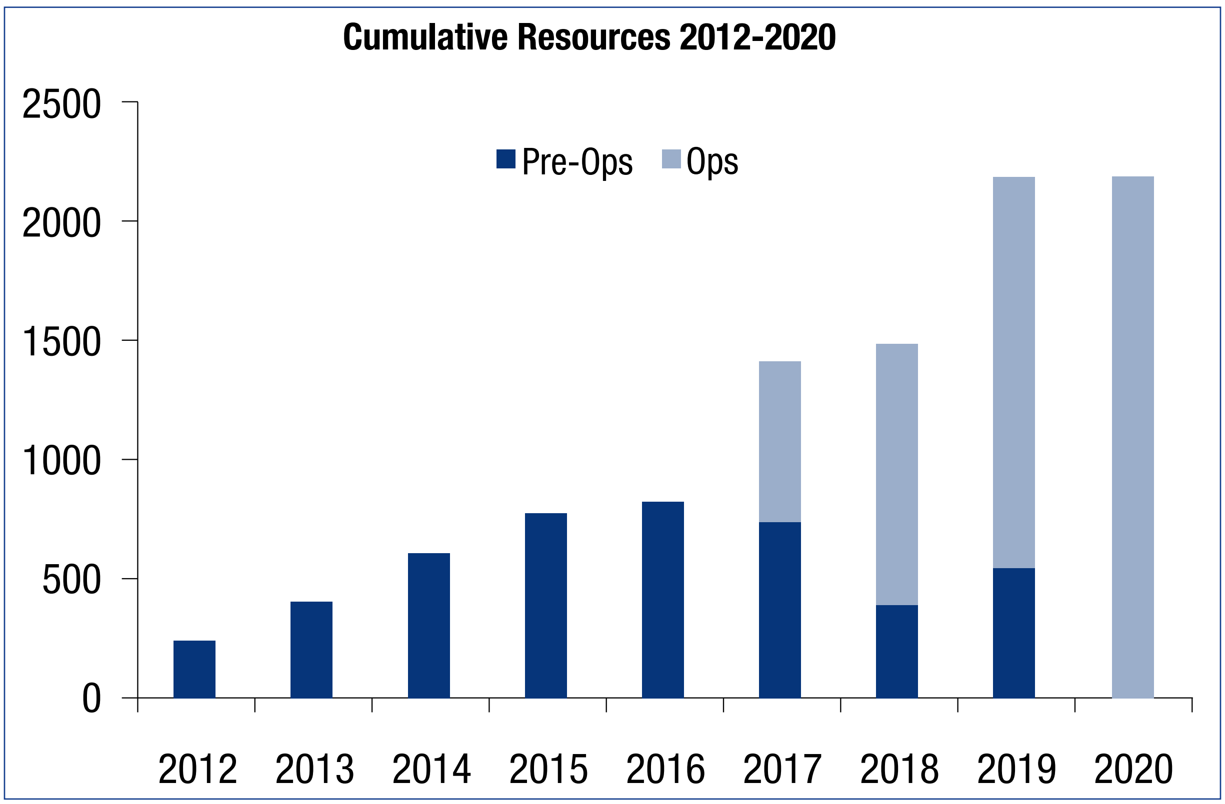
[10] "Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy," the UAE government, April 20, 2008.
[11] Ibid, p.14.

The country is taking a wide ranging approach to HRD in the civil nuclear sector. This strategy is led by ENEC and FANR in collaboration with domestic and international academic institutions and the Korean vendor consortium. Both ENEC and FANR have developed overarching internal human resource development strategies and are providing input to the design of training programs aimed at developing a nuclear workforce.

ENEC

As the UAE's Nuclear Energy Program Implementation Organization (NEPIO), ENEC is taking a broad and differentiated approach to its HRD strategy. The corporation has a department dedicated to capacity building and training and another to employee development. Based on an internal review, ENEC projects it will need between 900 and 1,000 "preoperational" staff by 2016, a combined workforce of around 1,400 preoperational and operational staff in 2017 when the UAE's first reactor is projected to come online, and a permanent operational staff of around 2200 in 2020, when the country's four reactors are scheduled to be operational (see **Figure 1** for more details). According to ENEC's evaluations, only a minority of the plant's staff need to be nuclear engineers.[12] Other professionals will include mechanical, electrical, chemical and power engineers; computer scientists; and technicians. ENEC says that IAEA's guidance on HRD has helped it to implement the commercial aspects of HRD and has provided helpful benchmarks and perspective.

FIGURE 1: Estimated Human Resources for the UAE's Nuclear Power Program



Source: ENEC

[12] Author interview with ENEC executives, January 2012.

Through its Capacity Building Team, ENEC is adopting a multi-pronged approach to developing the workforce necessary for operation of its nuclear power plants.

University Degrees in Nuclear Engineering; Scholarship Program

The foundation for the UAE's future cadre of nuclear engineers are the formal degrees offered domestically by the Khalifa University of Science, Technology and Research, and internationally through partnerships with overseas universities. Khalifa University offers a two-year Master's degree that is open only to UAE nationals. The program recruits candidates with undergraduate degrees in relevant engineering, science or math-based fields, and comprises a core taught curriculum, a self-directed project component, and field trips for the provision of hands-on experience and training. There is currently no nuclear engineering undergraduate degree offered within the UAE.

In partnership with FANR, ENEC provides students looking to pursue a career in the nuclear field with a full scholarship. The UAE Nuclear Energy Scholarship initiative is a collaboration between ENEC, FANR, and Khalifa University. The scholarship program is aimed at getting UAE nationals to study nuclear, chemical, 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. Upon graduation, those students who have received a scholarship are required to work for ENEC, FANR or Khalifa University for a minimum period of time (subject to the requirements of those institutions); graduates from undergraduate programs are required to work for at least the length of time they were studying under the scholarship program, while graduate students are required to work for twice the length of their academic programs. In 2012, ENEC offered 75 positions to Emirati students in the nuclear energy scholarship program.[13]

Higher Diploma in Nuclear Technology

To address the demand for skilled nuclear technicians and other non-engineering plant personnel, the UAE's Institute of Applied Technology (IAT) is developing a postsecondary 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 the flagship program of Abu Dhabi Polytechnic, a new institution established to train professionals for employment in areas of emerging technologies. Students in 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 at operating reactors overseas including the APR1400 reference reactor in Busan, South Korea, which will serve as the model for the UAE's plants. The inaugural class of students matriculated in September 2011, and the HDNT program received academic accreditation in February of 2012 following approval from an external review team comprised of faculty members from U.S. universities and elsewhere. The program is a three-year full time course of study, which trains students in the fundamentals of engineering, nuclear technology and APR1400 systems as well as providing four academic quarters of on-the-job training in South Korea. The program offers students the opportunity to specialize in preparation for specific roles, including plant operators, chemists, radiation protection technicians, instrumentation and control technicians,

[13] "75 Scholarships Available in Growing Nuclear Energy Industry," Emirates Nuclear Energy Corporation, May 14, 2012. (http://enec.gov.ae/media-centre/news/content/enec-opens-2012-intake-for-nuclear-energy-scholarship-program).

electrical maintenance technicians, and mechanical maintenance technologists.

Senior Reactor Operator Program

To build a cadre of managers and senior-level supervisors, ENEC has instituted a Senior Reactor Operator Pilot Program. According to ENEC, the training program, which is open to qualified engineers, includes basic training in plant systems and fundamentals of nuclear technology with over 480 hours of simulator training. The program, which is conducted in partnership with Westinghouse, graduated its first group of Senior Reactor Operator students in 2012. This first class of students will begin plant-specific training in reactor theory fundamentals, plant systems, and on-the-job-training at operating nuclear power plants in South Korea in February 2013. The plant-specific training includes an additional 600 hours of advanced simulator training and over 1,800 hours of on-the-job-training.

Vendor country training programs

The KEPCO-led Korean consortium constructing the UAE's first four nuclear reactors is an integral part of ENEC's training and human resource strategy. According to the terms of the primary contract, KEPCO is to provide up to 60 percent of the operating staff for the plants if necessary.[14] Training and human-resource development are included under the terms of the contractual agreement between ENEC and the consortium. According to ENEC, collaboration will include on-the-job training for senior Emirati personnel at Korea Hydro & Nuclear Power (KHNP), a subsidiary of KEPCO, as well as a mentoring program through which experienced Korean professionals will be assigned to trainees from the UAE for knowledge transfer and guidance. As part of its scholarship program, ENEC also sends scholarship students to Seoul for the Scholarship Korean Industry Program, which provides them with an opportunity to observe an operational nuclear plant and meet with nuclear industry organizations.

SUDO High School Program

Collaboration with Korean educational institutions is also being extended to include high-school students through the "SUDO program," which is a collaboration between ENEC, IAT, KEPCO, and the Seoul-based Sudo Electric Technical High School. Through the program, 11th-grade high school students are given the opportunity to travel to Korea during the summer to study practical and theoretical aspects of the civil nuclear industry. The annual program was first offered in the summer of 2010. In 2012, 36 high school students made the 12-day visit.

In addition to the Capacity Building team, ENEC has another initiative focused on Corporate and Technical Training and Learning and Development. According to ENEC, this initiative establishes training and education programs for all employees on an ongoing basis.

Culture and Recruitment

ENEC says it is relying on senior nuclear industry experts to design, implement, and nurture a nuclear safety culture across its organization, and the IAEA has praised the corporation for its progress in this regard, finding that in its 2011 Integrated Nuclear Infrastructure Review (INIR), that ENEC's and FANR's implementation of safety culture throughout their respective organizations "constitutes a good practice."[15]

[14] "Third Semi-Annual Report 2011," "Fourth Semi-Annual Report 2012," and "Fifth Semi-Annual Report 2012," International Advisory Board, 2011-2012.

[15] "Report on the Integrated Nuclear Infrastructure Review (INIR) Mission to Review the Status of the National Nuclear Infrastructure in the UAE," International Atomic Energy Agency, January 2011, p.15.

Senior ENEC executives emphasize the corporation's efforts at instilling a transparent and blame-free working environment, and the company has instituted a policy whereby any employee can initiate a "stop work" order at any time if they feel a situation is unsafe.[16]

In addition to its work on safety culture, ENEC is also working on ensuring that its employees subscribe to a desired set of working standards and level of motivation. In evaluating candidates for its scholarship program, ENEC executives say they have instituted a rigorous filtering system to identify committed students, which includes both psychometric and aptitude testing. According to ENEC, competition for jobs at the corporation is "fierce," and the corporation's rate of attrition in early 2012 of seven percent was in line with its targets.[17]

FANR

The Federal Authority for Nuclear Regulation (FANR)'s HRD strategy is based on short, medium, and long-term goals. In the near term, the regulator recognizes that it needs to recruit the requisite number of qualified staff to establish a comprehensive legal and regulatory framework for the civil nuclear sector, and conduct all licensing procedures and inspections. This staff, much of which is already in place, includes a large number of expatriate employees.[18] In the medium term, FANR plans to develop a skilled cadre of UAE nationals to take on an increasing number of responsibilities as the regulator while retaining a significant element of international personnel. In the longer term, the regulator sees its workforce consisting predominantly of UAE professionals with support from international experts.

In its plans for developing its domestic workforce, FANR is basing its strategy closely on technical advice from the IAEA, and particularly the competency framework outlined by IAEA Techdoc 1254.[19] Its strategy is based on four main technical areas for which staff need to be trained: security, safeguards, radiation safety, and nuclear safety; as well as three knowledge levels:

- **Basic Level***:* providing the basic concepts and principles of safety, security and safeguards. Basic level training requires trainees to attend both internal and external programs. The latter includes a master's degree program in partnership with the Korean Institute for Nuclear Safety and the Korea Advanced Institute of Science and Technology; and distance-learning postgraduate programs on health and safety in partnership with Risktec, a management consulting company, and Liverpool's John Moores University in the United Kingdom. It also sponsors training programs through the Gulf Nuclear Energy Infrastructure Institute (GNEII, described later in this section).

- **Specialized Level***:* preparing staff to conduct tasks of limited complexity under the supervision of a more senior staff. Specialized training is built around several qualification programs. The Inspector Qualification Programme is informed by a qualification committee that was

[16] See ENEC website's "Culture of Safety" section. (http://www.enec.gov.ae/culture-of-safety//)
[17] Interview with ENEC officials, January 2012.
[18] As of May 2012, FANR's staff comprised 52 percent expatriates, and 48 percent Emiratis, with a majority of operational positions filled by expatriates and the majority of administrative positions filled by Emiratis. "FANR Capacity Building Program," presentation by FANR, May 2012.
[19] "Training the Staff of the Regulatory Body for Nuclear Facilities: A Competency Framework," IAEA-Tecdoc-1954, International Atomic Energy Agency, November 2001.

established under the framework of the FANR's integrated management system. Other programs under development include a Safety Assessor Qualification Programme, a Security Qualification Programme, Safeguards Qualification Programme, and a training program for Emergency Preparedness and Response.

- **Advance Level**: preparing the staff to perform tasks under their own responsibility in an autonomous way. Advance level training is centered on the concept of on-the-job training, and is predominately supported by FANR's institution-wide mentoring program through which staff members are assigned a more senior mentor within the organization, who prepares a work plan, assists the mentee in setting developmental goals, and provides feedback to the mentee on a quarterly basis.

An overview of FANR's knowledge framework is presented in **Figure 2**.

Relationship with Korean Vendor Partner

FANR emphasizes the importance of the UAE's Korean partners in building its human capacity. In addition to the graduate degree program outlined above, the contract with KEPCO makes provision for extensive training support from the Korean partner. FANR currently has a secondee from the Korean Institute for Nuclear Safety among its staff in Abu Dhabi.

FIGURE 2: UAE Federal Authority for Nuclear Regulation Knowledge Framework

Knowledge Level	OPERATIONS AREAS			
	Security	Safeguards	Radiation Safety	Nuclear Safety
Basic (2 years)	FANR familiarization Programme			
	Risktec Programme / GNEII / Kaist-KINS			
Specialized (2 years)	Secondments at NRC / KINS / IAEA			
	Inspector Qualification Programme			
	Training on Emergency Planning and Response			
			Safety Assessor Qualification Programme	
Advanced (2 years)	On-the-job Training	On-the-job Training	On-the-job Training	On-the-job Training
	Technical Workshops	Technical Workshops	Technical Workshops	Technical Workshops

TRAINEE DEVELOPMENT

Source: FANR

Culture and Knowledge Management

As its near-term strategy for workforce development will include a large number of expatriate professionals, FANR emphasizes the need to prepare foreign workers for the working culture in the UAE. To do this it has implemented an induction program for new international staff, which includes lessons on cultural awareness. It has also initiated a program through which all employees —including non-technical employees are introduced to the fundamentals of the nuclear industry in order to promote a culture of safety, another element of best practice identified by the IAEA.[20]

FANR acknowledges the challenge of building and maintaining institutional knowledge. To address this issue, it has implemented a database that includes procedures and lessons learned from training programs. As part of its integrated management structure, it is working with the IAEA to formalize quality assurance processes and procedures, which can be used as a resource by all employees.

Other HRD Initiatives

GNEII Program

Another training initiative supported by ENEC, FANR and Khalifa University is the Gulf Nuclear Energy Infrastructure Institute (GNEII), a partnership between Khalifa University, Sandia National Laboratories and Texas A&M University's Nuclear Security Science and Policy Institute. The initiative is intended to provide a "regional educational, training and research hub for promoting a nuclear safety, safeguards, and security culture," according to Khalifa University, where it is based. The primary focus of the GNEII program is the "Fundamentals" course, which focuses on safeguards, security, and safety. The 16-week course, which is open to students from around the Gulf Cooperation Council and Jordan, culminates in a "capstone" research project. In 2012, at least 22 students completed the taught elements of the fundamentals course, according to Khalifa University.

International Collaboration and Assistance

In addition to the GNEII program and the other international programs previously referenced in this report, the UAE has engaged in a number of other forms of international engagement in order to develop its HRD capacity. The UAE is a member of several international networks and has signed Nuclear Cooperation Agreements with France, Japan, South Korea, the United Kingdom, and the United States. The UAE is also engaged in technical cooperation with the IAEA on a range of HRD issues.

Public Information and Stakeholder Engagement

From the publication of its 2008 policy paper outlining the concept of civil nuclear power and the steps and issues that needed to be considered in its development, the UAE government has demonstrated an understanding of the need to engage with and inform the public. Through public information sessions and coverage of civil nuclear development in the government-owned newspapers, the public has been kept abreast of the progress of the program. Despite the catastrophic accident in Fukushima in 2011, a poll in June 2011 conducted by TNS, an international research firm, found that 85 percent of a sample of 750 Emirati residents saw the nuclear program as being important for the country with 60 percent saying they would support the construction of a nuclear power plant in their own emirate. While the figures for public support of the program must be considered in the context of a country with a government-controlled press and

[20] "Status and Trends in Nuclear Education," IAEA Nuclear Energy Series No. NG-T-6.1, International Atomic Energy Agency, 2011, p.11.

without a robust civil society, the degree of communication between the UAE government and the public is in contrast to that of other countries, notably Jordan (see section 4 for more details).

The UAE government has also prioritized outreach to high school students as an important part of its HRD strategy. The IAEA recommends that "outreach activity toward secondary school and/or secondary school teachers is an important and good practice," and this guidance has been followed by ENEC through the SUDO program and through an initiative to tour high schools to raise awareness about the nuclear program.

Challenges

Emiratization

With an economy dependent on the sale of oil, gas, and related products—and industries reliant on low-cost energy—the UAE is looking to diversify its economic and professional base to ensure its long-term sustainability. One of the principal mechanisms for this diversification is the drive toward "Emiratization"—the increased participation of UAE nationals—in both the public and private sector labor forces. The success of Emiratization to date has been visible mainly in the public sector, where around 60 to 70 percent of employees are UAE nationals. In the private sector, the figure is less than 10 percent, despite the government having set quota targets for specific industries such as banking, insurance, and trade.[21] The disparity is due in large part to the higher salaries, more generous benefits, and shorter working hours that UAE nationals enjoy in public sector positions relative to those available in the private sector.[22] It is also due to the relatively small proportion of the UAE's population that comprises UAE nationals; according to the UAE's National Bureau of Statistics, Emirati nationals accounted for an estimated 11 percent of the population in mid 2010, the latest year for which figures are published.[23]

The civil nuclear industry provides a unique challenge for the UAE. The institutions responsible for the development and oversight of the nuclear program are in the public sector. However, to meet the program's ambitious timeline, they have been established on the basis of a large amount of expatriate expertise. The same is likely to be true in the early stages of operation for the nuclear plants: given the UAE's lack of experience in the civil nuclear sector, the contract with the KEPCO-led consortium includes a provision that the Korean vendors will help operate the plant after construction. With expatriates responsible for key aspects of the nuclear program and related institutions, and likely to remain so for the foreseeable future, an aggressive Emiratization policy in the civil nuclear sector comes with significant risk. Emiratization goals in the UAE's private sector have proven unsuccessful as, unable to find UAE nationals to fill the quota, international corporations have opted to pay fines rather than comply with targets.[24] However, as the civil nuclear program is government enterprise, it will not have the option of non-compliance if strict Emiratization targets are maintained. In such circumstances, there is a prospect of the displacement of qualified staff with less qualified and experienced personnel to the potential detriment of the program's safety and security.

[21] Jane Williams, "Emiratisation: The Way Forward?" INSEAD, July 25, 2011; "Emiratisation Hurdles Remain," *National*, March 11, 2012. (http://www.thenational.ae/news/uae-news/emiratisation-hurdles-remain).

[22] John Raven, "Emiratizing the education sector in the UAE: contextualization and challenges," Education, Business and Society: Contemporary Middle Eastern Issues, Vol. 4 Iss: 2, pp.134-141, 2011.

[23] UAE National Bureau of Statistics, "Population Estimates 2006-2010," March 2011. (http://www.uaestatistics.gov.ae/ReportPDF/Population%20Estimates%202006%20-%202010.pdf).

[24] Essa Al Mulla, Executive director of the Emirates Nationals Development Programme, quoted in *The National*, March 11, 2012.

Academic Quality Control

In order to meet the workforce requirements—and goals for Emiratization—in the nuclear sector, the UAE has developed plans for a multi-pronged approach to education and training as outlined above. The success of the country's structured approach to workforce development will depend upon continued political and financial commitment, and the ability of the programs to attract qualified candidates and develop them into professionals with the requisite knowledge, skills, and experience. While the UAE's civil-nuclear related training and education programs are still relatively new, there are indications that in some cases programs are having difficulty in recruiting students with the minimum levels of educational attainment necessary to complete a nuclear-related course of study.

In an indication of the challenge faced by higher education institutions when trying to recruit students, a 2010 paper by the UAE's Knowledge and Human Development Authority found that, "[of]a hypothetical group of 100 male Emirati students commencing Grade 6 public schooling, current figures suggest 32 will graduate on time, 47 will be kept behind at least once and thus cannot graduate on time, and 21 will leave education permanently."[25] The report noted that the weaknesses in the public school curriculum, coupled with the high dropout rate "severely restrict the number of national students able to enroll at high status universities without an initial foundation year prior to embarking upon formal undergraduate study". The scale of the challenge was underlined in 2012 when the Higher Colleges of Technology, the largest of the UAE's three federal universities, raised its entry qualifications to those of its peers. The result was a sharp downturn in the number of students eligible to enroll.[26]

Even in cases where incoming students do have the necessary qualifications, their actual academic ability can fall short of the minimum requirements necessary to succeed in technical disciplines such as nuclear technology. In at least one case, the curriculum of a nuclear-related higher education course has had to be adapted to accommodate the underperformance of enrolled students. The mismatch between the demands of nuclear-related training and education courses and the abilities of prospective and incoming students has the potential to negatively affect both the Emiratization goals and the longer-term sustainability of the UAE's civil nuclear program.

Competition from Other Domestic Sectors

The challenge of meeting the large staffing requirements of the UAE's nuclear program is compounded by the competition for qualified professionals—particularly engineers—from other established and nascent industrial sectors. Abu Dhabi's Economic Vision 2030 sets a target of non oil-sector related GDP of 64 percent, up from 41 percent in 2005.[27] To achieve this goal, the emirate is developing a number of strategic industries including semiconductors, aerospace, and renewable energy technologies. Each of these sectors will provide additional demands on the country's limited pool of talent. To the extent that these industries can attract students to feeder courses or engineering graduates, they will compete with the nuclear industry's human resources strategy.

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[25] "Dubai Schools Inspection Bureau Annual Report 2010," Knowledge and Human Development Authority, 2010, p.43.
[26] "Hundreds of UAE Students Turned Down for Places at University," *National*, July 25, 2012.
[27] "The Abu Dhabi Economic Vision 2030," Government of Abu Dhabi, November 2008.

Jordan

Nuclear Power Program Status

Between 2004 and 2006 the government of Jordan initiated a study to examine various options to meet the country's energy needs, including the potential for nuclear power. In January 2007, King Abdullah stated publicly that Jordan was "looking at nuclear power for peaceful and energy purposes," and by the end of that year an updated National Master Strategy of Energy was issued which called for six percent of Jordan's energy mix to be met with nuclear power by 2020.[28] In September 2011 the Jordan Atomic Energy Commission (JAEC), with the assistance of Worley Parsons, issued a "White Paper on Nuclear Energy in Jordan" describing the results of a pre-feasibility study and further elaborating the policy rationale for nuclear energy.[29]

The central motivation in the country's decision to explore a civilian nuclear energy program is its unsustainable domestic energy situation: with rising demand and limited natural resources, Jordan is nearly completely dependent on imports of increasingly expensive and, in light of recent regular attacks on the Arab Gas Pipeline (AGP) from Egypt, unreliable fossil fuels In addition, Jordan's discovery of uranium resources has strengthened its interest in nuclear energy; the government's views its uranium deposits as a potentially secure, domestic fuel source for its reactors, as well as a revenue source for funding its first nuclear power plant.

JAEC's proposal is to have a 700-1200 MW reactor operating by 2020, and a second by 2025. To achieve this, the Commission is pursuing a two-track strategy: 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 May 2010, JAEC shortlisted three firms for provision of the reactor technology and construction: Areva and Mitsubishi Heavy Industries (ATMEA 1 reactor), AECL Canada (CANDU-6 reactor), and AtomStroyExport (AES-92 VVER-1000 reactor). On May 1, 2012, JAEC "concluded that the ATMEA-1 and AES-92 technologies are the best two evaluated contenders in meeting the requirements and needs of Jordan as specified in the Bid Invitation Specifications."[30] JAEC has in-

[28] For sources and further information on the activities in this period, see "Brookings 2011."

[29] The pre-feasibility study was conducted in 2010 in cooperation with the IAEA using the Agency's scenario modeling techniques. Source: "White Paper on Nuclear Energy in Jordan," JAEC and Worley Parsons, September 2011. (JAEC 2011).

[30] "JAEC Concludes Technology Evaluation Phase for Jordan Nuclear Power Plant," Jordan Atomic Energy Commission, May 1, 2012. (http://jaec.gov.jo/News/NewsDetails.aspx?nid=30)

dicated it will take nine months to negotiate with each firm over financial and electricity rate details before making the final selection in time for construction to begin sometime in 2013.[31]

In addition to the reactor negotiations, in February 2011 JAEC requested bids for a strategic partner in the joint utility from GDF Suez of France, Datang of China, Rosatom of Russia, and Kansai Electric Power of Japan. According to JAEC, these bids are expected in late 2012.

JAEC envisions that the utility operator will be 50 percent owned by the government and 50 percent by other investors. Electricity will be sold under a power purchase agreement (PPA) to Jordan's National Electric Power Company (NEPCO), which is the transmission company and system operator in Jordan. Limited recourse financing will be used for the project, with debt (70 percent) and equity (30 percent) provided from variety of sources. The government has indicated that it intends to use revenues generated from uranium mining for its portion of the financing.

National Strategy for Human Resources Development

Government officials and others involved in Jordan's civil nuclear program acknowledge that human resource development is one of the central challenges confronting the program.[32] While the country's universities produce over 8000 graduates in scientific fields each year, Jordan does not currently have a sufficient base of domestic personnel with the professional and technical skills required for the development and implementation of a nuclear power program.[33] Unlike the UAE, Jordan does not have the financial resources to import external skills in large quantities. In recognition of these realities, the Jordanian government has focused primarily on training and education, with a long-term goal of having its nuclear program—both at the regulatory and operational levels—staffed primarily with Jordanian nationals.[34] To achieve this goal, the government is relying on a variety of approaches and tools, with JAEC responsible for coordinating overall efforts.

Universities and Training Facilities

Jordan has a well developed academic infrastructure, providing a strong foundation in disciplines required for a nuclear power program. The country has 25 universities (10 public and 15 private) offering BSc degrees in physics, chemistry, biology, health physics, electrical, mechanical, industrial, chemical and nuclear engineering. In addition, there are 35 community colleges (15 public and 20 private). JAEC has emphasized the need for institutional collaboration in order to "establish technical training and certification" in such areas as basic nuclear principles, radiological health protection, and nuclear material handling.[35]

Jordan University of Science & Technology

The Jordan University of Science and Technology (JUST) established a nuclear engineering department in 2007 to train future reactor operators by offering a five-year BSc course of study with 160 credit hours. The program has four faculty members and is equipped with radiation detection labs. The program has 145 students and the first batch of 19 students graduated in June 2011, of

[31] "Jordan Enters Talks with Russian, French Firms over Nuclear Reactor," *Jordan Times*, April 29, 2012.
[32] In addition to being cited by officials in discussions with the authors, HRD is also addressed in JAEC 2011.
[33] JAEC, 2011.
[34] JAEC officials have acknowledged that this approach, in which Jordanian nationals are "involved in every aspect of a nuclear power plant will take a generation." Comment from a JAEC official, quoted in "Education Key to Jordan Nuclear Future – Experts," *Jordan Times*, December 17, 2010.
[35] Information in this paragraph was provided to the authors by JAEC in May 2012. (JAEC presentation, May 2012)

which six are pursuing PhDs: five in the US and one in Germany. These six students are being supported by JUST with the understanding that they will return to join the university faculty. An additional 30 students completed studies in 2012.

JUST will also host and oversee the Jordanian Sub-Critical Assembly (JSA), a training tool constructed by the China Institute of Atomic Energy to allow students to "modify core configurations, work closely with the reactor core, and familiarize themselves with the basic features of the reactor."[36] The JSA is expected to be commissioned in 2012. The university will also be the site of the Jordan Research and Training Reactor (JRTR), although the reactor itself will be run by JAEC (see description below).

JUST has signed several cooperation agreements with international academic institutions including North Carolina State University (NCSU), University of Illinois, Ohio State University, and the University of California. The collaboration with NCSU links students with a virtual reactor for training purposes (1 MW PULSTAR research reactor).[37] The IAEA has expressed interest in replicating the model of the JUST-NCSU internet exchange elsewhere.[38]

University of Jordan

The physics department at the University of Jordan (UJ) has a total of 350 students, including 120 graduate students. Until 2011, the department offered an MSc in nuclear physics, which typically graduated about 10 students per year. However, the program has been suspended due a new university-wide requirement that all students complete a thesis as part of their graduate degrees. As there are only two faculty members for the program, the department found it did not have the capacity to supervise this number of theses. There is a plan to restart the program when graduates who are currently studying for their PhDs abroad return to serve as faculty.[39] UJ continues to offer programs in nuclear medicine and PhD programs in nuclear-related subjects.

Al Balqa Applied University

Al Balqa Applied University (BAU) has also launched a Master's of Science (MSc) program in nuclear physics, and in 2009, graduated nine students all of whom went to work at the Jordan Nuclear Regulatory Commission. As of 2011, the program continued to receive interest from students, but was put on hold.[40]

Jordan Research Training Reactor (JRTR)

In December 2009, JAEC awarded a $173 million contract for construction of the 5 MW JRTR at JUST to a consortium of the Korean Atomic Energy Research Institute (KAERI) and Daewoo Engineering & Construction.[41] The JRTR will produce radioisotopes for medicine, agriculture, and industry; provide training facilities; and serve as a Nuclear Science and Technology Center.[42] It is planned to be commissioned in 2015 and

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[36] "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.

[37] "Knowledge Transfer via Remote Learning: The Jordan-North Carolina Example," presentation by Ayman I. Hawari (PhD) to the International Conference on Human Resource Development For Introducing and Expanding Nuclear Power Programmes, March 14-18, 2010, Abu Dhabi, UAE.

[38] "Overview: the Remote Research Reactor Project," International Atomic Energy Agency. (http://www.iaea.org/OurWork/ST/NE/NEFW/Technical_Areas/RRS/documents/Internet_Reactor_Overview.pdf).

[39] Author interview with University of Jordan faculty, March 2012.

[40] Based on discussions with the author. See "Brookings 2011."

[41] "Korean Consortium for Jordan's First Reactor," *World Nuclear News*, December 7, 2009. (http://www.world-nuclear-news.org/NN-Korean_consortium_for_Jordans_first_reactor-0712097.html)

[42] "Jordan's Nuclear Energy Program," presentation by Khaled Touqan, (Chairman of the Jordan Atomic Energy Commission,), Amman, Jordan, February 2011. (JAEC, February 2011).

construction has started on the associated administration building.

Center of Excellence

To build the necessary capacity and coordinate the development of very large infrastructure projects in sectors such as energy, water and ports, the Jordanian government has established a virtual "Center of Excellence for Energy and Mega Projects". The Center is designed to serve as a coordination mechanism through which major institutions in academia and government can collaborate to develop the skills required, maximize resources, and avoid duplication of effort. In the nuclear area, the entities participating in the Center's efforts include JUST, JAEC, UJ, BAU, the German-Jordanian University, and the Ministries of Labor, Public Sector Development, and Higher Education & Scientific Research.[43] In the field of human resource development, responsibility is divided between JUST, through its undergraduate program in nuclear engineering; UJ, through its (currently suspended) graduate-degree programs in physics and project management; and BAU, through the training of technicians and vocational workers and through its MSc in physics.

Synchrotron-light for Experimental Science and Applications in the Middle East

One of the few facilities for regional scientific collaboration, the SESAME project incorporates a synchrotron light source for use in basic and applied research. The facility, which is based in Amman and which is scheduled to be fully operational in 2015, includes Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey among its membership. According to its governing document, SESAME reserves special support for "work of relevance to the region and scientific and industrial research."[44]

Jordan Nuclear Regulatory Commission

As the country's nuclear oversight body, JNRC recognizes the central challenge of developing the human resources capacity required to regulate the nuclear sector effectively. The Commission has conducted a detailed workforce planning exercise calling for 321 total staff by 2014, identifying specific skills to be added as the nuclear program progresses. In addition, the Commission has used a variety of external programs and partnerships to train its staff. For example, it has initiated pilot relationships with other nuclear regulators, including a memorandum of understanding with the European Union for technical assistance from European regulators. The JNRC also is participating in the Regulatory Cooperation Forum (RCF)—an IAEA initiative designed to share expertise and lessons learned from established regulators in member states with newly-created nuclear regulators. Jordan is serving as the first test case for the Forum: an RCF delegation visited Jordan in September 2010 to assess the progress of the Commission, defining 12 areas of technical assistance needs.

The Commission has also indicated its intent to establish a national Technical Support Organization (TSO) to function as an external specialist entity providing technical assistance to the Commission, with a focus initially on nuclear safety.

Recently, JNRC has been leading an effort to establish the Arab Network of Nuclear Regulators (ANNuR). The purpose of this entity is to "foster enhancement, strengthening and harmonization of the radiation protection, nuclear safety and se-

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[43] Brookings 2011.

[44] "Statues of the International Centre for Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME)," SESAME, April 15, 2004. (http://www.sesame.org.jo/sesame/about-us/governing-document.html#a1)

curity regulatory infrastructure and framework among the members of ANNuR" and to provide a forum for information exchange among nuclear regulatory bodies in Arab countries."[45] According to JNRC, support for ANNuR would be provided by the Arab Atomic Energy Agency (AAEA), the US NRC, and the Korean Institute for Nuclear Safety.

JNRC is also in talks with the IAEA to create a center for Nuclear Safety in Jordan, whose mandate would be regional. The IAEA has expressed interest in basing this center in Jordan.

International Collaboration and Assistance

Typical of new nuclear energy states, Jordan has emphasized various forms of external assistance as part of its HRD strategy. In addition to those programs mentioned above, Jordan's training and education efforts include scholarship support for international education programs, international training programs, and nuclear cooperation agreements with other countries and the IAEA.[46]

JAEC provides scholarship support for students pursuing masters degrees in nuclear engineering in a number of countries including Russia, China, France, Korea (specific to the JRTR), and Japan. As a matter of policy, JAEC is also requiring external vendors and consultants to provide training as part of their activities. This approach is included in the solicitation for the EPC contractor as well as that for the investor-operator.

Jordan is a member of several international networks and has signed Nuclear Cooperation Agreements with twelve countries to provide support in nuclear project management, research reactor utilization, nuclear power systems, reactor safety, nuclear waste management, and nuclear fuel cycle management.[47] Jordan also has a longstanding relationship with the IAEA, including recent technical cooperation on various HRD issues. Jordan and the IAEA engage in specialized training courses and workshops in nuclear and radiation safety and security, nuclear and atomic physics, nuclear chemistry and radiochemistry, nuclear engineering and technology, and nuclear and radiation safety and nuclear security. Other areas of technical cooperation between Jordan and the IAEA include fellowship programs and on-the-job training, scientific visits, national consultant visits, and expert missions, including two Integrated Nuclear Infrastructure Reviews conducted in August 2009 and January 2012. Finally, Jordan has used outside specialist contractors to assist in the early phases of the nuclear power program.

Challenges

Government Commitment and Coordination

High-level and sustained government commitment is essential to the establishment of a civilian nuclear infrastructure. This can manifest itself in several ways, but the IAEA highlights the need for financial support, cross-institutional coordination, and stakeholder involvement.[48] In each of these areas, Jordan is experiencing challenges.

Financial support and management

While Jordan has a strong academic and technical foundation from which to develop the specialized

[45] Terms of Reference of ANNur, January 2010.
[46] JAEC presentation, May 2012.
[47] NCAs have been signed with France, China, South Korea, Canada, Russia, the UK, Argentina, Spain, Japan, Turkey, Romania and Italy. Agreements are being discussed with the United States, Armenia, Ukraine and the Czech Republic.
[48] "Evaluation of the Status of National Nuclear Infrastructure Development," IAEA Nuclear Energy Series No. NG-T-3.2, International Atomic Energy Agency, October 2008.

skills required for a nuclear power program, its HRD strategy is threatened by lack of financial support. The country has been hard hit by the global economic crisis, placing severe financial constraints on a government already suffering from burgeoning budget deficits and a very large and growing national debt.[49] As a result, the Cabinet has instituted cuts in government spending and a hiring freeze.[50]

Numerous interruptions to the Arab Gas Pipeline, which transports natural gas from Egypt to Jordan, have exacerbated the situation: Jordan has spent increasing sums on back-up fossil fuels for power generation, just at a time when oil prices have been increasing. The country has spent at least $1.4 billion on heavy fuel oil and diesel to replace lost gas from the AGP.[51]

The worsening economic situation has elevated concerns over how Jordan can afford a nuclear power program—estimated to cost at least $5 billion—and brought greater attention to the possibilities for deploying more renewable energy resources.[52] It has also severely restricted funds available for hiring across all Government institutions, including in the nuclear sector.

The funding situation is particularly acute for the JNRC in its efforts to recruit professional skills adequate to regulate the industry. The Commission maintains that all existing staff have had extensive training, but sufficient funds have not been allocated to hire more professionals to meet its staffing targets. As noted, the JNRC has drafted a detailed workforce plan calling for over 300 total staff in the 2014-2015 timeframe, but in practice the Commission has not recruited any new technical staff since 2010. This situation is negatively affecting the Commission's capacity to carry out its mandate, including the ability to conduct outreach and public engagement. In an attempt to mitigate the problem, the JNRC has developed cooperative arrangements with other entities. For example, without the necessary funding to carry out its border monitoring project in collaboration with the US Department of Energy, the Commission is partnering with the border control authority to jointly implement the program. In other areas of its remit, however, JNRC's does not have the option of relying on the support of external parties.

Against this backdrop, the allocation of Jordan's limited financial resources to basic and applied science infrastructure, such as the SCA, the JRTR and SESAME program, could be viewed as reducing funds for immediate HRD needs. While these facilities have the potential to build Jordan's nuclear science base in the long-term, they can be seen as a source of competition with—rather than a complement to—the implementation of nuclear power infrastructure in the near-term.

Institutional Coordination

A recurring area of criticism from some within the Jordanian nuclear sector is the inability of the government to coordinate development of the nuclear power program. While JAEC has been created to oversee the implementation of all aspects the program, there is a perception that there is more limited support in other government institutions. The establishment of JAEC as

[49] According to IMF estimates.
[50] "Jordan Approves Austerity Moves to Reduce Deficit," *Reuters*, May 20, 2012.
[51] "Effects of Pipeline Attacks Spread Beyond Egypt," *USA Today*, March 14, 2012. (http://usatoday30.usatoday.com/news/world/story/2012-03-05/egypt-natural-gas-pipeline-jordan-israel/53520880/1)
[52] JAEC estimates that the total cost, including equipment, materials, and labor for the construction and operation phase of two, 1,000 MW units is US $8.4 billion. See JAEC 2011, p. 36.

the country's NEPIO—the program's lead coordinator—follows accepted international practice; however other important government entities, including the Ministry of Energy and Mineral Resources and the National Electric Power Company, have had a more limited, visible role in the nuclear program. The result is that the program is in danger of being identified overwhelmingly with JAEC rather than as an initiative that enjoys broad, cross-government support. In addition, there is a common view that government's coordination and commitment with regard to other key stakeholders in academia, the NGO community, and industry, are also lacking.

These commitment and coordination issues pertain directly to HRD. Some representatives from the academic community expressed disappointment, for example, that JAEC's project manager for the JRTR program was based in the United States rather than in Jordan. The Center of Excellence for Energy and Mega Projects currently appears to be more of a theoretical partnership than an actual one, and there is not as yet much coordination amongst the major entities: several representatives from the Center's constituent institutions, while aware of the broad concept of the Center, were not aware of any further specific implementation efforts.

Jordan's lack of government coordination with regard to HRD has been acknowledged by the IAEA: the findings of two INIR missions by the Agency illustrate that, despite Jordan's nuclear program effectively commencing in 2007, the government's approach to coordination, communication and HRD needs to be strengthened, and that an integrated, strategic approach to HRD and stakeholder involvement has yet to be established.[53] (The import of the INIR Missions is discussed further in the following section).

Communication and Stakeholder Engagement

The IAEA emphasizes that it is of the "utmost importance to provide opportunities for stakeholder involvement and to look for new ways to obtain stakeholder input" and recommended that "all countries create instruments that enhance stakeholder involvement" with regard to the development of new nuclear power projects.[54] To date, Jordan's approach to nuclear power development has not adhered to the IAEA's tenets and recommendations on stakeholder engagement. Despite the continued rise in the cost of imported energy —one of the primary drivers for the nuclear program—opposition to the program is growing.[55] Opposition to the nuclear project in Jordan has even spread to the Parliament. In May 2012, the Energy and Mineral Resources Committee of the Lower House recommended that the Government suspend the nuclear power program. The measure was approved by the Lower House by a vote of 36-27.[56] Those voting in favor accused JAEC of providing "misleading" facts concerning the costs of the reactor project and the country's uranium resources, stated that required feasibility studies had not been conducted in preparation

[53] For 2009 INIR, see "IAEA´s Integrated Nuclear Infrastructure Review (INIR) Mission to Jordan," presentation by Kamal J. Araj, (Jordan Atomic Energy Commission) to IAEA's Technical Meeting/Workshop on the Introduction of Nuclear Power Programmes: Management and Evaluation of a National Nuclear Infrastructure, Vienna, Austria, February 2011. (http://www.iaea.org/NuclearPower/Downloads/Infrastructure/meetings/2011-02-TM-WS-Vienna/Day-1/Araj_JORDAN.pdf) (IAEA TM/WS, February 2011); for 2012 INIR, see "JAEC Action Plan Following the INIR Mission," presentation by Hasan Abuseini, (Jordan Atomic Energy Commission) to IAEA's Technical Meeting/Workshop on Topical Issues on Infrastructure Development: Managing the Development of a National Infrastructure for Nuclear Power Plants, Vienna, Austria, January 25, 2012.

[54] "Stakeholder Involvement in Nuclear Issues," IAEA International Nuclear Safety Group, September 2006, p.13.

[55] See "Jordan's anti-nuclear movement gains steam," AmmonNews.net, August 1, 2011, and "Ramtha residents trash nuclear reactor building, destroy documents," Jordan Times, July 12, 2012.

[56] There are a total of 120 deputies in the lower house; 63 were present and voting on the measure. From "Jordan – Deputies Vote to Suspend Nuclear Project," *Jordan Times*, May 30, 2012.

for the project, and indicated that JAEC has not been forthcoming in providing requested information to the Committee.[57] JAEC has refuted these claims.

In the view of several Jordanian nuclear sector representatives interviewed in the course of this research, Jordan's poor stakeholder engagement is a symptom of a wider lack of strategic vision in relation to the country's nuclear power project. According to this view, the Jordanian government has failed to adequately manage expectations, to communicate the need for the technology, and to educate and respond to the public's concerns.

A related issue is the inconsistency of information provided to the public by the government on the costs of the program, the schedule for its implementation, and the volumes and quality of uranium reserves that were originally proposed as a means of partially financing the program. The dialogue that *has* taken place has often been fragmented with different statements coming from government organizations. The decision to move the proposed site of the nuclear reactor site from Aqaba in the south of the country to a more populous area closer to the capital of Amman has also left the government open to charges of overlooking public opinion.

Jordan's stakeholder engagement challenge has been made even more difficult by two exogenous factors: the accident at Fukushima Daiichi in March 2011 and the popular uprisings across the Middle East region known as the "Arab Spring". The Fukushima disaster raised safety concerns over nuclear energy globally, including in Jordan, where the accident has contributed to growing opposition to nuclear power. As is the case in other countries in the region, the Arab Spring is changing the relationship between the Jordanian government and its people who are increasingly willing to challenge official government policy.[58]

The government response to these emerging factors has not kept pace with the need for a coordinated and transparent communications effort that is essential to build support for the nuclear program, respond to demands for more information, and address concerns raised over the safety, environmental impact, and cost of the project. The IAEA's INIR results in January 2012 stated "a national committee has been established to coordinate public information and to prepare a national plan… and a committee will be established that includes the Ministries or Energy, Environment, JNRC, and NEPCO to develop national stakeholder involvement." This finding indicates that many aspects of the nuclear program—the establishment of nuclear policy, the tendering process, creation of the legislative and regulatory framework, and establishment of institutions—have outpaced the development and implementation of a high-level, comprehensive, and coordinated multi-institution plan for stakeholder involvement.[59]

The IAEA's Milestones document indicates that by the end of Milestone 1 (the completion of a preparatory phase and when the country is ready to invite bids for the first reactor), a government should have achieved the following in stakeholder involvement: open and timely interaction and

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[57] "House panel accuses nuclear commission of "misleading' public," *Jordan Times*, May 26, 2012. (http://jordantimes.com/article/House+panel+accuses+nuclear+commission+of+%E2%80%98misleading%E2%80%99+public-48371)

[58] For more analysis of the current political economy of Jordan, see "How Stable Is Jordan? King Abdullah's Half-hearted Reforms and the Challenge of the Arab Spring," Brookings Institution, November 2011. (http://www.brookings.edu/research/papers/2011/11/jordan-hamid-freer)

[59] JAEC sent a questionnaire to reactor vendors in January 2010, and shortlisted three firms in May of 2010; the "White Paper on Nuclear Energy" was published in September 2011.

communication regarding the nuclear program has been addressed from the beginning, and a strong public information and education program has been initiated by government and the NEPIO.

The Jordanian government has not sufficiently engaged stakeholders throughout society in a direct, comprehensive, and transparent dialogue from the beginning of the nuclear project. While JAEC has been faced with a confluence of very challenging circumstances outside its control, including the worsening economy, the Arab Spring, and Fukushima, there is also evidence that the Commission has lagged in establishing and coordinating a robust government-wide stakeholder involvement strategy resulting in distrust of official information, challenges to rationale for the nuclear project, and growing opposition. Moreover, the need for robust stakeholder engagement is emerging just as the government is faced with budget constraints, with one official suggesting that lack of funding is limiting the government of Jordan's ability to undertake the full range of stakeholder involvement activities.

The situation in stakeholder involvement has a direct impact on HRD in Jordan: it creates doubts about the long-term sustainability of the civilian nuclear program for those thinking about a professional career in the industry, and has the potential to tarnish the prestige of the program as a high-level national endeavor threatening the establishment of indigenous capacity over time.

JAEC has begun to take notice of the urgency and importance of the stakeholder engagement challenge. It recently acknowledged in a presentation at the IAEA discussing lessons from Fukushima for Jordan that "silence and defensive attitude create doubts…and the more people know, the more they support nuclear energy."[60] As a result, the commission is developing a public communication strategy.

Recruitment and Retention

Growing public skepticism and uncertainty regarding the nuclear power program, combined with the poor economy, are having a direct impact on recruitment and retention in the sector. With the country's current unemployment rate at 10 percent and a young population vying for limited jobs—around 40 percent of Jordanians are under the age of 30—education is viewed as a critical path for economic security and success. As such, when JUST and other universities began offering degrees and training in nuclear energy following the government's 2007 commitment to nuclear power, there was considerable interest among students looking to enter the industry. However, the situation may be changing. For example, JUST continues to fill the 20-25 positions available for its BSc in nuclear engineering each year, but interest in nuclear studies among students has waned; there are more students looking to expand or switch their field of study, especially into renewable energy. The reasons are varied—including undergraduates simply seeking to diversify their studies—but increasing public opposition to the nuclear program, along with the perception of limited domestic job opportunities, particularly among the two main nuclear entities—JAEC and JNRC—is negatively affecting students' decisions on choosing nuclear energy as a professional career path.

One potential alternative employment opportunity for graduates in nuclear studies lies in the Gulf countries, especially in the UAE. For qualified Jordanian professionals in many disciplines, employment in the Gulf can offer starting salaries

[60] "Evaluation Methodology of the Status of National Nuclear Infrastructure Development and Integrated Nuclear Infrastructure Review (INIR): Impact of Fukushima on Siting & Public Communication," presentation of J. Haddad (JAEC), 18-20 June 2012, Vienna International Centre, Austria, slide 17.

for recent graduates three to four times higher than those at home; for senior professionals it can be ten times higher.

With the UAE making rapid progress on the deployment of its own civil nuclear program, and with that country facing HRD challenges of its own, the situation provides a source of demand for qualified professionals, particularly those from a friendly regional neighbor. However, the opportunity for Jordanian nuclear professionals comes with some limitations and drawbacks. The UAE also has a goal of developing domestic professionals to staff their respective nuclear programs. While the scale of the UAE's human resources challenge may make it impractical to implement a comprehensive policy of indigenous talent development in the near-term, those non-Emiratis who do enter the UAE nuclear industry are likely to encounter limited job security and to find themselves at a disadvantage relative to their Emirati peers with regard to compensation. Moreover, one of the principal attractions for Jordanian professionals working in the Gulf is the potential to earn enough money to return to Jordan and start their own businesses. However, in the nuclear field this may not be possible, both because of the highly specialized nature of the business as well as the uncertain prospects for nuclear energy in the country at this point. The emigration of Jordanian nuclear professionals abroad is also likely to have a negative impact on the domestic nuclear program, both substantively—as those with the necessary expertise leave, preventing the development of a pipeline of human capacity; and symbolically, as would-be entrants see no domestic future in the industry.

Turkey

Nuclear Power Program Status

Turkey's approach to the development of civil nuclear power is unique among the new nuclear energy states in the Middle East. The country has entered into an intergovernmental agreement (IGA) with the Russian Federation for the construction and operation of four VVER-1200 pressurized water-type nuclear power reactors with a total generation capacity of 4,800MW to be built in Akkuyu Bay on the Mediterranean coast near the township of Büyükeceli. In addition to the unique "build-own-operate" (BOO) commercial model, the project is notable for its use of a new reactor design: although Rosatom, Russia's state-owned nuclear company, is constructing two other VVER-1200-design reactors in Russia scheduled to come online in 2014 and 2016, there are currently no other examples of the technology in operation.

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 Rosatom—which will be responsible for the construction, operation, and decommissioning of the nuclear power plants. The JSC, formally named Akkuyu NGS Elektrik Uretim A.Ş, was incorporated in December 2010 with ownership split between five Rosatom subsidiaries, including AtomStroyExport, the general contractor for the construction of the plant; Interrao EES, the entity responsible for a 15-year power purchase agreement between the JSC and the Turkish electricity authority for electricity generated from the nuclear plant; and Rosenergoatom, which is responsible for operations and maintenance.[61]

Transfer of land ownership for the nuclear project construction began in May 2011, and the JSC is currently investigating the site parameters at Akkuyu, after which it will submit its design permits for approval. According to the Turkish Atomic Energy Agency (TAEK), the country's nuclear regulator, the JSC is expecting the issuance of the construction license and the pouring of first concrete to take place in mid-to-late 2014. It expects commissioning of the first reactor to take place in 2019.

The legal and regulatory basis for the nuclear power program is still being developed. The JSC will be subject to regulation and oversight by TAEK, and to Turkish energy laws. Turkey is working on a draft liability law, which still has to be approved

[61] Akkuyu NGS Elektrik Uretim presentation to the 17th International Energy and Environment Conference and Exhibition, Istanbul, Turkey, June 2011. (Akkuyu NGS Elektrik Uretim 2011)

by the treasury and finance ministries. There are also unresolved issues around the mechanisms for managing funds and disbursing compensation in the event of an accident.

National Strategy for Human Resources Development

Unlike the UAE and Jordan, Turkey has not made public a white paper outlining its overall strategy for its nuclear program. According to estimates from Hacettepe University, Turkey's leading nuclear-related university, total operational staffing needs of the four reactors at the Akkuyu site will be around 1500 people. Turkey's current nuclear law, which predates the IGA with Russia does not make explicit reference to human resource development, but does state that vendors have to outline their plans for "at least 60% of localization" of any new nuclear project.[62] According to Rosatom, the controlling entity in the JSC, the model for its contracts with host countries for construction of a new reactor program includes a 2/3-1/3 split between host country and Russian workers respectively.[63]

Turkey has a number of academic institutions with a history of nuclear-related education. Compared with other countries in the region, it also has a large and well-educated population with a high level of technical competence; indeed one of the challenges the country is facing is finding employment for its large number of university graduates. In theory, the country's nuclear power project will be able to draw on this pool of talent. In practice, the principal HRD initiative that has been promulgated to date is a partnership between Russia and Turkey under the terms of which Turkish engineering undergraduate students are educated in nuclear engineering in Russian universities with a view to returning and working on the Turkish nuclear program (see details below).

Universities and Training Facilities

Established in 1982, Hacettepe University's nuclear engineering department is the only one in Turkey to offer an undergraduate degree in nuclear engineering. The department has graduated around 300 students over the past three decades, around half of which found work in the United States and elsewhere abroad. Around 50 graduates of the program are currently working in Turkey. According to Turkey's Higher Education Council, Hacettepe University is required to take a minimum number of students per year into its nuclear engineering course; in 2012, this number was 45. Other universities in Turkey offer some nuclear-related programs, including Istanbul Technical University (ITU), which offers nuclear related courses at the graduate and PhD levels; and Ege University, which focuses on the teaching of nuclear technicians, radiation protection, and other practical applications. ITU also hosts the country's only operational research reactor, which has been used for practical training by Hacettepe University students. (The country's other research reactor used for training is the Cemecke reactor near Istanbul and is in a state of extended shutdown).

Training Partnership with Russia

As part of the intergovernmental agreement between Russia and the Turkish government, the wholly Russian-owned JSC is providing scholarships to around 600 Turkish students to train

[62] "Criteria to be Met by Investors Who Will Construct and Operate Nuclear Power Plants," Turkish Atomic Energy Authority, September 17, 2009, p.4. (http://www.taek.gov.tr/belgeler-formlar/func-startdown/94/)

[63] Rosatom, "Staff's Preparation for Monounit NPP in Partner Countries and Russian Federation" presentation given to Haccettepe University, April 2011.

them in nuclear engineering in preparation for work in the Turkish nuclear power program. An initial batch of 50 students, all undergraduates was sent to Russia in the 2011-2012 academic year to begin training at the National Research Nuclear University (also known as the Moscow Engineering Physics Institute, or MIFI).[64] Of the first intake, 10 of the students were nuclear engineering undergraduates, with the remainder from other engineering and technical fields. According to the JSC, more than 70 students have been selected for the program for the 2012-2013 academic year.[65]

The students selected for the program have a rigorous program of study: upon arrival they are required to study one year of Russian, after which they are required to begin their undergraduate training again. Following completion of their degree, students are required to undergo eighteen months of practical on-the job training. At the end of the study program, students will be qualified as "specialists," a designation comparable to a graduate-degree level qualification. The first workers trained in the Russian scholarship program will therefore not be available until 2016 at the earliest.

Other International HRD Cooperation

In addition to the international cooperation with Russia mentioned above on HRD issues, Turkey has signed international technical cooperation agreements with Argentina, Canada, France, Germany, Jordan, South Korea, Ukraine, and the United States. Turkey has also been actively engaged with the IAEA in a number of technical cooperation projects relating to HRD. In 1997 and 2001, Turkey engaged in Human Resource Development and Nuclear Technology Support programs with the IAEA. The country has also coordinated with the IAEA on regulatory and stakeholder engagement programs, including a 2005 program to enhance the regulatory competence of TAEK, a 2011 program to enhance TAEK's "capabilities for regulatory oversight of construction, commissioning, and operation of new nuclear power plants," and a 2001 program on stakeholder engagements and public awareness of nuclear energy.[66]

TAEK

The Turkish Atomic Energy Agency (TAEK) has existed in its current form since 1982 and has responsibility for overall nuclear policy, licensing and regulatory oversight of all nuclear facilities in the country, and nuclear research and education. The Authority, which reports to the Ministry of Energy and Natural Resources, also has responsibility for the operation of the country's research reactors.[67] According to TAEK, its current staff of 800 includes around 50 technical personnel involved in licensing application reviews. The regulator's internal strategy for HRD includes the arrangement of seminars and training courses and the provision of on the job training.

TAEK is also in the process of setting up training programs with Russia in order to understand the licensing process. As there is no operational version of the VVER-1200, and therefore no precedent for the licensing of the reactor design, TAEK is working with its counterpart in Russia to observe the licensing process and quality-assurance inspection activities at the Novovoronezh-2 reference plant in Southwest Russia with a view to applying the lessons to the Akkuyu project. TAEK

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[64] According to the Akkuyu NGS Elektrik Uretim A.Ş Website (http://www.akkunpp.com/in-ankara-taner-yildiz-minister-of-energy-and-natural-resources-of-the-republic-of-turkey-addressed-students-of-the-second-stream-going-to-russia-in-the-nearest-time-to-study-there/update)
[65] Ibid.
[66] See IAEA Technical Cooperation website. (http://tc.iaea.org/tcweb/projectinfo/NationalProjectByRegion.asp?cid=RAS)
[67] "Country Nuclear Power Profiles: Turkey," International Atomic Energy Agency, updated in 2011. (http://www-pub.iaea.org/MTCD/Publications/PDF/CNPP2011_CD/countryprofiles/Turkey/Turkey2011.htm)

also emphasizes its coordination with the IAEA and the international community on the development of its human capacity.

In July 2012, TAEK issued a tender for a technical support organization (TSO) to provide assistance in the "proper handling of its first NPP licensing activity."[68] According to the tender, TAEK is looking for three categories of technical assistance: support services; pre-application services for assistance in preparation for the construction license application for the first unit at the Akkuyu site, which it expects in 2013; and assistance in the review and assessment of the license application itself. In the first category, the regulator specifies that it is looking for external support "in meetings with [the JSC] and transfer of knowledge on review and assessment process through sharing and/or developing procedural documents, sharing all necessary inputs on models and analyses performed". In the pre-application phase, the services required include the drafting of technical bid specifications, the drafting of "a comprehensive list of acceptance criteria for the review and assessment process," and guidance of TAEK staff on how to participate in the review, assessment and reporting process. In the review and assessment phase, the tender calls for support organizations to evaluate applications for limited work permits for the construction license according to pre-determined timelines. In doing so, bidders are required to perform computer modeling on accident analysis across a range of scenarios, and to provide a review and safety assessment of the differences between the VVER-1200 reference plant in Russia and the Akkuyu site.

According to the terms of the tender, the successful TSO will have to provide personnel fluent in both Russian and English. Bidders are also asked to emphasize any relevant "experience on VVER-1000 or VVER-1200 designs…and review and assessment services carried out in regulatory infrastructure based on Russian regulation."[69]

Challenges

Regulator-Operator Information Asymmetry

Given Turkey's lack of experience in commercial-scale civil nuclear power production, one of its biggest HRD challenges will be the competent oversight of the licensing, construction and operation of the Russian VVER-1200 reactors. The breadth of services required outlined by TAEK in its July 2012 tender for technical support underlines the scale of the challenge the regulator faces. According to the tender, the regulator will be relying on external support for everything from the development of the basis of licensing evaluation criteria to training of its staff in the process of license evaluation, to the implementation of computer safety models.

The challenge is exacerbated by the nature and origin of the reactor technology. With no VVER-1200 reactors in operation anywhere, TAEK is severely limited in the pool of external international expertise it can draw on for support for competent oversight of the program. The only regulatory personnel with experience with the VVER-1200 design will likely be affiliated with Rosatom through the two construction projects in the Russian Federation. Even if TAEK widens its TSO selection criteria to include those consultants with experience in other VVER reactor designs such as the VVER-1000, the preponderance of qualified candidates will also be Russian. If the TSO select-

[68] "Technical Specifications for Call for Tender to Procure Technical Support Services During Review And Assessment Of Construction License Application for Akkuyu Nuclear Power Plant," TAEK Tender, July 2012 (http://www.taek.gov.tr/eng/documents/func-startdown/615/) (TAEK Tender, July 2012).

[69] Turkish Atomic Energy Authority: "Technical Specifications for Call for Tender to Procure Technical Support Services During Review And Assessment Of Construction License Application for Akkuyu Nuclear Power Plant," July 2012.

ed to provide the wide range of necessary technical regulatory services is from the Russian nuclear sector, TAEK will find itself subject to a situation in which the vendor/operating company has an institutional affiliation with the regulator, leading to the possibility of a conflict of interest. The situation is exacerbated by the current institutional structure, in which TAEK reports to the Turkish Ministry of Energy and Natural Resources instead of having statutory independence from the policy making body for the nuclear power program.

If TAEK does not hire a TSO affiliated with Rosatom, it will put itself at considerable risk of information asymmetry between the regulator and vendor company. Without the adequate internal human capacity to conduct the license application review itself, TAEK will be relying on the expertise of the TSO to ensure the safety and security of its program. However, even leading independent consultants will likely not have the same level of experience and technical familiarity with the VVER-1200 design as the Russian-owned JSC, which will be applying to construct it.

While the above-mentioned initiatives to train Turkish students in Russia and TAEK's exchange programs with Russian regulators will assist TAEK in building its internal regulatory capabilities, the proposed timeline for the development and implementation of Turkey's nuclear power program (with construction projected to begin in 2014) suggests that Turkey will struggle to build the internal capacity to meet the IAEA's recommendation of being an "intelligent customer" prior to the construction phase.

Fragmentation of the HRD System and Nuclear Culture

The arrangement between Turkey and the Russian Federation for the training of Turkish students in nuclear engineering provides a good opportunity for future plant personnel to become acquainted with the technology and the practical operating realities of the VVER-1200 reactor design. The model does, however, come with an opportunity cost with regard to the development of an indigenous pipeline of nuclear professionals. By relying on Russia to train nuclear engineers for the Akkuyu project, Turkey is outsourcing its human capital development at the possible expense of building up its domestic educational infrastructure. While the nuclear engineering undergraduate program at Hacettepe University is still running, it is unclear whether its graduates will be permitted by the JSC to work in senior roles at the Akkuyu project.

Turkey's need for a domestic nuclear workforce also goes beyond the requirements of the Akkuyu plant. The country is currently in negotiations with other potential (non-Russian) vendors for the development of a second nuclear power project at Sinop on the Black Sea coast. It has also expressed an interest in a third nuclear project in the north west of the country near the Bulgarian border. If additional nuclear energy projects are developed, Turkey will need to have a domestic academic infrastructure to provide skilled personnel both at the plants themselves and in the regulatory authority.

The further risk of such a high level of dependence on a vendor for the flagship training program is that there may be a negative impact on the country's vital non nuclear-engineering HRD requirements in relation to the program, and on the development of a robust nationwide safety culture. As stated in earlier chapters, nuclear engineers make up a minority of the workforce at a nuclear power project; the majority of the workforce required for the operation of a nuclear power plant consists of non-nuclear engineers and skilled technicians. The structure of the exchange program, through which Turkish nuclear engineering students complete all their training in Russia, fragments the Turkish nuclear HRD effort, preventing the capture and exchange of knowledge and the development between the various parts of the education and training system. It also comes with the risk of fragmenting efforts to build a rigorous universal safety culture throughout the civil nuclear industry, which must be promoted and reinforced by experienced and senior professionals. The challenge of instituting such a culture in Turkey, where "the cultural traditions may work against such an approach which necessarily implies a healthy challenge to authority" has already been highlighted by some of the country's leading policy analysts.[70] This challenge will be made more acute with relation to the Akkuyu project by the diversity of the workforce, which will comprise Russian expatriates (who will have primary responsibility for construction and operation of the plant), Russian-trained Turkish nuclear engineers, and domestically trained Turkish nationals.

[70] "The Turkish Model for Transition to Nuclear Power," Center for Economics and Foreign Policy Studies (EDAM), December 2011, p.3.

Conclusions and Recommendations

HRD Strategy and Status

Each of the three countries in the case studies above is approaching the development of its first commercial-scale nuclear power project from a different starting point. Turkey has had several decades of nuclear-sector experience, including a long-standing nuclear regulator, and has in place more institutional capacity than both the UAE and Jordan. With smaller populations and more recent plans for civil nuclear power, the latter two will have far more work to do to build the necessary capacity to develop and implement their programs. There are also differences among the countries with regard to financial resources, decision-making structures, and levels of civil-society engagement. The UAE has the financial resources to establish and staff a wide array of institutions and programs in a very short time, and to attract a large cadre of senior expatriate expertise to occupy senior positions in a number of key institutions. While Jordan does not have the financial resources to undertake a similar approach, it does have a strong domestic academic foundation in engineering and other technical areas, especially at the university level, which the UAE lacks. Turkey's agreement with the Russian Federation is aimed at minimizing the financial burden of developing both its nuclear program and the associated capacity-building.

Given their differing economic and political conditions as well as their varying levels of experience with civil nuclear power, each country faces unique challenges with regard to human resource development. Turkey has a number of legacy institutions that have operated irrespective of the country's nuclear power status. The challenge is for these legacy institutions to adapt to the needs of the new nuclear power project, ensuring that human resources needs are addressed. Jordan and the UAE are designing their HRD strategies from scratch specifically to meet the needs of the nuclear power project, providing a different set of challenges.

However, there are some common approaches among the three countries' HRD strategies. The governments of the UAE, Turkey, and Jordan recognize at the highest levels the importance of HRD in building a civilian nuclear energy program. Each country is developing and implementing a variety of training and education tools to address HRD needs of the nuclear programs. Regardless of the commercial model being employed, each country's strategy for introducing nuclear power relies heavily on the involvement of outside nations and institutions. Each has worked with the IAEA to set up its program, with Agency's guidance often providing the blueprint for HRD and workforce planning, and training and fellowship programs providing needed technical support. Each country has also put in place a number of bilateral agreements. For UAE and Turkey, the most important of these are the agreements with their respective vendor countries. In the case of the UAE, this support is taking the form of training of local staff in Korea, exchange programs, secondment of vendor staff to the UAE regulator, and support for scholarships. In the case of Turkey, the relationship with the Russian Federation is the primary tool for HRD development through the student training program.

Given their geographic proximity, largely similar motivations for pursuing nuclear power, and shared culture and language, it has been suggested that some countries in the Middle East should develop joint efforts in key areas of HRD to maximize resources, particularly in the context of shared use of training facilities or the establishment of regional training programs. However, while the concept is intuitively attractive and there is broad recognition of potential benefits, in practice there is very little emerging consensus on how to proceed in this regard. While programs such as GNEII demonstrate a minimal amount of intraregional cooperation, there are considerable logistical and political barriers to the wider shared use of existing facilities, such as research reactors and national training institutes. Barriers to regional collaboration include: a tendency by certain countries to see civil nuclear-sector HRD as a source of competitive advantage; national security concerns around granting access to nuclear-related facilities to foreign nationals; and questions of cost allocation and siting for any proposed new facility or institution.

Major Challenges

As outlined in the introduction, this study assumes that a successful HRD strategy should incorporate both competence and sustainability. These two elements are interrelated, and each in turn requires a set of conditions to be met. In cases where these conditions are not being met, there is the possibility of HRD-related risks materializing. Through a thorough evaluation of the civil nuclear HRD plans of the UAE, Turkey and Jordan, it is clear that there exist major challenges that, if not adequately addressed, could develop into risks. These risks are outlined below. It should be noted that all of the HRD issues discussed do not apply to all of the countries under review; however, they do pertain to at least one of the countries in this study, and can also serve as lessons for other countries pursuing nuclear energy.

1. Risks to Competence

The case studies revealed several challenges that countries must address with regard to competence:

i. Improper Academic Program Design

Matching education and training with the actual needs of the nuclear power program is one of the most important aspects of a successful HRD strategy. Leading practice, as highlighted by the IAEA, indicates that countries should first conduct a workforce planning exercise for the entire program and then build an HRD plan around the results. In some cases, this process can be complicated by the presence of incumbent institutions and programs that may have been in place for a long time before the current efforts to develop civil nuclear power. This is a challenge in Turkey, which has longstanding educational programs that are a legacy of previous, failed attempts to develop nuclear power. In this case, there is a risk that the academic and training infrastructure is not aligned with the needs of a new nuclear power program. For Jordan and UAE, the issue of legacy institutions is less of an issue as both countries are starting with limited indigenous capabilities in nuclear energy. However, even programs established recently in preparation for the development of a nuclear program can suffer if the political or economic basis of the program is brought into question.

Another challenge to matching institutional capacity with actual workforce demand is the tendency to overemphasize the more prestigious aspects of nuclear education. The IAEA and others suggest that only a minority of the workforce is required to be educated to college-degree level and a small proportion of these are required to have a nuclear engineering degree. In the three countries under review there is a strong emphasis placed on higher education, particularly at the degree level for nuclear engineers. In Turkey and Jordan, this has the potential to come at the expense of non-nuclear engineers and technicians. The UAE's is the exception in the regard; its Higher Diploma in Nuclear Technology provides a good model for vocational training.

ii. Lack of Quality Control

A civil nuclear power program is a serious undertaking and one that requires qualified people in place for a sustained period of time. For those countries looking to build domestic capacity to meet these requirements, the standard of training and the professional capabilities of the graduates will be of critical importance. To the extent that such gradates can be produced with the necessary knowledge, skills, and attitude, countries will be able to improve the sustainability of its nuclear program. Building the educational foundation for a highly skilled labor force is an endeavor that can take a significant amount of time and incremental progress. This is particularly true in the UAE. The country has a clear strategy, as well as the financial wherewithal, for the establishment of robust educational and training infrastructure, which in turn has the potential to contribute positively to the longevity of the country's civil nuclear program. However, there is evidence that some new civil-nuclear related academic institutions in the UAE are experiencing challenges in meeting the necessary levels of recruitment of high-caliber candidates, and of academic achievement among enrolled students. This challenge of student quality is compounded by competition from other sectors as the nuclear industry will have to compete for a limited number of qualified graduates with other expanding industries in the country including aluminum, semiconductors, aerospace, and oil and gas.

This challenge also has the potential to be exacerbated by predetermined quotas. The development of nuclear power in the UAE is taking place according to an aggressive time frame: less than a decade from the formal articulation of the country's nuclear policy to the projected operation date for the first reactor. It is also taking place in a country that is setting very ambitious targets for the proportion of the workforce to be made up of domestic citizens through the country's drive toward Emiratization. In the long term, the strategy of Emiratization also has the potential to work to the advantage of the sustainability of the program. However, if the country maintains a rigid focus on quotas of citizens in the nuclear industry irrespective of the availability of skilled candidates, the near-term safety and security of the program may be brought into question.

iii. Regulator-Operator Information Asymmetry

Even for those countries that do not plan to build an extensive domestic civil-nuclear power workforce, the IAEA is clear that they need to meet the requirement of being "intelligent customers" of the products and services being provided by external parties. For countries with no history of nuclear power, the role of the regulator in the host country is of particular importance in this regard. Turkey provides an example of a country that is susceptible to regulator-operator asymmetry risk. According to the agreement between Turkey and the Russian Federation, the country's first civil nuclear program will be implemented through a Russian-owned joint-stock company (JSC). The JSC will be responsible for the financing, construction and operation of four nuclear reactors at Akkuyu on Turkey's Mediterranean coast. With no history of civil nuclear power production, Turkey will have to build the human capacity to develop and enforce regulation over a vendor/operator with considerably more experience. The risk is increased as Turkey's nuclear program is being based on a reactor design—the Russian VVER 1200—that has no operational history to date. While two VVER 1200 units are currently under construction in Russia and are planned to be operational by the time Turkey's nuclear project is initiated, the challenge of asymmetry will still remain as Rosatom, the Russian regulatory authorities, and any third parties associated with them will be the only entities with operational experience of the reactor design anywhere in the world. As the party responsible for comprehensive oversight of the program, including the issuance of construction and operation licenses, the Turkish Atomic Energy Authority is likely to need significant external assistance in carrying out its mandate.

iv. Language

A potential barrier to effective training and HRD is language differences between students and teachers. This poses a risk that ineffective communication leads to misunderstandings and suboptimal performance of nuclear sector professionals and institutions. In most formal academic settings in the region, the language of instruction is English. As many of the technical materials relating to nuclear power operation are in English and as many of the expatriate experts that will assist in the launch of a nuclear program will likely be English speakers, ensuring a minimum level of English-language proficiency is an important part of HRD.

Other language-related challenges relate to the vendor-customer relationship. In the countries under review (UAE, Turkey, and possibly Jordan), the nuclear vendor is from a non-English speaking third party country. Given that the vendor/operator will not only have to communicate with government officials, but also with the regulator and the general public, this suggests the need for ensuring adequate common language skills to be able to communicate with a variety of different audiences at different levels of society.

In the case of the UAE and Jordan—and possible other newcomer civil nuclear states in the Middle East, there is also a challenge in ensuring that the version of Arabic being used to translate technical documents from English or other languages is relevant for the host country. While the IAEA's documents are generally translated using Egyptian Arabic, other countries may use different versions of the language, leading to the potential for misunderstandings or omissions that could have negative consequences.

2. Risks to Sustainability

i. Lack of Government Commitment and Coordination

Given the sensitive and complex nature of nuclear energy, governments have always played a major role in its development, implementation, and oversight, including responsibility for ensuring appropriate human resources are in place throughout the life of the program. For all countries, especially for new nuclear energy states, the IAEA emphasizes the importance of government commitment, coordination, and communication. For civilian nuclear power programs to be successful and sustainable, they need political and financial support from their host governments. The IAEA places considerable importance on the need for governments to study the rationale for developing a civilian nuclear energy program, and determining a comprehensive strategy to proceed. In the area of HRD, this commitment includes ensuring that sufficient funding and other support is provided; the IAEA clearly identifies funding and financing as one of its 19 pillars of the milestones guidance.

Implementing a nuclear energy program for the first time also requires that the government provide cross-institutional planning and implementation among stakeholders. In HRD, this means that the government must work with all levels of academia, industry, and relevant government institutions in evaluating workforce needs against existing capabilities, and identifying an overarching strategy for developing the indigenous capacities to manage and operate all aspects of a nuclear power program.

In all new nuclear programs there needs to be a high degree of coordination between all stakeholders to ensure the effective preparation of workers. Countries are confronted with finite timelines and often limited resources for building human resources across multiple institutions. Lack of coordination can lead to competition between nuclear-related institutions, duplication or variation in standards, variable human resources quality or duplication in skill sets.

There is evidence of widely varying degrees of institutional coordination in the countries under review. The UAE demonstrates an overall strategy for HRD involving a strong degree of communication between different entities and mutually reinforcing efforts such as the GNEII program. In Jordan, there has been less coordination, with the potential for duplication or gaps. While the country has established a virtual "Center of Excellence" to address such coordination challenges, there is evidence that the organization and administration of the center itself is suffering from lack of coordination. A likely cause and a symptom of this lack of coordination is the underfunding of certain components of Jordan's nuclear program that may keep it from having the necessary resources to maintain or build up its human capacity.

ii. Expatriate Dependence and "Brain Drain"

The nuclear power industry is international in nature, and a wide variety of positions are routinely staffed with expatriate personnel both in established nuclear energy states and those building their first reactors. However, long-term dependence on such expertise, particularly if not coupled with a strategy to transfer knowledge to the domestic work force, can leave a program at risk of unsustainability. With the older generation of nuclear professionals in established nuclear energy states approaching retirement (and some of those states scaling back or discontinuing their nuclear power programs), the pool of international experts available for new programs is limited. There are also likely to be several other countries seeking to develop their first nuclear power project in the coming years, adding to the competition for talent. While the UAE is likely to be highly reliant on expatriate expertise for the foreseeable future, the country has in place a strategy for addressing the issue of sustainability through mentor programs and on-the-job training.

Turkey is also prone to sustainability challenges: with the overall responsibility for the construction and operation of the Akkuyu project resting with the Russian Federation, the long-term plan for a large part of the project's staffing is out of the hands of the Turkish authorities. While there is a program in place to train Turkish nuclear engineers, this is also being overseen by Russian third parties and will take place in Russia. The outsourcing of the training of the core of the Turkish civil nuclear workforce in this way has the potential to fragment the country's efforts to build a self-sustaining domestic capacity.

Jordan suffers from a different sustainability challenge. The country's strained public finances mean that all aspects of the civil nuclear program face funding difficulties. This problem has a direct effect on HRD as both academic departments and nuclear-related entities may find themselves underfunded and therefore unable to build the necessary human capacity. With large differentials between the salary levels in different parts of the region, there is the prospect of trained Jordanian nuclear professionals migrating to higher-paying countries leaving a potential shortfall of indigenous talent.

iii. Lack of Stakeholder Communication

Stakeholder involvement and public outreach is essential to promote understanding of the advantages of nuclear power, as well as how its risks will be addressed, and to legitimize the program in the eyes of the public, thereby securing its political feasibility. The IAEA identifies stakeholders broadly to include media, NGOs, the general public, opinion leaders, and national and local government officials; and emphasizes that stakeholder involvement is a dialogue and includes "participation in the decision-making process."[71]

Human resource development is an integral part of the development of a nuclear energy strategy and policy, and adequate stakeholder engagement is essential in order to lay the foundations for the future workforce by educating the next generation about the opportunities for a career in the nuclear sector. A government's ability to demonstrate the rationale for a nuclear power program, coordinate its implementation, and communicate with stakeholders is therefore directly related to creating an environment that attracts qualified professionals and technicians at all levels to meet the human resources needs of the program.

The countries under review demonstrated widely varying levels of stakeholder engagement. In the UAE, there has been a concerted effort to communicate the need for nuclear power to the population and to take the message to high schools and outside the nuclear community. In Jordan, the lack of a clear stakeholder engagement strategy has been a major contributing factor to resistance to nuclear power in general and reduced interest on the part of would-be nuclear professionals specifically. Turkey's performance in stakeholder relations has also been criticized with Turkish-based research organization EDAM finding in a recent report that "A more regular and comprehensive communication strategy with the public at large focusing on the adopted safety and security measures would be helpful in defusing the polarization surrounding the transition to nuclear power.[72]

Recommendations

The above conclusions demonstrate that the aspirant nuclear energy states in the Middle East have a large number of issues to address with regard to HRD. While all of the challenges to do not pertain to all of the countries, the experiences of each country holds lessons for the others and for states outside of the region that are looking to establish nuclear power programs. To address their HRD-challenges, such states should seek to implement the following recommendations.

HRD Should be a Central Part of a New Nuclear Energy State's Strategy

States looking to develop nuclear energy for the first time are entering a rapidly changing global nuclear market. In the wake of the Fukushima accident of 2011, which has been attributed in large part to human error, there is a renewed focus on the competence and safety culture of the nuclear workforce around the world.[73] With large

[71] "Stakeholder Involvement in Developing a National Position," presentation by Brian Molloy (IAEA Nuclear Power division) to IAEA TM/WS, February 2011.
[72] EDAM, 2011, p.4.
[73] Kiyoshi Kurokawa et al., "The official report of The Fukushima Nuclear Accident Independent Investigation Commission," National Diet of Japan, July 2012

numbers of experienced nuclear professionals retiring in the coming two decades, newcomer nuclear states will have to compete with incumbent nuclear energy states and each other to secure or retain nuclear-sector talent. Consequently, every state looking to develop civil nuclear power should make HRD a central consideration from the earliest stages of its policy development. One way to articulate such a strategy is through the development and public dissemination of a policy white paper that explicitly details the country's HRD challenges and plans over the long-term, and that raises the profile and the value of the program in the eyes of the potential workforce. However they are articulated, national policies for civil nuclear power projects should prioritize the allocation of resources for HRD to ensure that the specific needs of the power project are met.

HRD Programs Should Place a Large Emphasis on Safety Culture

The countries under review acknowledge the importance of instilling a safety culture. However, the implementation of this concept will be critical to the success and the sustainability of their programs. Investigations following Fukushima show how difficult it is to instill this kind of corporate culture in a society that does not have a tradition of transparent and open communication. NEPIOs, regulators, and operating organizations in the region need to create an environment that encourages open communication, frank evaluation of performance, and the reporting of safety incidents. Such a culture requires the establishment of an environment in which individuals feel confident challenging authority.

Quality Control Initiatives Should Include Merit-Based Recruitment, International Benchmarking and Vendor Involvement

Personnel employed in or training to enter the nuclear industry need to conform to strict standards of performance in order to ensure the safety and security of the program. Recruits for both academic programs and positions within the industry itself should be evaluated solely on their ability to perform the necessary responsibilities. To ensure quality control in academic programs associated with the nuclear industry, education establishments should seek accreditation for the curriculums based on recognized international benchmarks. To ensure that established standards are upheld, academic institutions should consider the implementation of external advisory and review boards, possibly with the participation of the IAEA. Countries should also make use of vendors, which have more nuclear-sector experience than the host country and the incentive to ensure that the best people are hired for the nuclear program, in the selection of candidates for scholarships, training programs, and employment.

Stakeholder Engagement Should Be a Core Element of New Nuclear Energy Programs' HRD Strategies

Stakeholder involvement and public outreach is essential to promote understanding of the advantages of nuclear power, as well as how its risks will be addressed, and to legitimize the program in the in the eyes of the public and thereby to secure its political feasibility. It is also critically related to a country's ability to attract, motivate, and retain qualified individuals. States should work to engage stakeholders—including media, NGOs, the general public, opinion leaders, and national and local government officials—in the discussions and decision-making process related to the introduction of civil nuclear power. Having made the decision to proceed with nuclear power, states should ensure that their engagement and communication with stakeholders keep pace with the program's development.[74] An important part of the engagement strategy should be highlighting the value of the civil nuclear program in order to ensure

[74] The IAEA discusses guidelines for development and implementation of strategies for stakeholder engagement in "Stakeholder Involvement Throughout the Life Cycle of Nuclear Facilities," IAEA, 2011.

that potential recruits and existing workers are attracted to the industry.

HRD Strategies Should Be Designed Around the Operational Needs Of the Nuclear Industry Rather than Around High-Profile Academic Programs

In developing the educational infrastructure to build a domestic human capacity, there is a tendency among newcomer nations to focus on graduate and research-based university engineering programs at the expense of more vocational and technician-level positions. In addition to—and in some cases instead of—building undergraduate and graduate-level nuclear engineering programs, countries should focus their limited resources on developing training programs that prepare the technicians that will make up the majority of the workforce at a nuclear power plant. Newcomer nuclear states should also conduct an assessment of the state of other mature domestic industries such as aerospace and oil and gas to determine the extent of the base from which qualified engineers and experienced managers may be drawn into the civil nuclear sector.

New Nuclear Energy States Adopting New Reactor Technologies Should Allocate Additional HRD Time and Resources to Become an "Intelligent Customer"

All new nuclear energy states face a large number of HRD challenges. However, the challenges are vastly increased if the technology that the country selects for its nuclear program is itself new and has relatively little operational history. In such cases, the new energy state regulator and many—if not all—international third-party support organizations will lack the operational experience or knowledge necessary to oversee the program's implementation and operation. Even if third-party support organizations can be found, a heavy reliance on such organizations calls into question the competence of the national regulator to oversee the construction and operation of a new nuclear program. Countries looking to avoid such regulator-operator information asymmetry need to allocate additional time and resources to developing the indigenous capacity to competently oversee the implementation of new reactor technologies.

National Quota Policies Should be Flexible to the Needs of New Nuclear Programs

Some countries see the introduction of civil nuclear power as an opportunity to develop a domestic capability in a high-value, technologically advanced global industry. While the encouragement of host-country nationals to participate in the civil nuclear workforce is to be commended as a means of furthering a country's capacity to be an intelligent customer, the setting of strict targets for a minimum level of domestic employment in the nuclear industry comes with a risk to the program if the quota is upheld at the expense of ensuring qualified personnel fill the necessary positions.

Regional Cooperation Should Not Be Relied Upon as a Major HRD Mechanism

Despite the intuitive appeal of mechanisms for exploiting respective national comparative advantages in the nuclear sector, there is little prospect for such mechanisms materializing in the near term. While there may be some opportunity for international students to participate in nuclear-related academic programs abroad, the training programs in each country are geared to the specifics of the national nuclear program, making shared used of facilities difficult. As such, new nuclear countries should plan to bear the entire responsibility—either directly or with vendor partners—for the provision of training for their civil nuclear workforce.

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