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SOLAR POWER IN SAUDI ARABIA: PLANS VS POTENTIAL

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Summary
The recently adopted national plan "Saudi Arabia Vision 2030" aims to reduce the kingdom's dependence on oil and generate 9.5 GW of power from renewable energy sources. The plan acknowledges that the kingdom's high potential of renewable energy is still untapped. This Policy Brief examines what the requirements are for high solar penetration for electricity production in Saudi Arabia. It also aims to verify different deployment scenarios to estimate the investment and opportunity costs due to the use of solar power, in addition to outlining the policy changes needed to increase the role of renewables in the Saudi energy mix. Compared to the "Saudi Arabia Vision 2030", a new scenario is suggested, reaching 20% of renewable penetration by 2030. Our study also found that under the current energy framework in the kingdom, it would be difficult to implement high penetration of renewable energies in general, unless certain measures and policies are adopted.

MAIN FINDINGS

- **High penetration of solar energy in Saudi Arabia requires a structural transformation of the energy sector which implies a strong political will coupled with a technology and market readiness, adequate investment climate, and permitting rules;**
- **Saudi Arabia's private sector is involved in a number of renewable energy projects outside the kingdom but is reluctant to invest inside the kingdom mainly due to a distorted energy market;**
- **Coupling solar energy and gas-fired technologies in Saudi Arabia offer a cheaper and faster alternative to investing in nuclear power;**
- **Solar energy offers Saudi Arabia opportunities for localization of the energy value chain through research, development and manufacturing.**

Realities of Saudi Arabia's electricity sector

With 266 billion barrels of proven crude oil and 8.3 trillion m³ of natural gas reserves, Saudi Arabia has one of the world's largest proven reserves; oil returns make up 87% of government revenues and it represents 90% of Saudi Arabia's export earnings, illustrating the key role oil plays in the economy. Recently, the oil market has experienced a downturn as prices have decreased from more than $100 USD per barrel in 2014 to around $50 USD today (January 2017). Consequently, Saudi Arabia's budget deficit increased dramatically, and the kingdom was forced to tap into the global bond market to balance its finances. While the kingdom has been going through an economic crisis, it has been experiencing a surge in domestic energy demand. Demand for electricity has been increasing in the kingdom at a rate of 7.5% per year, while peak demand during summer has increased by 93% from 2004 to 2013.

The kingdom has been relying on oil and gas to cope with its demand for electricity and desalinated water, missing out on opportunities to exploit the huge potential of renewable energy which could contribute in a major way to electricity production. Until now little has been done concerning renewable energy, with a total installed capacity not exceeding 17 MW, while another 125 MW is in the pipeline in the coming years.

Electricity generation in the kingdom is dominated by gas turbines, representing 60% of the total generation. Although they are less efficient (15-30% efficiency) than combined cycle or steam turbines, gas turbines offer a cheap alternative to cope with the increased energy demand, with the advantage of running on different types of fuel (crude oil or associated gas) and can also operate without water for cooling which is a great advantage for Saudi Arabia.

Saudi Electric Company (SEC) controls 71% of generation capacity while 16 other companies provide the remaining capacity. Energy generation and water desalination companies as well as other industrial companies sell fuel at a very low price.

In 2014, the SEC sold 274,503 GWh of power, of which, 50% was consumed by the residential sector, 21% by the industry, 15% by the commercial sector, and 12% by the governmental sector. Between 2007 and 2014, peak load increased from 35 GW to 57 GW. By 2030, it is expected that the maximum peak power will reach 120 GW, with the minimum peak power around 60 GW, with the calculated ratio between low and high peak load being 56%. This is considerably high compared to the United States, for example, where peak load ratio varies between 27-33%.

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Renewable energy plans in Saudi Arabia

In 2010, the King Abdullah City for Atomic and Renewable Energy (KA-CARE) was created to expand the kingdom's power generation capacity through introducing solar, wind, geothermal, waste and nuclear power. According to the KA-CARE plans, nearly 50% of total electricity production within the kingdom should come from non-fossil fuel sources, 17.6 GW from nuclear, and 41 GW will come from solar power (with 16 GW from PV and 25 GW CSP), by 2040; little has been done until now in terms of implementing these plans. Recently, the Saudi government adopted the "Saudi Arabia's "Vision 2030" plan. The plan aims to open up opportunities for the private sector, particularly in the energy sector, and redesign the energy subsidy system, with an initial target of generating 9.5 GW of electricity from renewable sources.

Three scenarios for solar power

To study the impact of high penetration scenarios of solar energy on the Saudi electricity sector, the hourly load variations of 2009 was used to represent the 2030 load pattern, assuming no change in the consumption patterns, and no implementation of an aggressive energy efficiency program, and that the growth rate of electricity demand is 7.5% per year. Based on such assumptions, we estimated the electricity sold in 2030 to be about 786,500 GWh.

Three scenarios were analyzed in this Policy Brief. Scenarios 1 and 2 are based on the "Saudi Arabia 2030 vision" and "KA-CARE plan", respectively. While scenario 3 reflects the authors' proposal, which, in a way can be taken as a compromise between scenario 1's modest targets and scenario 2's ambitious, perhaps unrealistic, plans. The main comparison between the three scenarios are shown below.

Figure 1

Three scenarios for solar power

Scenario 1 (Saudi Arabia 2030 vision)

- 9.5 GW (PV)
- 8% of installed capacity
- 2% of 2030 demand
- Cost: $24 billion USD

Scenario 2 (KA-CARE plan)

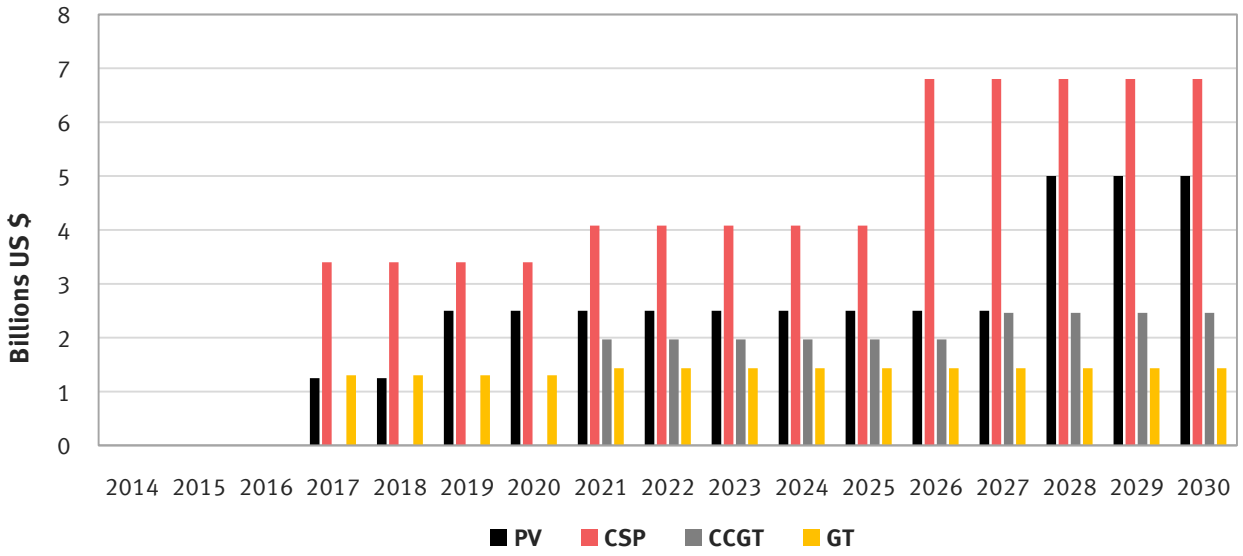
- 41 GW (16 PV and 25 CSP) + 17.6 GW of nuclear power
- 34% of installed capacity
- 18% of 2030 demand (only solar)
- Cost: $360 billion USD

Scenario 3 (Authors' proposal)

- 26 GW (16 PV and 10 CSP) + 17.6 GW of CCGT
- 22% of installed capacity
- 9% of 2030 demand (only solar)
- Cost: $150 billion USD

Figure 2

Investment in Billion US$ needed to implement authors' proposed plan (16 GW PV, 10 CSP and 17.6 GW CGGT and 30 GW GT).



Investments and localization

A cheaper and more feasible scenario would be to replace nuclear reactors with CCGT power plants. Another 30 GW of gas turbine will be needed to cover the intermittency of the renewable resources (16 GW PV and 10 CSP are equivalent to 9.6 GW of full disputable sources according to simulation calculation). The total investments needed for the third scenario amounts to about $150 billion USD, which represents nearly half of what is needed by the KA-CARE plan, initially.

Any high penetration of renewable energy in Saudi Arabia should be accompanied by localization of some part of the value chain in the kingdom. For PV, the localization of BOS (balance of the system) activities can be the first step; this could include manufacturing support structures, trackers, mounting hardware, electric protection devices, wiring, monitoring equipment and installation.

As a second setup in localization the kingdom can build a manufacturing facility in the country; the capital required to build a 1GW/yr PV facility ranges from $1 billion USD to $2 billion USD per plant. Starting with a 500 MW plant and increasing the plant capacity by 500 MW yearly the size of the plant will reach by 2030 a capacity of 7 GW, a typical PV plant will need 2 persons/ MW in the construction stage, 7.5 person/MW in the operation stage and 0.5 person/ MW for maintenance; by the end of the project 57,000 persons should be employed directly.

"The total investments needed for the authors' scenario amounts to about $150 billion USD, which represents nearly half of what is needed by the KA-CARE plan, initially."

Conclusion and recommendations

The KA-CARE plan which was developed in 2010 was perhaps too ambitious and costly to be executed. The recently articulated "Saudi Vision 2030" is perhaps more attainable but its target for solar power deployment is modest. An alternative scenario was suggested in this Policy Brief, reaching nine percent of renewable penetration by 2030, costing about half of the KA-CARE plan. Gas-fired CCGT plants can be used to cover base load, and PV and CSP plants used to cover the peak load (and part of the base-load when possible). Another strength of the proposed scenario is that it allows policy-makers in Saudi Arabia to incrementally increase their solar power capacity while having also enough time to observe costs and efficiency behaviors, and adjust accordingly.

From a policy perspective, the research also found that under the current energy framework in the kingdom, it will be difficult to implement high penetration of renewable energies, mainly due to the presence of heavy subsidies. Schemes such as Feed-in-Tariff should be envisaged with a strong political leadership to promote investment in renewable energy. It is important to note that only utility scale solar systems were covered and that there is a great potential for roof mounted PV systems, which in many areas are used to provide electricity to the national grid.

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The Energy Policy and Security Program

The Energy Policy and Security Program at the Issam Fares Institute for Public Policy and International Affairs was launched in 2016 as a Middle East-based, interdisciplinary, platform to examine, inform and impact energy and security policies, regionally and globally. The Program closely monitors the challenges and opportunities of the shift towards alternative energy sources with focus on nuclear power and the Middle East. The Program has been established with a seed grant support from the John D. and Catherine T. MacArthur Foundation to investigate the prospects of nuclear power in the Middle East and its potential to promote regional cooperation as a way to address the security concerns associated with the spread of nuclear power.

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