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Economic risks of Jordan's nuclear program

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ABSTRACT

Jordan has recently embarked on establishing a nuclear program in the hope that it would resolve its energy security problems, meet its increasing demand of electricity and promote economic growth through localization. This paper examines the economic risks and challenges associated with Jordan's nuclear program. It is based on a comparative cost analysis and interviews conducted with current and former Jordanian policy makers. Economically, nuclear power represents a high-risk option for Jordan as it involves three potentially costly scenarios of varying impact: project cancellation, unplanned outages and the declining costs of renewable technologies, particularly solar power. The paper also highlights other challenges facing Jordan in its pursuit of nuclear power such as opaque decision-making process and the need for an independent and competent nuclear regulatory body.

Introduction

The Jordan Atomic Energy Commission (JAEC) promotes nuclear power as an economic option that would resolve Jordan's energy security problems and meet the increasing demand for electricity (Jordan Atomic Energy Commission, 2012; Al-Bakhit, 2013). Jordan lacks indigenous fossil fuel resources and has suffered some major disruptions in its primary energy imports over the past few decades, primarily the loss of the subsidized oil from Iraq following the wars in Iraq in 1991 and 2003 (Swaidan and Nica, 2002; Lasensky, 2006). More recently, the Egyptian pipeline that supplies Jordan with natural gas, that was used to produce most of Jordan's electricity, has been attacked several times since 2011, disrupting gas-fired electricity production and forcing Jordan to shift to diesel and heavy oil to meet demand (Saleh and Dziadosz, 2013). This unexpected shift is believed to have had a substantial impact on Jordan's budget (Udasin, 2013).

The electricity sector

Jordan relies heavily on imported hydrocarbons to generate electricity. In 2013, the electricity sector in Jordan consumed about 3600 thousand tonnes of oil equivalent (35.8% heavy fuel, 25.2% natural gas and 39% diesel) to generate 99.6% of its total electricity production of 16,975 GWh (NEPCO, 2013). Since Jordan's needs of electricity exceed the amount generated, additional power is imported from Egypt and Syria. However, the amount of imported electricity has been sharply fluctuating due to circumstances in the region, particularly in Syria. The fuel consumed by the electricity sector in 2013 constitutes 45.6% of Jordan's total fuel consumption (NEPCO, 2013). The cost of imported hydrocarbons in 2013 was about 4 billion Jordanian Dinar (5.62 billion USD) (Al-Nugrush, 2014), about 17% of Jordan's GDP. The decline of oil prices in 2014 has provided Jordan with some relief from high energy costs and helped the National Electric Power Company (NEPCO), cuts its losses (Obeidat, 2014).

The total and sectoral electricity consumption in Jordan between 2007 and 2013 are shown in Table 1. The average annual growth rate in electricity demand between 2008 and 2013 was about 4.8%. The domestic sector, which includes government consumption, accounts for the largest share of demand and has witnessed the highest increase since 2008. Fig. 1 shows the projected electricity generation capacity that is needed to meet demand until 2030. The average annual growth rate in electricity demand between 2014 and 2030 is about 6%.

Timeline of Jordan's nuclear program

The idea of acquiring nuclear power in Jordan started to gain momentum in November 2006 when a ministerial committee was formed to develop a plan to introduce nuclear power in Jordan and establish a nuclear energy program (Saeedan, 2011). In 2007, the nuclear law was modified and the Jordan Atomic Energy Commission was established to help plan, manage and oversee the nuclear program, along with the Jordan Nuclear Regulatory Commission (JNRC), which was charged with providing a regulatory framework.

In order to build human resource capacity, a nuclear engineering department at the Jordan University of Science and Technology (JUST) was established in 2007. The department's main mission is to "graduate qualified engineers who are capable of contributing valuable engineering skills and knowledge toward the design, building and

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Table 1
Sector-wide electricity consumption in Jordan. (Source: Jordan's National Electric Power Company (NEPCO, 2013)).

Year	Total	Domestic	Industrial	Commercial	Water pumping	Street lighting
	(GWh)	(%)	(%)	(%)	(%)	(%)
2013	14,565	43.02	24.15	16.58	14.25	2.00
2012	14,277	42.91	24.24	17.00	13.69	2.13
2011	13,535	41.87	25.75	16.05	14.03	2.29
2010	12,857	40.64	25.37	17.01	14.53	2.45
2009	11,956	40.88	24.14	16.56	14.88	2.59
2008	11,509	38.74	27.12	16.73	14.88	2.55

running of Jordan's first nuclear power plant" (Website of the Nuclear Engineering Department at JUST, 2015). To consolidate the nuclear training programs, Jordan signed an agreement with the China Institute of Atomic Energy (CIAE) to build Jordan Subcritical Assembly (JSA) at the JUST, its first research and training facility in 2008 (World Nuclear News, 2008).

In 2008 and 2009, JAEC launched site feasibility studies for the location of Jordan's first nuclear power plant (Jordan Atomic Energy Commission, 2012). In September 2009, JAEC hired Tractebel Engineering, a Belgium-based engineering consultancy, to conduct the required characterization studies for a site close to Al-Aqaba, Jordan's only coastal city (World Nuclear Association). Tractebel later concluded that the proposed site in Al-Aqaba is suitable to build a nuclear power plant (Mustafa, 2010). However, in 2010, JAEC decided to shift attention to the inland Al-Amra site in the Majdal area, about 70 km east of Amman. JAEC's official justification of changing the nuclear reactor site is that the "terrain and its high elevation above the water source would require extensive extra work" (Jordan Atomic Energy Commission, 2012). Cooling water for the plant in Al-Amra site would be provided by Khirbet As-Samra, a waste-water treatment plant in Al-Zarqa. The locations of these two sites are shown in Fig. 2.

In parallel with the above efforts to startup Jordan's nuclear program, JAEC embarked on exploring the potential for mining and exporting Jordan's uranium reserves. In October 2008, JAEC and Areva, a French multinational company specializing in nuclear energy, formed the Jordan French Uranium Mining Company (JFUMC), a joint venture to assess the commercial potential of uranium deposits in central Jordan (World Nuclear Association).

To promote research and training in nuclear science and technology, JAEC selected a South Korean consortium led by the Korean Atomic

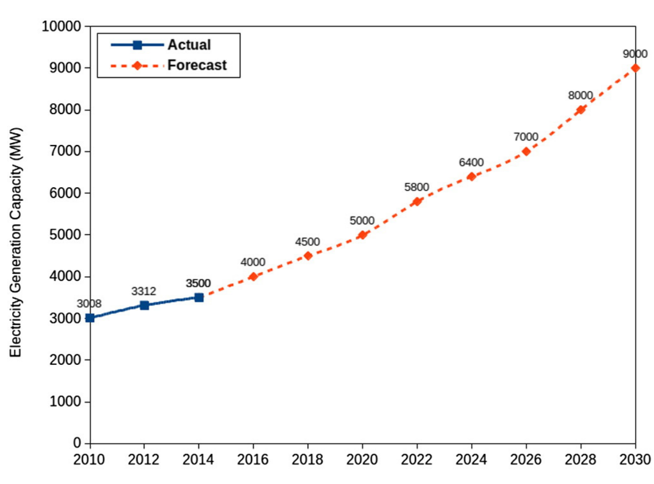

Fig. 1. Actual and projected electricity generation capacity in Jordan (Jordan Atomic Energy Commission, 2012).

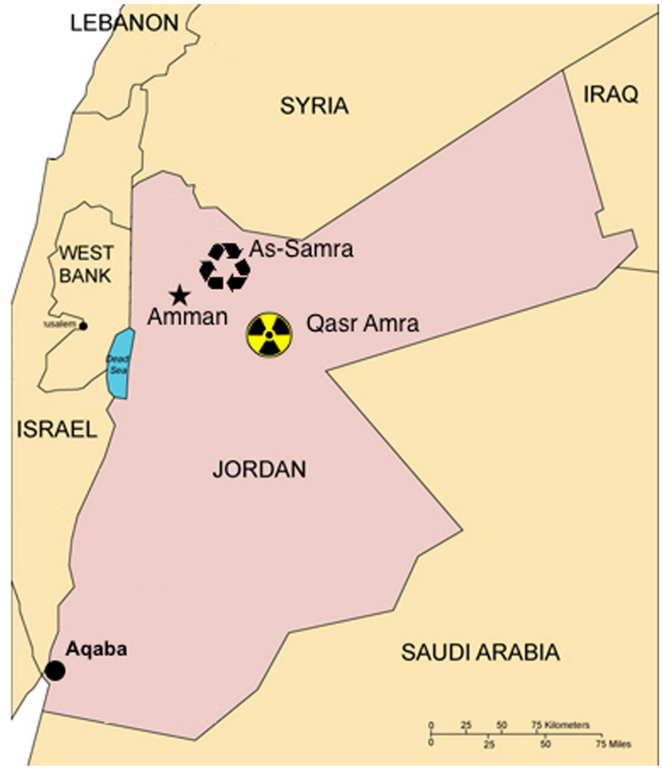

Fig. 2. Locations of Jordan's proposed nuclear power plant site (Al-Amra) and the wastewater treatment facility that would provide cooling water (As-Samra).

Energy Research Institute (KAERI) and the South Korean Group DAWEOO to build Jordan Research and Training Reactor (JRTR), a 5-MWth pool-type reactor, at the JUST in December 2009. The research reactor is currently under construction and expected to be completed by 2016. Besides providing a venue for research and training, JRTR is also envisioned to produce radioisotopes for medicine, industry and agriculture (World Nuclear News, 2013a).

In May 2010, JAEC selected three vendors to enter a bidding process to build Jordan's first nuclear power plant. The shortlisted designs were the 1100 MWe Atmea-1 pressurized water reactor (PWR) from Areva-Mitsubishi, the 700 MWe Enhanced Candu 6 (EC6) heavy water reactor from the Atomic Energy of Canada Limited (AECL) and the 1000 MWe VVER PWR from Rosatom (World Nuclear News, 2010).

In May 2012, the Jordanian parliament voted to suspend the nuclear program based on recommendations of the Parliamentary committee on Energy and Mineral Resources, which stated that Jordan's nuclear program "will drive the country into a dark tunnel and will bring about an adverse and irreversible environmental impact" (Omari, 2012). This parliamentary motion, however, was subsequently ignored by the government and did not seem to affect JAEC and its continued process of selecting the reactor technology supplier (Nuclear Threat Initiative).

JAEC ended its uranium mining cooperation with Areva and terminated the work of the joint venture company JFUMC in October 2012 due to its failure to "submit reports on time" (Nuclear Power Daily, 2012). As a replacement of JFUMC, Jordan established a state-owned uranium mining company, JUMCO, to oversee and manage the uranium exploration and mining efforts in January 2013.

In October 2013, JAEC selected the Russian's Rosatom to be the nuclear technology supplier (World Nuclear News, 2013b). JAEC and Rosatom signed a project development agreement in September 2014 with the hope to start construction work in 2016. However, the Jordanian government stated that a final decision on proceeding will not be made until late 2015. The agreement states that AtomStroyExport (AES), a reactor export subsidiary company of

Rosatom, would supply Jordan with two units of the ASE-92 technology, each with an installed capacity of 1000 MWe. This agreement was followed by an intergovernmental agreement that was signed in March 2015 to "outline responsibilities for stage 1 of the project, including setting up the project company" (World Nuclear Association).

Method

This paper presents a combination of quantitative and qualitative description of economic risks of Jordan's nuclear program. The main quantitative element is related to estimating cost risks and calculating cost cross-over values of nuclear electricity compared to other options such as natural gas and solar power. The comparative cost analysis of electricity generation is based on the levelized cost methodology (LCOE), which accounts for time-value of money. It should be noted that the used levelized cost method used accounts for auxiliary or in-plant electricity consumption, however, it does not account for transmission and distribution costs.

The qualitative component involves unstructured interviews conducted with current and former Jordanian policy makers. Some of the interviews were conducted in confidentiality, and the names of such interviewees are withheld by mutual agreement. Supporting evidence has been extracted from media sources and government reports and documents.

Economic risks

Overview of economic challenges

Nuclear power has some major economic disincentives such as high capital costs and lengthy construction times. These disincentives are globally recognized regardless of geographic location (Schneider and Froggatt, 2015). Jordan's profile, however, highlights additional important factors that could negatively affect the suitability of nuclear power in the kingdom. Historically, nuclear power states generally had a relatively high gross domestic product (GDP) at the time of establishing a nuclear power program. High GDP alone is by no means an indication of a healthy economic status, however, it reflects the financial capacity of a state to embark on capital-intensive projects such as building nuclear power plants. Of course, Jordan may be able to find external sponsorship partner(s) (most likely Russia), though even providing part of the total funds required is likely to severely affect Jordan's budget.

JAEC estimates the cost of the project to be around 10 billion USD with Jordan to cover 50.1% of the total cost and Rosatom to join also as an investor and cover 49.9% (Russia Today, 2013). It is not clear, however, where this money will come from. Initially, JAEC hoped that profits from uranium mining would cover costs of establishing the nuclear program and even pay part of Jordan's equity share in the project (Seeley, 2014). JAEC promised that by 2012 Jordan would be exporting uranium with 1.25 billion USD in gross annual revenues (Al-Khaledi, 2009). Assuming a uranium price of 100 USD per kg, this would require mining 12,500 tonnes per year — approximately 20% of the global uranium demand. Extensive uranium exploration studies concluded that Jordan's uranium reserves and quality are modest compared to the initially claimed values.[1] It has also been reported that JAEC is trying to get some funds from the Jordan social security corporation, which manages Jordan's pension fund assets, to invest in the project (Al-Zoubi, 2013).

Another economic, and also technical, challenge of nuclear power in Jordan is the modest electricity generation capacity. Nuclear reactors typically add substantial generation capacities. The power output of the twin AES-92 reactor units, which will be purchased by Jordan, is about 2000-MWe. The size of Jordan's generation capacity is about 3.4 gigawatts (GW), a very modest value compared to most nuclear power states and countries in the Middle East that aspire to build nuclear power plants. According to JAEC's projections, shown in Fig. 1, the capacity demand of electricity in Jordan by 2030 would be about 9 GW. Therefore, an addition of 2000 MWe, even by 2030s, would cover a large part of Jordan's generation capacity. Such an addition would pose serious technical challenges related to grid stability and add further financial burden.[2]

JAEC's officials are aware of the mismatch between their electricity grid size and the added capacity of large power reactors but they envision a scenario in which Jordan would export its surplus capacity to a regional grid (Toukan, 2014). However, such a scenario would first require increasing the currently limited capacity of about 600 MW that can be traded via regional interconnections, which can be very challenging technically and financially. Further, expanding current interconnections would also require political stability and agreements between states in the region on financing such a project, which also seem very challenging to achieve at the moment.

Allocation of economic risks

The allocation of economic risks depends on how the proposed nuclear power plant in Jordan will be financed and operated. Financing could be achieved by raising funds through a combination of debt and equity. As mentioned earlier, Russia is expected to join Jordan as an equity shareholder with Jordan holding the majority share of 50.1%. This government-to-government financing is an emerging trend of financing nuclear power projects and is currently practiced by Russia in several countries such as India, Vietnam and Turkey. The proposed bilateral cooperation between Jordan and Russia is based on the Build-Own-Operate (BOO) model, which is a form of project financing. Generally speaking, in BOO contracts a non-governmental entity is granted the right to develop, build, own and operate a costly infrastructure project such as a power plant (Russia Today, 2014). This arrangement transfers financial and operating risks, as well as potential profits, from the public to the private sector but, nonetheless, require strong governmental support particularly with regard to regulation and taxation. The adoption of the BOO model by Rosatom aims to facilitate the acquisition of nuclear power in newcomer countries like Jordan with no adequate infrastructure, financial and human resources.

It is not yet clear where Jordan would raise its equity funds from. In principle, these can be obtained from tax revenues or by borrowing money from financial institutions. Given Jordan's modest GDP and the fact that the tax revenue component of GDP has dramatically declined since 2008, reflecting Jordans government resistance to increase taxes, Jordan will likely seek loan(s) from financial lenders.[3] Borrowing the billions of dollars needed to finance its portion of the nuclear project, however, is also challenging given Jordan's weak credit rating, which would impact its ability to offer sovereign guarantees.[4] It should be noted, however, that offering a long-term power purchasing agreement (PPA) that would ensure future stable revenue streams could play a positive role in persuading investors and lenders, if electricity tariff collection produces adequate revenues. From the owner's side, equity

[1] After four years of field and laboratory work, the French nuclear supplier Areva has estimated that the uranium reserves in Jordan are about 20,000 tonnes and that the concentration is lower than 100 ppm (Luck, 2012a).

[2] A plant with a large power output relative to the size of the total generation capacity in a country could destabilize the electric grid as a large fraction of the power supply to the grid would be unavailable and it would not be possible to meet the demand unless there is correspondingly large backup capacity. Additionally, when a large unit is suddenly shut down, then there would be large and rapid changes in frequency, voltage and power flow (Anon., 2012).

[3] In 2007, tax revenue (% GDP) in Jordan was at about 25% and has since declined to about 15% in 2012 (World Bank).

[4] Standard & Poors' credit rating for Jordan is BB while Moodys' rating Jordan sovereign debt is BA2. These rating suggest that Jordan is to subject to high credit risk (defaulting risk).

holders would bear non-operational economic risks such as the risk of project cancellation and delayed construction. The distribution of such risks would be stated in the contractual agreements between Jordan and Russia.

Project cancellation risks

Based on past experiences, nuclear projects are not only susceptible to cancellation in the early stages of planning but many have been cancelled just before completion or even after completion.[5] Having a regulated electricity market such as the case with Jordan may lower the probability of project cancellation since nuclear electricity will not have to compete against other electricity generation sources given the proposed fixed price and long-term PPA arrangements. However, other factors that are specific to Jordan may potentially lead to the cancellation of the nuclear project: first, Jordan's modest budget and financial standing would impede its ability to deal with cost escalations due to construction delays and inflated infrastructure costs. The risk of cost escalation on Jordan would be reduced in case the equity partner (Russia) guarantees covering cost overruns. If Jordan were to bear such escalated costs, wholly or partly, Jordan's government could be forced to suspend the project due to insufficient funds and failure to obtain further loans to support the project.

Second, large segments of the Jordanian public do not share its government enthusiasm about the nuclear project and the anti-nuclear sentiment has been growing due to the perceived mismanagement of the nuclear project (Abuqudairi, 2014). The political establishment in Jordan might find itself in a confrontation with the public over the nuclear project and be forced to suspend the project to contain public anger. Large areas of Jordan, particularly where the site of the nuclear power plant is proposed, are occupied by tribal communities, which have long served as the popular backbone of the political establishment in Jordan, but some of these communities are now opposing government's plans to build nuclear reactors close to their homes (Su, 2013; Barari, 2014). The fact that Jordan's siting options for nuclear power plants are very limited makes reaching a compromise with the public a very challenging prospect. The recent and ongoing political instability in the Middle East makes it more difficult for governments in the region to implement unpopular policies. Although public unrest in Jordan has been relatively low compared to other countries in the region that have witnessed regime change, controversies such as building a nuclear reactor may damage further the relationship between the government and the public.

Third, growing security concerns might lead Jordan to reconsider its nuclear plans. Since the effects of a terrorist attack on a nuclear power plant in Jordan could extend to neighboring countries, Jordan's government might be exposed to high political pressure to abandon its nuclear power project. The political chaos that surrounds Jordan, especially in Syria and Iraq, added to the increased presence of non-state actors and terrorist groups in the region pose some serious internal and external security threats.

The economic impact of suspending or cancelling the nuclear power program in Jordan would increase with how far the project has progressed. At any stage of development there will be four major effects: sunk investment funds, substantial opportunity costs associated with favoring nuclear power over other options for electricity generation, damage of Jordan's reputation and reduced public confidence of governance and decision-making in Jordan.

Unplanned outages risk

Because of the "safety first" principle associated with nuclear power, reactors not only require planned outages to perform refueling and maintenance activities but sometimes may require forced outages to remedy safety concerns. During the period of planned outages, which could last for an average of two months every refueling cycle (18 or 24 months) (U.S. Energy Information Administration, 2011), Jordan can rely on fossil fuel power generation and/or electricity imports from neighboring countries.

While planned outages have a substantial cost due to the need of securing an alternative generation capacity when the reactor is offline, unplanned outages are more economically problematic. Plant operators can estimate the cash flow needs for planned outages but they would not be able to do so in the case of unplanned outages because of factors related to regulatory restrictions, uncertain recovery time and arrangement and cost of substituting generation capacity that may fluctuate with fuel prices.

Unplanned outages involve a substantial cost due to lost generation capacity, which, in the case of Jordan, could be as high as 50% of the total generation capacity. The cost of an unplanned outage of a nuclear generation capacity in Jordan can be assumed to be comparable to that of replacing the capacity generated by the imported Egyptian natural gas with fuel oil and diesel following the disruption of natural gas supply in 2011. Energy officials told the Jordan Times in May 2012 that the cost of electricity generation jumped from 0.073 JD (0.1 USD) to about 0.184 JD (0.26 USD) per kWh following the disruption of the Egyptian gas supply (Luck, 2012b). The estimated cost of an unplanned outage of 1000-MWe nuclear reactor unit in Jordan, based on these numbers, would be about 3.8 million USD per day.[6] This value may vary depending on oil prices.

Cost risk

In a previous study on the economics of nuclear power for Saudi Arabia by the author, it was shown that solar electricity is well on its way to become cheaper than that generated by nuclear power plants (Ahmad and Ramana, 2014). In the same study, the cross-over value of natural gas price below which nuclear power will be uneconomical for Saudi Arabia was also estimated. Of course, Jordan lacks the natural resources Saudi Arabia has but Jordan can still import natural gas and therefore a new estimate of the cross-over value for Jordan can be calculated. There is a substantial risk that nuclear generated electricity will be more expensive than that generated by the combination of solar power and natural gas. In other words, nuclear power may well have an opportunity cost in Jordan if the costs of solar power continue to decline, as they are likely to do according to analysts from the McKinsey Consulting Company (Aanesen et al., 2012).

By calculating the levelized costs (LCOE) of nuclear electricity based on the assumptions shown in Table 2, one can estimate the cross-over cost value between nuclear and solar power on one hand and between nuclear and natural gas on the other hand. The two most important parameters in calculating the LCOE for nuclear power plants are the overnight capital costs and the discount rate. For capital costs, a value of 3333 USD/kW is assumed. This value is based on latest estimates of the construction costs of the first and second units at the Novovoronezh nuclear power plant in Russia (Diakov, 2013). Of course, building Russian reactors in Jordan might entail several other additional costs given the difference in the level of industrialization and availability of infrastructure between Jordan and Russia, but these are not taken into account. As for the discount rate, a value of 10% is assumed. Note that this is a real discount rate, and inflation is implicitly taken into account.

Based on the assumptions listed in Table 2, the estimated levelized cost of nuclear generated electricity is about 98 USD per MWh. For Concentrated Solar Power (CSP) and Photovoltaics (PV) to offer cheaper electricity generation, their capital costs should be lower than 2300 and 1800 USD per kW, respectively. As for natural gas, nuclear power will be

[5] For example, the Zwentendorf Nuclear Power Plant, in Austria, was fully completed in 1978 but never operated after it was opposed by a referendum.

[6] This estimate is based on the assumptions that the electricity generation cost using fossil fuel is the one reported in May 2012 (0.26 USD per kWh).

Table 2
Cost assumptions for various technologies (Source: EIA (U.S. Energy Information Administration, 2013) and Author's own calculations and assumptions).

	Nuclear	Natural Gas	Solar CSP	Solar PV
Unit capital cost ($/kW)	3333	1023	Variable	Variable
O& M cost ratio			1.33%	0.65%
Fixed O& M ($/kW-y)	93.28	15.37	40.43	15.10
Variable O& M ($/MWh)	2.14	3.27	0.00	0.00
Heat rate (BTU/kWh)		6430		
Fueling costs ($/MWh)	10.11	Variable	0.00	0.00
Economic life (years)	60	40	25	25
Capacity factor	90%	90%	35%	25%
Auxiliary consumption	8%	8%	0.25%	0.25%
Discount rate	10%	10%	10%	10%

uneconomical if Jordan can obtain natural gas at a price of 12 USD per mmBTU or lower.[7]

The estimates of how fast solar costs are expected to decline are striking. If the sharp decline in the cost of solar photovoltaic panels over the past decade (more than 75% since 2009 IRENA, 2015) continues till the end of this decade, the cost of generating nuclear power will exceed that of photovoltaic energy. There are good reasons to expect solar power costs to decline further in a similar fashion, including the relative lack of maturity of underlying technologies. According to a recent study by the International Renewable Energy Agency and Masdar Institute of Science and Technology, solar PV has been cost-competitive in the UAE since 2014 (IRENA Press Release, 2015).

Other risks and challenges

Due to their important role and mission, nuclear regulatory bodies are supposed to act independently and function separately from other government organization and institutions, particularly those promoting the use of nuclear energy. Additionally, regularity bodies need sufficient authority to monitor the various activities related to ensuring nuclear safety and security.

Jordan started developing their nuclear regulatory activities in the early days of the nuclear program in 2007 with the establishment of JNRC, which was tasked with monitoring and licensing nuclear facilities in Jordan, including nuclear reactors. During my interviews with Jordanian policy makers, three main regulatory challenges have been identified: JNRC's authority, independence and technical competence.[8]

JNRC's undermined role and authority has been a central element in the debate on the suitability of nuclear power for Jordan.[9] In April 2014, the Jordanian government approved a restructuring of JNRC and merging it into the newly established Energy and Minerals Regulatory Commission (EMRC), which also oversees the Electricity Regulatory Commission and the Natural Resources Authority (Nuclear Intelligence Weekly, 2014). According to the head of the International Atomic Energy Agency team that reviewed the new regulatory framework in Jordan, the move "added" to the challenges faced by Jordan's nuclear regulator "because it now has to operate as part of a new body" (IAEA Press Release, 2014).

In addition to the regulatory issues, lack of transparency and centralized decision-making have also been identified by interviewees as factors that could have economic effects through inducing reputational damage. This would negatively affect the confidence required by various stakeholders, including the general public and investors, in Jordan's ability to commission a successful nuclear power program.

Conclusion

From an economic point of view, nuclear power is a risky option for Jordan. First, costs and time overruns added to growing public disapproval and emerging security threats represent serious elements that could lead to the suspension or cancellation of the nuclear project. In that case, Jordan would incur substantial financial and reputational loses. Second, unplanned outages of nuclear reactors are a major operational risk that could prove very costly given Jordan's small electricity generation capacity and the time uncertainty of such events; and third, nuclear power in Jordan has a cost risk associated with the fact that the levelized costs of electricity generated by solar power are declining dramatically which might see it becoming cheaper than nuclear before any reactor in Jordan is actually built. For Concentrated Solar Power (CSP) and Photovoltaics (PV) to offer cheaper electricity generation, their capital costs should be lower than 2300 and 1800 USD per kW, respectively. As for natural gas, nuclear power will be uneconomical if Jordan can obtain natural gas at a price of 12 USD per mmBTU or lower.

[7] 1 mmBTU = 1.05587 gigajoule (GJ).

[8] The three main regulatory challenges were discussed in a hearing by the Jordan Parliamentary Committee on Energy and Natural Resources on 15 June 2014, which was attended by the author. Reported regulatory challenges have also been reported in interviews with Ziad Hamza, former health minister, Saed Dababneh, former vice chairman of JNRC, and a current staff member of JAEC.

[9] The author obtained a copy of a letter that was sent to Jordan's Prime Minister in June 2013 and was signed by five Jordanian scientists, who took part in the nuclear program in various capacities and occupied some senior positions in JAEC and JNRC. The letter lists JAEC's attempts to interfere in the work of JNRC and weaken its authority and was signed by Jamal Sharaf (former Chairman of JNRC), Saed Dababneh (former Vice Chairman of JNRC), Ali Al-Mur (Former head of Nuclear Energy Department at the Ministry of Energy and Mineral Resources), Kamal Khdier (former head of nuclear sites in JAEC) and Nidal Al-Zoubi (former JAEC commissioner for nuclear fuel cycle).

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