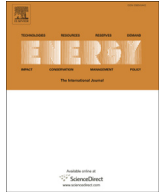




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Too costly to matter: Economics of nuclear power for Saudi Arabia

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ABSTRACT

Saudi Arabia has ambitious plans for nuclear power. Given this context, this paper examines the economics of nuclear power and compares it to two other sources of electricity, natural gas and solar energy. It calculates the costs of electricity generation, water desalination and the opportunity cost associated with forgone oil and gas revenues. A sensitivity analysis is included to account for variations in important parameters within the comparative cost analysis. Our results suggest that for a large range of parameters, the economics of nuclear power are not favorable in comparison with natural gas, even if the currently low domestic natural gas prices in Saudi Arabia were to rise substantially. Further, electricity from solar plants has the potential to be cheaper than nuclear power within the next decade if the rapid decline in solar energy costs in the last decade continue, i.e., before the first planned nuclear power plant would be completed. However, unless the price of oil drops substantially below current values, it would be more economically optimal to export the oil than using it for generating electricity.

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1. Introduction

The leaders of Saudi Arabia have announced that the country is embarking on an ambitious energy diversification plan, including a massive addition of nuclear power. The official reasons for this proposed expansion are laid out in a royal decree from April 2010: “The development of atomic energy is essential to meet the Kingdom’s growing requirements for energy to generate electricity, produce desalinated water and reduce reliance on depleting hydrocarbon resources” [1]. Unlike some neighboring countries, such as Bahrain, Kuwait and Oman, which abandoned their nuclear plans in the wake of the multiple accidents at the Fukushima nuclear plant, Saudi Arabia has reiterated its commitment to the acquisition and expansion of nuclear power. In November 2013, a Saudi spokesperson announced plans to call for preliminary bids for the first nuclear reactor, or set of nuclear reactors, the following year, with the first to start construction in 2017 and be completed in 2022 [2].¹

There is some indication that, while desirous of diversifying their energy production, Saudi policy makers are cognizant of the high costs associated with nuclear energy. It is reported that the finance ministry is wary of the nuclear program’s need for “massive capital outlays and decades of subsidies” [4]. Given these potentially high costs, it is important to assess the economics of nuclear power.

This paper attempts such an assessment by calculating the cost of generating electricity and desalinating water using nuclear power and compares it to two alternate ways of meeting energy demands—natural gas and solar energy—in Saudi Arabia. The cost comparison is supported by a sensitivity analysis to account for any potential changes in the parameters in the future. Prior to that, we explain the historical background to this issue.

2. A brief history

Saudi Arabia has had a long-standing, although limited, interest in nuclear technology. As early as 1978, the country entered into a multi-year Technical Cooperation Project entitled “Nuclear Energy Planning” with the IAEA (International Atomic Energy Agency) [5]. Over the decades, many have advocated Saudi Arabia acquiring nuclear power. Their arguments typically stressed the country’s growing demand for electricity and desalinating water. In some cases, specific niche needs, such as mining and industrial clusters, have also been offered as arguments for constructing nuclear reactors [6]. However, these arguments did not succeed and Saudi

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¹ In contrast, *Nuclear Intelligence Weekly*, a trade magazine, reported in January 2013 that Khalid al-Sulaiman, a senior official in the organization responsible for nuclear development, announced that it would “take 7–8 years before the organization is ready to tender a nuclear program” [3]. This should not be taken as a firm timeline, but as an indication that the Saudi nuclear program is subject to internal domestic disputes.

Arabia's interests were "largely limited to applied nuclear research for industrial, agricultural and medical purposes, and radiation monitoring" [7]. The primary institutional vehicle for these activities was the Atomic Energy Research Institute established in 1988 within the King Abdulaziz City for Science and Technology [7]. According to its website, its mission is to "employ and develop nuclear technology as to serve agricultural, industrial, health, research, economic, security & preventive development" [8].

The current wave of interest came about after a December 2006 meeting in Riyadh during which leaders of the GCC (Gulf Cooperation Council) states announced that they intended to start a joint nuclear energy development program.² Speaking to reporters, Prince Saud al-Faisal, Saudi Arabia's foreign minister, declared "Nuclear technology is an important technology to have for generating power, and the gulf states will need it equally" [9]. The following year, GCC states and the IAEA agreed to cooperate on a feasibility study on regional plans for a nuclear energy program [10]. By late 2007, the IAEA prepared a draft study for the GCC; according to the study, nuclear energy was expected to become operational in the region in 2025 [11]. Among these countries, it was the UAE (United Arab Emirates) that, in 2008, set up an implementing organization and, in December 2009, entered into a contract with South Korea for four APR-1400 nuclear reactors estimated to cost \$20 billion [12,13].

The Saudi nuclear program started to gain momentum in 2010 with founding of the KA-CARE (King Abdullah City for Atomic and Renewable Energy) in Riyadh [14]. The order establishing KA-CARE motivates the action by talking about "an ever-increasing pressure on the country's non-renewable hydrocarbon resources" and the need for "alternative, sustainable and reliable sources of energy for generating power and producing desalinated water" [15]. It went on to say: "Following extensive technical and economic analysis the decision has been taken to introduce atomic and renewable energy for a significant portion of Saudi Arabia's future energy mix. The two sectors will provide substantial capacity, advanced technology, efficient use of resources and will be fully compliant with international best practices, conventions and treaties". Thus, even during its founding, the Saudi nuclear program was conjoined to a renewable energy program.

Shortly thereafter KA-CARE turned to Pöyry, a Finland-based engineering consultancy company, to "help prepare a draft of the national vision and high-level strategy in the area of nuclear and renewable energy applications for Saudi Arabia and help define KA-CARE's strategy, operating model, key short and longer term priorities, and the immediate initiatives and action plan" [16]. The following year, KA-CARE appointed the consulting company WorleyParsons to conduct site surveys and regional analysis to identify potential sites for a planned tender for a nuclear plant [17].³ Saudi Arabia has signed bilateral cooperation agreements on nuclear power with France, South Korea, Argentina and China; agreements with other countries are reportedly under negotiation.

By May 2012 KA-CARE had come out with its first set of projections of nuclear and renewable energy generation capacity for two decades ahead. KA-CARE envisioned that by 2032, out of a total 123 GWe of electricity generation capacity in the country, 18 GWe would be contributed by nuclear power [17]. Others reported that a survey of sites to construct the nuclear reactors now was under way and that ground-breaking for the first nuclear reactor site was to take place in 2014 [18]. KA-CARE also projected ambitious

expansions of renewable energy capacity, with 16 GWe of solar PVs (photovoltaics), 25 GWe of CSP (concentrated solar power), and 4 GWe from geothermal, wind and waste. More recently, wind energy projections have risen to 9 GWe by 2032 [19].

It is not clear if these projections for renewables and nuclear power have been approved by the highest levels of government [20]. Specifically, political support for the nuclear plans appear to be more questionable and some analysts suggest that KA-CARE will likely prioritize renewables in the near term [21,22].

Questions aside, these announcements have been welcomed by the nuclear industry, which sees Saudi Arabia as a major potential market for reactors, in part because of the country's considerable financial resources [23]. Companies like Westinghouse and Areva are trying to sell their reactors to the Saudis [24,25]. Likewise, if the solar energy plans were to materialize, Saudi Arabia would likely become the world's largest market for renewable energy [26]. As with nuclear vendors, solar energy companies have also been quick to realize the potential opportunities offered by the plan with companies terming Saudi Arabia as "one of [the] key growth markets" [27]; the consulting company Ernst & Young noted that Saudi Arabia has "quickly made it onto the list of focus markets for investors and technology providers" in the arena of renewable energy [28].

Saudi policy makers do, however, emphasize two requirements for both the solar and nuclear programs: that they have "to be economically viable in the long term... [and have] to make available jobs for the Saudi youth" [2]. For this reason, we examine the relative economic competitiveness of these different sources of energy. Questions about the potential for localization of these technologies are, however, outside the scope of this paper.

3. Motivations

Officially, the primary motivation behind the proposed construction of nuclear reactors is that Saudi Arabia's current sole reliance on oil and gas to generate electricity and to desalinate water is widely perceived to be unsustainable, both economically and politically, in the future. A recent business-as-usual simulation concluded that the Kingdom would become a net oil importer by 2038 [29]. The study also indicated that the global economy will be affected if Saudi Arabia lost its market stabilizing power due to not being able to maintain a sufficient amount of oil export capacity. Several other studies have also discussed the need to diversify energy sources in the GCC in general and Saudi Arabia in particular [30,31].

This situation will likely be affected by the expected increases in production of oil from non-conventional resources, such as shale oil, in various countries, and potential declines in oil prices. These increases could occur in both Saudi Arabia as well as in other countries and will have implications for Saudi nuclear program. As analysts have pointed out, "Renewable and nuclear energy projects and infrastructures are capital intensive and will need a great deal of government subsidies and support to maintain them for many years to come. Should world oil and gas prices experience dramatic declines those countries could find themselves unable to sustain such investments" [32].

In addition to the argument about diversification, Saudi Arabia's interest in nuclear power is also a response to Iran's acquisition of nuclear technology. It has been argued, for example, that "GCC states want to show Iran, their own people, and the broader world that Arabs also have the prowess and power attributed to nuclear technology" [33]. Some go further and assume countries like Saudi Arabia—despite the country being a signatory to the Nuclear NPT (Non-Proliferation Treaty) since 1988 and continued cooperation with the IAEA—are embracing nuclear technology largely due to

² The GCC is a grouping of Arab states bordering the Persian Gulf, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

³ Such reliance on consulting companies suggests weaknesses in the technical capability of KA-CARE.

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