



The prospects for coal-fired power generation in Saudi Arabia



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ABSTRACT

Almost all of Saudi Arabia's electric power generation is fueled by oil and gas. Plans for future capacity envisage nuclear and renewables supplementing this mix and thereby freeing up oil for other revenue-generating opportunities. Coal-fired generation has been promoted in some Gulf Cooperation Council (GCC) countries but not, so far, in the Kingdom. Our analysis finds that:

- Imported coal would provide lower cost generation than either solar or nuclear power in the near-term.
- At current administered prices of oil and gas, other resources of energy such as solar, nuclear, or imported coal are not competitive for power generation.
- If decisions were made based on deregulated oil and gas prices:
 - At the reference coal price, only moderate levels of coal-fired capacity would be introduced. Having remaining capacity comprised of nuclear and solar would result in lower Saudi CO₂ emissions from power generation than under a 'business-as-usual' scenario.
 - At the low coal price, CO₂ emissions in 2030 cannot be maintained at their current level since coal, rather than solar and nuclear, is used to displace oil and gas from the generation fuel mix.

Some forecasts of coal markets anticipate significant increases in real export prices, which would make coal-fired power generation unattractive compared to nuclear power.

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1. Introduction

Due to constrained natural gas supply, substantial quantities of crude oil are burned to satisfy electricity demand in Saudi Arabia. The Electricity & Co-generation Regulatory Authority (ECRA) reported that crude oil and refined products constituted 54% of the fuels used to generate electricity in 2013 [1]. Furthermore, the low administered oil and gas prices offered to utilities do not encourage the deployment of alternative power generation technologies. As we look ahead, Saudi decision-makers have expressed interest in displacing the use of oil by adding other fuels and technologies to the domestic power generation mix.

Several countries in the region have already shown willingness to use coal for electricity generation. In this paper, we explore the

potential role of coal in the Saudi power system. We use an updated version of the KAPSARC Energy Model for Saudi Arabia (KEM-SA) that contains supercritical coal steam plants as a prospective technology. The analysis is conducted from 2015 until 2030. Projections of macroeconomic parameters and market prices used to inform our policy scenarios are derived from Oxford Economics' Global Economic Model (GEM) and Global Industry Model (GIM).

We assess the economic feasibility of using coal in two policy scenarios:

- A scenario where we maintain the current pricing policies throughout time;
- A scenario where industrial fuel prices are immediately deregulated. Transfer prices of fuels between sectors are raised to world market equivalents, but prices for households are kept unchanged.

We also examine the effects of preventing the construction of

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coal plants when fuel prices are deregulated. We find small deviations in the overall economic benefits, indicating that even without coal, the deployment of other technologies can still be a viable option for decision-makers. The electricity that would be supplied by coal plants until 2030 is then mostly produced by nuclear plants and some solar thermal capacity.

The paper is structured as follows: the next section explores the interest in coal for power generation in the Gulf Cooperation Council (GCC) and surrounding countries. The following two sections describe how coal is incorporated in KEM-SA and the slate of scenarios analyzed. The paper finishes with a discussion of the results and a conclusions section.

1.1. The regional interest in coal for power generation

Before examining the regional interest in coal, let us first summarize the global context. Coal-fired generation accounted for 40% of total world electricity generation in 2012. In the reference case of the Energy Information Administration's (EIA) International Energy Outlook 2016 [2], coal continues to be the largest single fuel used for electricity generation worldwide until the end of the projection period, with renewable generation beginning to surpass coal-fired generation in 2040. Coal-fired electricity generation declines to 29% of the total in 2040, despite a continued increase in coal-fired generation from 8.6 trillion kWh in 2012 to 10.6 trillion kWh in 2040. China and India alone account for 69% of this projected worldwide increase, while the OECD nations reduce their reliance on coal-fired electricity generation.

Saudi Arabia and the greater Gulf region have not been endowed with large coal reserves. As a result, and given the relatively low domestic prices of oil and natural gas, coal has not been part of the Saudi energy mix. Domestic gas production will likely not keep up with the forecasted growth in the Kingdom's electricity demand. Therefore, coal-fired power plants can be considered as one option, as are renewable technologies, to reduce the consumption of oil in power generation. Similar considerations have encouraged countries in the GCC region to look for alternative fuel resources for power generation.

Matar et al. [3,4] and Matar [5] previously employed KEM-SA to investigate the effects of reforming industrial fuel prices and residential energy efficiency in Saudi Arabia. In a static analysis, they found that more than 850 thousand barrels per day of crude oil could have been saved in 2011 by altering industrial fuel prices and introducing investment credits for alternative power generation technologies. They later explored the effects of similar fuel-pricing policies in an analysis from 2015 to 2032, particularly looking at encouraging price-induced investments in renewable and nuclear power generation technologies in Saudi Arabia. As an extension to the previous analyses, we here investigate the viability of importing coal for electricity generation.

Some countries in the Arabian Peninsula already import coal for industrial production, motivated by the limited gas supply and the need to provide reliable supply of fuel for electricity generation. In the United Arab Emirates (UAE), Fujairah Cement operates a 40-MW coal-fired power plant to support its production, and other cement plants currently use imported coal to produce clinker [6]. Yemen and Kuwait also use small quantities of imported coal for cement production. As shown by Fig. 1, coal has so far been mainly imported from South Africa and Indonesia, with small quantities of the fuel sourced from Australia.

Logistics are favorable for bulk commodity trade in the region. Saudi Arabia has access to deep water ports in the Red Sea, which facilitate the use of large cape-size bulk carrier vessels of up to 16 m in draft and would potentially result in relatively low coal transportation costs. Access to the eastern coast might be more limited

due to draft restrictions, but Panamax or Supramax vessels could be used, albeit with slightly higher transportation costs per ton.

1.2. A more diverse energy mix in the United Arab Emirates

The Dubai Integrated Energy Strategy 2030 showed the emirate's ambition to diversify its power generation mix. The initial electricity mix targets called for 5% solar, 12% coal, 12% nuclear power, and 71% natural gas by 2030. Presented by Fig. 2, the Dubai Electricity and Water Authority (DEWA) increased the target for renewables from the initial plan, slightly reducing the share of coal to 7% [7]. The target to diversify the power generation mix would be an improvement over the situation in 2010, when gas-fired plants generated 99% of the electricity.

As part of the Energy Strategy plan, DEWA tendered for the construction of a clean coal independent power producer in April 2014. This power plant will be part of the Hassyan complex, which is planned to become one of the largest power parks in the world with a capacity of 9 GW. The facility will include a 1.2-GW ultra-supercritical coal-fired plant. In May 2015, bids for the engineering, procurement and construction contract were opened, with a lowest price of 5.17 US cents/kWh for a 1.2-GW plant, and 4.90 US cents/kWh for a 1.8-GW plant [8,9].

The use of coal has raised concerns over carbon dioxide emissions. The possible implementation of carbon capture and storage (CCS) for the Hassyan power plant has been discussed but no decision has been made. It is also unclear whether the project will be awarded as a CCS-ready plant with plans to include CCS at a later stage. The Gulf region is participating in the development of CCS technologies with the Uthmaniyah project in Saudi Arabia and the Abu Dhabi CCS project in UAE. In both of these cases, carbon is captured and used for enhanced oil recovery [10,11]. Successful development of this technology can help significantly reduce the impact of carbon emissions from coal, and could help public acceptance of the construction of coal-fired power plants in the region.

1.3. Egypt is exploring the use of coal to meet its demand for electricity

Egypt has also been considering coal to mitigate its electricity supply challenges. The Egyptian power mix is currently composed of fossil fuels and renewable energy sources, with 88% of total installed capacity burning oil and gas. With declining hydrocarbon production domestically and electricity demand growing at 6% annually, the country intends to diversify its energy mix by increasing the share of renewables and possibly introducing coal-fired generation.

In April 2014, Egypt's cabinet approved the use of coal to generate electricity. The move was seen as supportive to the local cement industry, a sector that is responsible for ten percent of all industrial energy use in Egypt. The energy-intensive cement companies are the first affected by gas cutoffs because priority is given to power generators in order to avoid public unrest [12].

The Egyptian government has announced preliminary plans for four coal-fired power projects totaling 15.6 GW of generation capacity. These projects aim to use coal for 20% of the electricity generation, which would reduce dependence on oil and gas and lower electricity generation costs. The use of coal in Egypt could help alleviate the current energy shortages, but it will not come without public resistance [13]. However, a reliable source of base load power is so much in need that the compromise might be worthwhile for the Egyptian government.

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