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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 wastewater 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

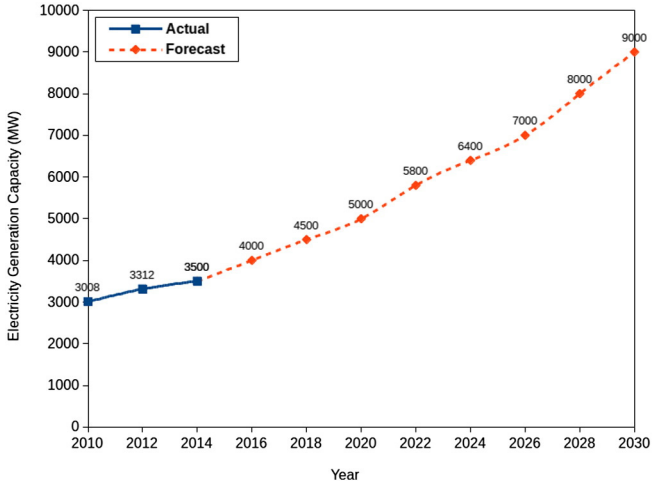

Fig. 1. Actual and projected electricity generation capacity in Jordan (Jordan Atomic Energy Commission, 2012).

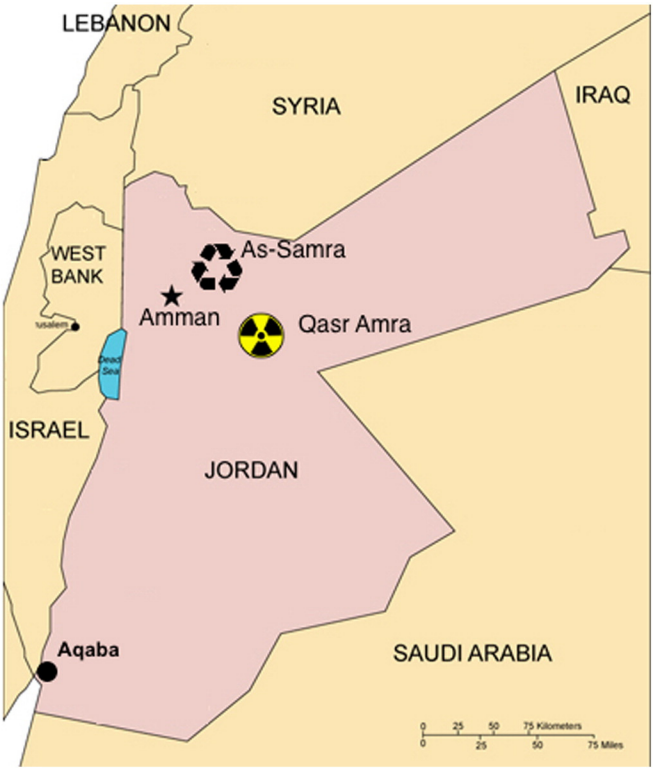

Fig. 2. Locations of Jordan's proposed nuclear power plant site (Al-Amra) and the wastewater treatment facility that would provide cooling water (As-Samra).

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