Note de l'Ifri

The Saudi electricity sector: pressing issues and challenges

Said NACHET and
Marie-Claire AOUN

30 March 2015

ifri Centre Énergie

The Institut français des relations internationales (Ifri) is a research center and a forum for debate on major international political and economic issues.

Headed by Thierry de Montbrial since its founding in 1979, Ifri is a non-governmental and a non-profit organization.

As an independent think tank, Ifri sets its own research agenda, publishing its findings regularly for a global audience.

Using an interdisciplinary approach, Ifri brings together political and economic decision-makers, researchers and internationally renowned experts to animate its debate and research activities.

With offices in Paris and Brussels, Ifri stands out as one of the rare French think tanks to have positioned itself at the very heart of European debate.

The opinions expressed in this text are the responsibility of the author alone.

ISBN: 978-2-36567-370-9

Ifri
27, rue de la Procession
75740 Paris Cedex 15 – France
Tel: +33 (0)1 40 61 60 00
Fax: +33 (0)1 40 61 60 60
Email: ifri@ifri.org

Ifri-Bruxelles
Rue Marie-Thérèse, 21
1000 – Brussels – Belgium
Tel: +32 (0)2 238 51 10
Fax: +32 (0)2 238 51 15
Email: info.bruxelles@ifri.org

Website: *ifri.org*

Authors

Marie-Claire Aoun *is the Director of the Centre for Energy at Ifri and lecturer at Paris Dauphine University.*

She holds a PhD in Economics from Paris-Dauphine University (2008) and is the author of a thesis focusing on oil rent and the economic development of oil-exporting countries. She began her career in 2004 at the Centre of Geopolitics for Energy and Raw Materials (CGEMP) at the same university.

Between 2008 and 2014, she served as Economist for the French energy regulator (Commission de Régulation de l'Energie) working on European gas market integration and on the implementation of the 3rd energy legislative package.

Said Nachet *is Adjunct Professor at Sciences Po (Paris), IFP School and INSTN-CEA (Saclay), a Senior Lecturer at IFP Training and Director of the Paris Petroleum Seminar.*

From 2006 to 2012, he served as Energy Director of the International Energy Forum IEF Secretariat. Said Nachet served as Energy Advisor at the French Economic Mission in Dubai from 2004 to 2006, following a 5-year position as Energy Attaché at the French Embassy in Riyadh (1999-2004).

Prior to his assignments in the Middle East, Said Nachet was Deputy Head of Oil and Gas Markets Division at the French Ministry of Industry (1995 to 1999). He holds a PhD in energy economics.

Table of contents

Introduction

With 266 billion barrels of proved oil reserves (16% of world total), Saudi Arabia holds the world's largest (conventional) crude oil reserves, was the largest exporter of total petroleum liquids in 2013, and the second largest petroleum liquids producer behind the United States[1]. The Kingdom has the lion share of the global oil production spare capacity, which proved to be crucial for the oil market stability on many occasions in the past, allowing Saudi Arabia to replace missing barrels from any other oil producer in the world. In the same manner, Saudi Arabia's decision last November not to step-in and reverse the oil price decline thus, abandoning its historical role as a "swing producer," revived the old debate on the use of oil as a "political weapon" on the international energy scene.

In addition to its well known predominant role in the oil markets and in the Organisation of Petroleum Exporting Countries (OPEC), several other features make the Kingdom of Saudi Arabia a major player in the world economy and global geopolitics.

- Although the Kingdom does not export nor import natural gas, Saudi Arabia is embodied with the 5th natural gas proved reserves (8.2 trillion cubic meters (tcm), 4.4% of world natural gas proved reserves), behind Russia, Iran, Qatar and United States. With a production of 103 billion cubic meters (bcm), Saudi Arabia is also a gas producer solely for its domestic demand[2].

- Because the Kingdom relies heavily on hydrocarbons for its present and future prosperity, the country is very active in climate change negotiations, as mitigation measures resulting from such negotiations will impact global oil demand. In the international talks on climate change, Saudi Arabia has often been calling for the need to address the vulnerabilities of the economies dependent on a single resource.

- The Kingdom of Saudi Arabia is member of G20 Group, putting upfront oil producers' interests in a forum which

[1] According to BP (2014).
[2] *Ibid.*

accounts for 85% of the global GDP and two thirds of world population.

- Saudi Arabia is the host of the Muslim holy places Mecca and Medina, attracting some two million pilgrims annually from all over the world, putting the Kingdom as one of the most prominent countries in the Islamic world.

However, the Kingdom's role on the global energy scene is endangered by several domestic aspects, mainly linked to its fast-growing population, creating significant economic challenges in providing sufficient employment for its young population. Furthermore, the domestic energy demand is growing at an unsustainable high rate. Some observers see the country becoming a net energy importer if the present path of domestic energy consumption (mainly oil and natural gas) continues in the future.

Relying heavily on hydrocarbons as feedstock for the electricity sector, Saudi Arabia is by far the largest user of crude oil for power generation in the world. Oil accounts for two thirds of the input into electricity generation, with natural gas providing most of the remaining portion. The Saudi authorities have realized that there is an urgent need to review the domestic energy policy. With a particular focus on the electricity sector, the policy is based on an ambitious diversification program of the energy mix towards renewable and nuclear energy. However, should the recent slip of oil prices reflect a new level for a long period of time, Saudi authorities, like other oil producing countries, may revise their global energy investment policy. The passing of King Abdallah on January 23 also raises questions about the energy policy path, which could be either confirmed or amended by the new Saudi leadership.

This paper reviews the electricity demand patterns and structure in Saudi Arabia. It examines the recent Saudi power sector developments and draws possible avenues to address the numerous related challenges ahead.

The Saudi economy and its unsustainable energy system

Despite stable and favourable macroeconomic indicators in the past years, the Saudi economy faces many challenges. The main concerns are related to its demographic dynamics leading to an urgent need to generate enough employment for its young population and addressing the issue of its energy system sustainability.

The Saudi economy: a heavy reliance on hydrocarbon resources

Saudi Arabia has an oil-based economy with strong government control over major economic activities. The oil sector accounts for around 43% of the economy in real terms[3], roughly 45% of budget revenues, 55% of GDP and oil revenues constitute 85% of Saudi Arabia's total export revenues (IMF, 2014b). The oil price required to balance the budget has been steadily rising during the last decade, $78 a barrel in 2012 and $89 per barrel in 2013 (IMF, 2014b). In addition, the oil price decline by about 55% between September 2014 and January 2015 has led to significant losses in oil exports value. Losses are expected to reach 20% of the Saudi GDP in 2015 according to the IMF, reflecting a fiscal deficit of 10%. The accumulated foreign currency reserves (more than $750 billion[4]) allow the Saudi economy to exhibit resilience to the low oil price environment, at least for a certain period of time.

In addition to its dependency on oil-sourced revenues, the main challenge faced by Saudi Arabia is still related to a strong demographic pressure, with almost 30 million inhabitants (with median age of 26 years). The level of its oil reserves relative to the population, dropped from 16 thousand barrels in 1990 to 9 thousand barrels in 2013. Albeit several reforms, notably in the business environment[5], the economic diversification is a crucial challenge for Saudi Arabia as non-oil exports remain limited. The incentives for

[3] Jadwa Investment, January 2015.
[4] Sovereign Wealth Fund Institute, <www.swfinstitute.org/fund-rankings/>.
[5] <www.doingbusiness.org/~/media/giawb/doing%20business/documents/profiles/country/SAU.pdf>.

diversification are not yet fully developed, notably with more attractive wages, benefits, working hours and job security in the public sector, in comparison to the private sector (IMF, 2013).

In parallel to its huge endowment in oil and gas resources, and thanks to the sustained high oil prices since 2007 (until June 2014), Saudi Arabia's economy has been growing at a strong rate during the last few years (5.8% in 2012, 4% in 2013). The economy has experienced large external and fiscal surpluses, a very low level of government debt (2.7% of GDP), high level of macroeconomic stability and a significant improvement of the human and social development indicators[6]. The Kingdom is ranked among the highest in human development levels, preceding the United Arab Emirates (UAE) and Kuwait. According to the global Human Development Index, it is currently ranked 34th, progressing from its previous 47th position in 2008[7].

The demographic pressure raises huge difficulties in terms of youth employment and a rapidly growing population, mainly because the oil industry is highly capital intensive and generates little direct employment for nationals. As in many other Gulf Cooperation Council (GCC) countries, Saudis are primarily employed in the public sector, while non-Saudis dominate employment in the private sector.

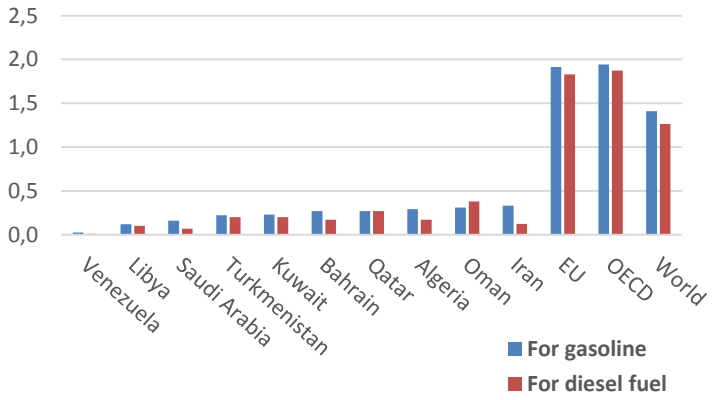
A deep reform of the labour market has been implemented during the past decade in order to boost the private sector job creation for nationals and strengthen education and training, generating slight positive effects on the labour market. While the overall unemployment rate has been fluctuating between 4 and 6% since the 1990s[8], the unemployment rate of Saudi nationals fell from 12% in 2012 to 11.5% in 2013 (IMF, 2014b). Still, the public sector continues to be the dominant source of new jobs, reflecting the attractiveness of high government wages compared to international standards (more than 10% of the GDP). Education in Saudi Arabia has been set as a priority for the Saudi government, with levels of public spending (around 8% of GDP) much higher than in the other GCC countries and the achievement of significant improvements in the labour productivity (IMF, 2013). However, there is still substantial room for improvement notably for the quality of education, labour market efficiency and the gender ratios among the educated job force. The public sector, the largest employer in the Kingdom, can no longer absorb the 200,000 young graduates leaving university every year.

Saudi Arabia is considered as a rentier state[9] and as in many other energy-rich countries, subsidies to energy products are seen as

[6] See the Global Competitiveness Report, 2014 and IMF (2014b).
[7] <http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf>.
[8] World Bank data.
[9] For Beblawi and Luciani (1990), rentier states are characterised by economies relying heavily on external rents, mainly perceived by the State with only a small

a direct way of redistributing the hydrocarbons rent to the population. They are also considered as part of the "social contract." The pump prices for gasoline and diesel in Saudi Arabia are among the lowest in the world. Similarly, the fuel prices paid by the electricity producers represent a minor fraction of the international prices, reflecting a substantial government subsidy aiming at reducing the final consumer electricity bill.

Figure 1: Average pump prices in 2012 (in US$ per liter)



Source: World Development Indicators, World Bank.

The energy subsidies in Saudi Arabia represent undoubtedly a heavy burden for the economy. They account for 9% of the GDP, both for the oil products (around $46 billion[10]) and for the electricity sector (almost $15 billion[11]). In total terms, Saudi Arabia is the second highest subsidizer in the world with an average subsidization rate of 77.3%[12]. With rising energy consumption, such high spending on subsidies will increase the burden for the Saudi budget, and is not sustainable in the long run.

Energy consumption and electricity demand in Saudi Arabia: an unsustainable path

The Saudi energy demand growth has been spurred by the economic boom as a result of historically high oil prices and large fuel subsidies. The Kingdom is already the largest consumer of petroleum in the Middle East with more than 3 million of barrels per day of domestic oil consumption. It is ranked the 6th largest oil consumer in the world (behind the US, China, Japan, India and Russia) with a domestic

share of the population involved in the generation of the rent. Because of these substantial rents, these states face difficulties to develop a strong domestic productive sector.

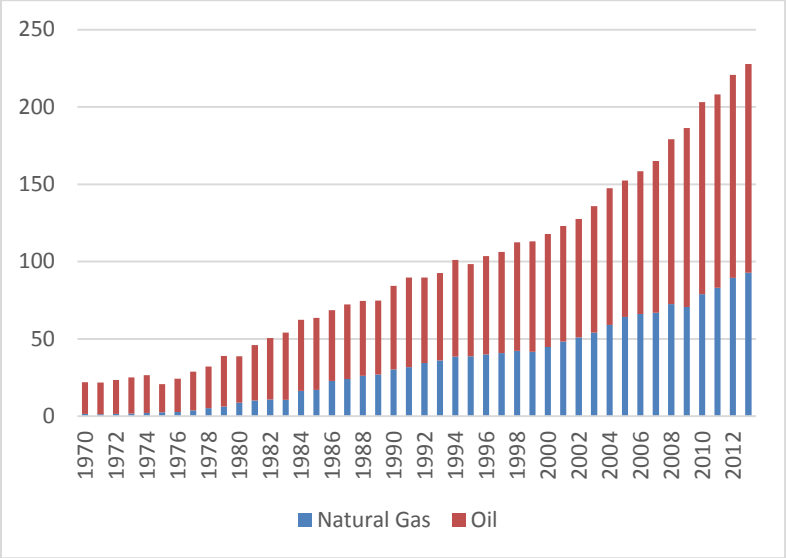
[10] IEA Subsidies Database, 2013.

[11] IEA Subsidies Database, 2013.

[12] According to the IEA, <www.iea.org/subsidy/index.html>.

consumption almost doubling since 2000[13]. With 6.7 tons oil equivalent (toe) *per capita* in 2013, its energy consumption is among the highest in the world (13th position) (7 toe in the US, 3.2 toe in the EU and 1.9 as a world average)[14]. Thus, unlike the general trend observed in most countries, the Saudi energy consumption has been growing at a faster pace than its GDP, resulting in an increased energy intensity (137 toe of energy use per 1000$ of GDP in 2011; 95 toe in the EU[15]).

Figure 2: Saudi Arabia primary energy consumption pattern (in Million of toe)



Source: BP (2014)

The Saudi primary energy mix is exclusively based on oil (59%) and natural gas (41%). The country's gas consumption is met by domestic production. As more than three quarters of the gas produced in the Kingdom is associated with oil, gas production is impacted by the Kingdom crude oil production adjustment policy with reduced oil flows resulting in lower gas extraction. According to Saudi Aramco's forecasts, natural gas demand is expected to almost double by 2030 from 2011 levels. Therefore, all current and future supplies (except natural gas liquids) remain dedicated to domestic use, drawing more attention to the need of minimizing the use of crude oil for power generation.

With the transportation sector and water desalination, the electricity sector is the main consuming sector of oil (Nachet, 2014), with around 700,000 bbl/d of oil consumed during the summer peak

[13] According to BP (2014).
[14] World Development Indicators.
[15] *Ibid.*, $ constant 2011 PPP.

demand[16]. The Saudi electricity generation is heavily dependent on hydrocarbons, with crude oil accounting for 29% of electricity production in 2013, diesel (15%), heavy fuel oil (10%) and natural gas providing the remaining 46% (ECRA, 2014).

Driven by population growth, a rapidly expanding industrial sector led by the development of petrochemical cities, high demand for air conditioning during the summer months, and low electricity tariffs, the electricity use in Saudi Arabia has risen by about 7-8% annually over the last decade, with summer peak demand increasing by 93% between 2004 and 2013 (from 28 to 54 GW) (ECRA, 2014). Between 2013 and 2020, the Saudi electricity demand is expected to increase by over 6% annually. This future electricity demand growth will require power generation capacity to increase to 120 GW by 2032[17]. The demand in the residential sector particularly remains strong, with the sector consuming 50% of the Kingdom's total electricity production, the remaining being split among industry, commercial sector and governmental agencies (21%, 15% and 12% respectively). Climate is a major factor as 70% of the electricity sold is attributed to air conditioning (ECRA, 2014), adding to the seasonality of demand, with summer peak demand nearly twice the winter average.

The water "sector" is another major energy consumer in Saudi Arabia. The strong population growth, as well as the development boom in Saudi Arabia, has resulted in an unprecedented demand for water. The growth of cities and increased population, coupled with the rise in the living standards, caused domestic and industrial water consumption to increase significantly.

To meet increasing drinking water demand, Saudi Arabia is already the world's largest producer of desalinated water, with 30 desalination plants in the country, accounting for about 18% of the total world output and the Kingdom plans to double desalination capacity over the next decade. Despite the efforts made by the government to develop water supplies in the country, the consumption of water in Saudi Arabia has reached alarming levels. It stands at a rate that is twice the world average, using much more water than countries endowed with more (and replenishable) water resources.

When assessing the reasons behind the strong growth of water demand in the households sector, three main issues emerge: the lack of awareness among the consumers about the cost of bringing water up to their taps, the inefficient water distribution network with leakage estimated around 50%, due to aging pipelines and poor maintenance, and the price of water which is far below the cost of production and does not encourage conservation.

[16] As an average during the summers from 2009 and 2013 according to EIA estimations, <www.eia.gov/todayinenergy/detail.cfm?id=18111>.
[17] <http://www.eia.gov/countries/cab.cfm?fips=SA>.

Desalinated sea water provides 60% of the water consumed by households with the remaining coming from groundwater aquifers. Desalinated water consumption is growing at around 14% per year; that is twice the total domestic consumption of water and six times the growth rate of the population. Desalination already accounts for more than half of the kingdom's domestic oil consumption, with the demand for water and electricity co-production growing by 8% every year.

The issue here is that desalination is very costly and is not sustainable in the long run. It accounts for 10% to 20% energy consumption in Saudi Arabia. The low water costs paid by the end-users in the Kingdom are equivalent to 5-10% of the actual production cost in the public sector.

Unless alternative energy and energy conservation measures are implemented, the overall demand for fossil fuel for power, industry, transportation and desalination are estimated to grow from 3.4 million barrels of oil equivalent per day in 2010 to 8.3 million barrels of oil equivalent per day in 2028[18].

In light of these facts, there is now a wide acceptance in Saudi Arabia that the present path of energy and electricity consumption is not sustainable in the long run. Saudi Aramco's CEO Khalid al-Falih warned that rising domestic energy consumption could result in the loss of 3 million barrels per day of crude oil exports by the end of the decade if no changes were made to current trends. Others see Saudi Arabia to become a net oil importer by 2038 if the domestic consumption is not curbed significantly (Lahn and Stevens, 2008).

[18] Arab News, 10 August 2014.

The main challenges for Saudi Arabia's electricity sector

The systemic structure of the hydrocarbons/electricity/water nexus in Saudi Arabia is not sustainable; electricity and water consumptions are both rising above the international standards rate, mobilizing increasing volumes of hydrocarbons. Because of the huge investments needed to strengthen the electricity network in view of meeting the rising electricity needs, the Kingdom decided to engage in a progressive restructuring and liberalization of its electricity sector. Regardless of the future energy supply choices that Saudi Arabia may decide to implement, demand-side management, in particular enhanced energy efficiency, remains an urgent measure to deploy throughout all segments of the Kingdom's economy. The other key tool to improve electricity efficiency is to engage a deep reform of the electricity tariffs.

Deploying energy efficiency

The Kingdom, like any other major consuming country, understands the urgency of addressing the pressing need of energy conservation, both in consumption and electricity generation. Of all options available to contain electricity demand growth, energy efficiency can achieve quick results in a very cost-effective manner.

The Kingdom is implementing a host of policies in order to achieve better conservation of electricity and unlocking more efficient electricity generation and supply. The first National Energy Efficiency Programme (NEEP) was launched in 2003 as a three-year term temporary programme to improve the management and the efficiency of electricity generation and consumption in the Kingdom. The programme defined eight objectives, including energy audit services and industry support, efficient use of oil and gas, energy efficiency labels and standards for appliances, construction codes and technical management and training. During the years that NEEP has been active, it has successfully established the concept of energy efficiency in the national dialogue and laid the groundwork for further initiatives. It has also identified a number of barriers to energy efficiency in the Kingdom, and has proposed key measures to help overcome these obstacles and facilitate energy efficiency.

The growing concern over domestic energy consumption led the government to establish the Saudi Energy Efficiency Center (SEEC) in 2010. The SEEC's mission is to "preserve the national wealth of energy resources, which consequently strengthens development and national economy, and achieves the lowest levels of possible consumption levels in comparison to the general national product and populations"[19]. The Saudi Energy Efficiency Program was launched in 2012, with a primary focus on buildings, transportation and industry sectors, which represent more than 90% of the energy consumption.

Particular emphasis is put on the cooling of buildings, accounting for half of the electricity consumed in the country, in order to increase the minimum energy performance standards for air conditioners and align them with international best practices. According to the IEA (2014a), the increase of energy efficiency of air conditioning to current best practices levels would free up about 120,000 barrels of oil per day and almost 5 bcm of natural gas per year used to generate electricity, i.e. saving almost $7 billion per year at current international prices. In the last few years, significant progress was made, yielding a 30 – 35% electricity savings for cooling in 2015 compared to the business-as usual scenario. Furthermore, around 50 air conditioner suppliers declared more than 800,000 non-compliant AC units to be re-exported or dismantled for spare parts (Prince Abdulaziz bin Salman al-Saud[20], 2014). The industrial sector has also contributed to these efforts. In 2011, Saudi Aramco energy management program achieved energy savings of approximately 10,000 barrels of oil equivalent per day[21]. In May 2014, Saudi Aramco also announced a lead-by example program targeting a minimum of 35% savings in the company's energy use in non-industrial sectors by 2020[22].

Energy efficiency measures could bring substantial gains for the country. Annual energy costs could be reduced significantly, assuming constant electricity production costs, with most of the savings generated by the residential sector. Setting building and appliance standards can considerably contribute to consumption reduction in the household sector. However, sustainability practices are still uncommon to the Saudi market due to limited returns on investment, higher costs of environment-friendly products and more importantly, a lack of public awareness for the need to use energy more efficiently. Incentives and a properly designed strategy are key drivers for the Saudi's construction sector sustainability. The remaining obstacle is undoubtedly linked to the huge electricity price subsidies discouraging investment in energy efficiency.

[19] SEEC website.
[20] Deputy Minister, Petroleum and Mineral Resources.
[21] <http://www.aramcoservices.com/News-Events/Saudi-Aramco-receives-top-energy-management-aw.aspx>.
[22] <http://eeforum.sa/2014/ar/img/Speakers/pdf/Al-Usaimi.pdf>.

Achieving greater energy efficiency would allow Saudi Arabia to divert some of the $100 billion in planned capital investments in the domestic power sector over the next decade to other sectors or applications, such as renewable energy[23]. In addition, many energy efficiency measures can pay for themselves in form of reduced energy costs that compensate the investment associated with the deployed efficiency measures. Furthermore, energy efficiency creates new business opportunities for SMEs and therefore feeds job creation. The Kingdom considers that "it is a strategic imperative for the Kingdom that energy efficiency becomes a major topic for all decisions related to an increase in demand for fuel and feedstock" (Prince Abdulaziz bin Salman al-Saud, 2014). Despite its benefits and SEEC's objective to achieve the world average energy intensity by 2020, the energy efficiency potential remains largely untapped in Saudi Arabia.

Reforming electricity tariffs

One of the central ways to contain the electricity consumption is to ensure that electricity wholesale and retail prices reflect total costs.

As in many oil producing countries, fossil-fuel subsidies are often implemented to help alleviate poverty by making energy economically accessible to the poor. Keeping energy prices low has also been a tool for the Saudi government to manage inflation. In reality, fossil-fuel subsidies generate negative impacts that outweigh the benefits. There is a progressively widespread consensus around the need to reduce these substantial subsidies, notably because of their adverse effects on CO_2 emissions. In Saudi Arabia, CO_2 emissions per capita amount to 17 metric tons, almost equivalent to the USA (against 7 in the EU, 6 in China and 5 on a world average)[24]. Furthermore, fossil fuel subsidies generate a pricing scheme that leads to a dead-weight welfare loss. The government's lost revenue from subsidizing domestic consumption (instead of exporting) is greater than the increase in domestic consumers' surplus. By lowering the end-user prices, fossil fuel subsidies encourage over-usage of energy and high fuel consumption growth rate.

In reality, non-targeted subsidies are not an efficient means of improving access to energy and redistributing income to the poor, as they essentially benefit the richer households, and create adverse impacts on social equity. These subsidies deter investment in the energy sector, create incentives for waste and smuggling and lead to foregone revenues from oil exports. This is particularly evident in Saudi Arabia, which charges $5 a barrel of crude sold domestically,

[23] Saudi Arabian General Investment Authority (SAGIA).
[24] World Development Indicators, World Bank.

while exporting the same can generate more than $100 per barrel (between 2011 and 2014 on average)[25].

Figure 3: Comparison of fuel prices paid by Saudi electricity producers with international prices (in $/MMBtu)

	Price paid by electricity producers	International prices
Heavy fuel oil	0.43	15.43
Natural gas	0.75	9.04
Diesel	0.67	21.67
Crude oil	0.73	19.26

Source: ECRA, 2014

Prices paid by the power producers in the Kingdom are obviously too low to encourage the power sector to undertake investment in non-fossil fuels powered plants and to deploy more efficient measures and practices. A pricing review will not only send the right signal to consumers regarding the real cost of electricity, but will also provide electricity generators with revenues that commensurate with their investment and operating costs. The revision of the energy pricing structure is imperative, since the non-economic price of one form of energy or feedstock inevitably leads to the distortion of all energy or feedstock prices.

Domestic natural gas price remains among the lowest in the world. The low price leads to a high demand from large gas users such as Kingdom-based petrochemical companies (Saudi Arabia does not import natural gas) and gas quantities have to be allocated by the Ministry of Petroleum and Mineral Resources through a quota system. While low natural gas prices helped develop the petrochemical industry with more than 20 mega-complexes, compared to 1 in 1983, the low buying rate for natural gas set by the government creates very little incentive for sizeable investments needed to bring gas fields on-line and develop the infrastructure necessary to process the gas and transport it to market. Rapid development of gas reserves is necessary for Saudi Arabia's plans to fuel the growth of the petrochemical sector, as well as for power generation and water desalination. According to the IEA (2014b), the average efficiency of gas-fired plants in Saudi Arabia is very low, around 27%, mainly due to the harsh climatic conditions and large daily variations in power demand.

In the short term, the (upward) energy price revision may be socially sensitive for the population of Saudi Arabia (energy end-users). However, this situation should not dismiss the idea of raising the end-user energy prices in the long term. As a first step, it is possible to examine how to increase inter-sector energy transfer

[25] See Krane (2014) or IMF (2014a).

prices[26] among energy intensive sectors (petrochemicals, electricity, desalination, cement, refining, etc.) to induce higher efficiency and lower energy consumption.

Indeed, there are many inconsistencies that are preventing the Saudi pricing structure from sending the right signals to the main players in the energy sector. For example, the price at which desalination plants sell electricity to the grid is fixed in long-term contracts, without any modulation across the day. Since the prices of gas used by these plants as well as that of the water produced are also fixed, there is no incentive to use the water plants for peak shaving purposes, thus losing a very cost effective method.

Matar et al. (2014) have shown that raising inter-sector transfer prices (to world markets level) will lead to substantial reductions in fuel consumption in the Kingdom and annual economic gain exceeding $23 billion (in 2011), or almost 5% of Saudi Arabia's GDP for the year. Such outcome could be achieved without increasing current end-consumer prices.

Progressive liberalization of the Saudi electricity sector

Both Saudi officials and international observers underline the urgent need to address the challenge of fast growing energy demand by attracting more private investment in the electricity sector, and by introducing more competition to increase efficiency and reduce the burden on the public budget.

Box 1: Structure of the Saudi electricity sector

The Saudi electricity sector used to consist of four regional companies, Saudi Consolidated Electricity Companies (SCECOs), for the east (SCECO-East created in 1976), for the south (SCECO-South in 1979), south west and the central region (SCECO-Central). The General Electricity Corporation (GEC) had overall responsibility for the Kingdom's electricity system and had a direct responsibility for the provision of electrical supplies to rural areas not then covered by the consolidated companies. The GEC represented the government equity holdings in all the independent electricity generating companies and was a source of finance for those companies' capital requirements. The present Saudi electricity sector landscape is the result of historical development and reforms that led to a myriad of players.

[26] Inter-sector energy transfer prices are the prices paid by any player in one sector to acquire energy or energy services from another player. Prices paid by the electricity generation, petrochemicals, desalination, sectors for methane, electricity and oil are all regulated.

- In 1998, the Government announced the reorganization of the electricity sector by establishing a stock-market company, **the Saudi Electricity Company (SEC)**, through the merger into a single joint stock company. The merger included all Saudi electricity companies in the Central, Eastern, Western and Southern regions, the ten small companies operating in the North of the Kingdom and all other electricity operations managed by the General Electricity Corporation. **The SEC is by far the largest utility in Saudi Arabia,** mainly owned by the government and Saudi Aramco (81% of SEC shares[27]). SEC accounts for 74% of the country's total installed capacity (69,781 MW in 2013).
- The other main electricity producers in the Kingdom are the Saline Water Conservation Corporation (SWCC), with 7% of the total generation capacity and Jubail Water and Power Company (4%). **Saudi Aramco, which generates power for its own needs,** figures are among the other producing entities (ECRA, 2014).
- In 2013, the Electricity and Cogeneration Regulatory Au**t**hority (ECRA) allowed Saudi Aramco to sell any excess electricity it produced through the intermediary of SEC.
- The **Electricity & Cogeneration Regulatory Authority (ECRA) is a financiall**y and administratively independent Saudi organization, in charge of the regulation of the electricity and water desalination industry in Saudi Arabia[28].
- The **Water and Electricity Company (WEC)** has been established with the aim of creating an independent entity with a legal character to buy water and electricity from the companies that will own projects for production of both water and electricity. This entity will then sell water to the Saline Water Conversion Corporation (SWCC) and electricity to the Saudi Electricity Company (SEC).
- **SEC has the monopoly of electricity distribution to consumers in the Kingdom** (except in two areas operated by Marafiq in Jubail and Yanbu). The National Electricity Transmission Company (NETC), wholly owned by SEC, is responsible for planning, building and operating the transmission system.

Following a long consolidation of the electricity sector that led to the establishment of the Saudi Electricity Company (SEC), the Kingdom is gearing its electricity system towards a more competitive power market, in order to ease the investment burden on public spending with the expected fast growing electricity demand in the upcoming years. In an attempt to achieve a more efficient electricity system, Saudi Arabia recently embarked on a series of regulatory changes.

While the transmission and distribution of electricity to final consumers still falls under the SEC monopoly, the Saudi government is pushing ahead with plans to restructure the SEC into separate firms overseeing electricity generation, transmission and distribution. The Saudi authorities are also working on unbundling the domestic power chain (generation, transmission and distribution), to remove entry barriers for new producers, with the aim of achieving greater

[27] ECRA annual report 2013.

[28] "Its mission is to develop and pursue a regulatory framework, in accordance with government laws, regulations, policies, and standards, as well as international best practices, in order to guarantee the provision of safe, reliable, reasonably priced and efficient electric power and desalinated water to the consumers of Saudi Arabia." (ECRA website.)

efficiency and reducing public capital spending in the electricity sector.

Saudi Arabia is also committed in the development of a wider regional interconnection. The Kingdom is the host of the Gulf Cooperation Council Interconnection Authority (GCCIA), aimed at linking the GCC electrical power networks. It will provide the necessary investments for the exchange of electrical power in emergency situations. The interconnection of GCC countries' grids is designed to allow the sharing of power on an emergency basis, but can already enable market participants to reduce the spinning reserve needed to ensure grid stability. In September 2014, the GCC interconnection[29] was successfully used for stability and support of the grid in around 1100 incidents. However, with a utilization rate of about 8%, the interconnector is still not used for economical trade of energy[30]. The GCC's efforts to link the power grids of member countries to reduce shortages during peak power periods, is a good example of cooperation that enhances collective energy security while sharing the burden of the investment cost. The ultimate objective of the GCCIA is to increase electricity exchanges among the Members States. A study presented in September 2014 at the 3rd Power Trade Forum showed that the total expected benefits for electricity exchanges during the period 2012-2030 are significant (about $106 million per year for the exchanges between Saudi Arabia and Bahrain, $154 million per year for the exchanges between Saudi Arabia and the UAE Abu-Dhabi and 181 between Saudi Arabia and Qatar, considering a utilization factor of 50%)[31].

In addition, integrating the electricity grids of the GCC countries could provide the region with an additional potential for cross-border and intercontinental energy exports during off-peak season. Saudi Arabia and the neighbouring countries could benefit from the connection of their northern Gulf grid connection (linking Saudi Arabia, Kuwait and Qatar) with the Turkish and European grids to take advantage of the very large spare capacity the Saudi system has in the winter months. Saudi Arabia plans to set up a grid connection with Egypt to take advantage of differences in each national system's daily demand peaks; the connection could operate at a level as high as 3 GW. An even more ambitious plan under consideration is to share power on a seasonal basis. Such a system could supply as much as 10 GW to help meet European winter peak demand, while sending back power in the summer to reduce the peak demand in the Gulf (Segar, 2014; Dii, 2013).

[29] See Appendix 2.
[30] <http://www.gccia.com.sa/publications/2014/Session%203/Developing%20Power%20Trade%20through%20the%20GCC%20Interconnector%20-%20Ahmed%20Ali%20Al-Ebrahim%20(COO,%20GCCIA).pdf>.
[31] *Ibid*.

Diversifying the power mix towards renewable energy and nuclear

Beyond the demand-side management measures, the main long-term focus of the Kingdom has been oriented towards the diversification of the energy mix, in view of meeting the rising domestic energy demand, extending the lifetime of oil reserves and releasing additional domestic oil resources to exports. Ambitious targets were set for 2032 for the deployment of renewable and nuclear energy. Established by Royal Order in April 2010, the King Abdullah City for Atomic and Renewable Energy (K.A. CARE) is the central body[32] responsible for defining and establishing Saudi Arabia's atomic and renewable energy program with the aim of developing alternative energy capacity and building a domestic supply chain.

Deploying renewable energy

Despite being abundantly blessed with sun throughout the year, Saudi Arabia, like other countries in the MENA region, has traditionally shied away from investing in solar, citing reasons of commercial unprofitability in the long term. Attitudes have drastically changed in last few years, pushed by the need for economic diversification in oil-exporting nations and diminishing production costs, making solar a viable option for countries in the Middle East. Qatar has built a 300 MW solar manufacturing plant and sees 2.5 GW of production in its future. The UAE's Abu Dhabi region just completed a 100 megawatt concentrated solar power plant (CSP) and also sees a great future for solar (IRENA, 2014).

Having vast renewable energy resources mainly in the form of solar energy, Saudi Arabia has realized there are huge benefits in curbing domestic oil consumption in order to generate billions of

[32] The highest authority of K.A. CARE is the Supreme Council, which was chaired by King Abdullah in his capacity of Prime Minister, and co-chaired by the Deputy Prime Minister, HRH Salman bin Abdulaziz Al Saud, Crown Prince until 21 January 2015. In addition to its Chair and co-Chair, the Supreme Council comprises nine Ministers, as well as the Presidents of General Intelligence Presidency, President of K.A. CARE, and the President of King Abdulaziz City for Science and Technology. The K.A. CARE Supreme Council was disbanded by decision of Saudi Arabia's new King, Salman bin Abdulaziz Al Saud.

dollars by exporting the savings at higher prices. Unlike other countries exhibiting high population density, the Kingdom's vast desert can host large solar installations and huge deposits of clear sand that can be used to manufacture silicon photovoltaic (PV) cells. In addition to the diversification of the Saudi domestic mix, renewable energy will contribute to the reduction of their emissions growth (NOx, Sox and CO_2), effluents and water usage, and will provide alternative means of serving remote areas in a more economic and clean manner.

The Kingdom has set a goal of producing almost half of its power from renewable fuels by 2020 in order to meet domestic power needs, free-up oil for export and drive natural gas consumption towards sectors with higher added value such as petrochemicals. In 2012, Saudi Arabia launched an ambitious plan, costing US$109 billion, to install 41 GW of solar energy (25 GW CSP and 16 GW PV), 9 GW of wind, 3 MW of waste-to-energy and 1 MW of geothermal by 2032, corresponding to 30% of electricity generation.

The Saudi government believes renewable energy can contribute to reducing unemployment. Domestic content requirements in procurement are also aimed at encouraging the development of a local supply chain. Saudi businessmen and investors are looking to establish companies that are not only focused on supplying the Saudi market with products and services but also exporting them. In February 2013, K.A. CARE released a White Paper[33] detailing the proposed competitive procurement process of its renewable energy program. Local content is one of the key criteria for the evaluation of the bids, increasing from 50% or higher, depending on the item to 60% (or higher) in the first round and 70% thereafter. Joint ventures with technology companies establishing a local manufacturing plant to meet the planned scale of deployment will probably be needed to abide by the K.A. CARE local content requirements. The local benefits of the renewable energy program also include the provision of training, research advice, and procurement from local manufacturers. A tax of 1% on project revenues is also planned for the Solar Energy Training Fund, to train local employees on solar PV and CSP technologies, and also for the Solar Energy Research Fund for local renewable energy research and development projects (IRENA, 2013).

In addition to the advantage of diverting significant quantities of oil and gas from power generation to other more efficient uses, the Kingdom can enjoy additional returns from the alternative energy economic sector, in particular in terms of jobs. According to Dii (2013), an investment of €1 billion in Saudi Arabia for CSP power plant construction can generate between 3,000 to 4,000 jobs, between 1000 and 4,000 for a PV power plant and between 3,000 and 6,000 for a wind power plant. Other estimates, direct employment

[33] <http://www.kacare.gov.sa/en/?post_type=cpp>.

opportunities in alternative energy generation could reach 137,000 jobs and $51 billion as GDP contribution from alternative energy employment opportunities for Saudis (K.A. CARE, 2012).

At the end of 2013, Saudi Arabia had the second highest solar PV installed capacity among the Arab states, with 19 MW, right after the UAE (33 MW) (IRENA, 2014). Among the completed PV installations, we can mention the KAUST solar rooftop (2 MW) by Saudi Aramco, the Aramco Solar Carport (10.50 MW), the King Abdullah Petroleum Studies and Research Center (KAPSARC) Riyadh 3.5 MW PV plan. Furthermore, some Saudi companies such as ACWA Power, have been active both, domestically and internationally (Haug, 2014 and SASIA, 2014).

To provide some context on the competitiveness of renewable energy in Saudi Arabia, the expected costs for CSP are situated between 9 and 15 €ct/kWh, between 5 and 8 €ct/kWh for PV and around 5 €ct/kWh for wind until 2020 according to Dii (2013) estimations. Though the comparison of the current levels of the heavily subsidized domestic prices for electricity (starting at 0.013 $/kWh for residential users as indicated in Appendix 1) may suggest that renewable energy cannot be competitive in Saudi Arabia, the results are completely different when the “opportunity cost” – i.e. the opportunity of not selling oil on the international market – is taken into account (El-Katiri, 2014; IEA, 2014c).

Saudi Arabia’s climate conditions such as high temperatures and dust pose many challenges on photovoltaic plants and CSP plants. However, these challenges could be overcome with the implementation of adequate solutions. One such example is the successful project of Princess Noura Bint Adbul Al Rahman University for Women (PNUW) in Riyadh. It is the world’s largest operating solar heating project, providing space heating and hot water needs for nearly 40,000 students and staff in combination with the university’s conventional diesel boilers. The project is estimated to save around 52 million litres of diesel and 125 kCO_2, during its expected 25-system life, in comparison to standard diesel boilers (IEA, 2014d).

In addition to the technical and operational issues, there are several other challenges for the deployment of renewable energy in the Kingdom. The first one is to develop a suitable regulatory and commercial framework. The ambitious goals announced by the Kingdom imply a large development of renewable energy in the medium term. However, only a small pipeline of renewable projects has emerged to date, due to still-pending actions on the policy side. The IEA (2014c) highlighted that although the long-term policy environment appears to be supportive, there is still a lack of clarity over the timeline and implementation details of the program, which is considered to be a major source of uncertainty to renewable development through 2020. Furthermore, the demanding local content provisions included in the program may present economic challenges to development. Still, in its baseline scenario, the IEA

expects that Saudi Arabia takes the lead in the MENA region, with renewable generation growing more than 8TWh over 2013-2020, dominated by solar (2.5 GW), followed by onshore wind (+1.3 GW) and CSP (+1.0 GW).

Nuclear energy path in the Kingdom

Until recently, nuclear energy was not considered by any of the GCC countries as a possible option due to the historical reliance of these countries on oil and gas and the traditional position taken by GCC countries against any nuclear development (and proliferation) in the region. Meanwhile, the GCC announced the commissioning of a study, in cooperation with France, on the peaceful use of nuclear energy. The introduction of civilian nuclear programs to the Arab Gulf countries illustrates a more structural shift of the region's energy policy. The only country in the region with a nuclear program is Iran, which is suspected of developing a nuclear military program, raising concern, in particular in the Gulf Arab countries.

The year 2009 could be considered as the year of the region's shift towards nuclear energy. In December 2009, the UAE awarded a $20 billion contract to the Korea Electric Power Corporation (KEPCO) to construct four nuclear reactors. The first reactor (1,400-megawatt) is scheduled to come on-line in 2017, with the others expected to be completed by 2020. Upon completion of the first reactor, the UAE will become the second country in the region (after Iran) to develop a domestic nuclear program.

In 2009, Kuwait announced plans to develop nuclear energy and to establish a nuclear commission. In January 2010, the head of the National Nuclear Energy Committee announced a 20-year cooperative deal with the French Atomic Energy Commission to develop nuclear power in Kuwait. Kuwait was considering constructing four nuclear reactors, set to become operational by 2022. Following Japan's Fukushima nuclear accident in 2011, Kuwait dissolved its National Nuclear Energy Committee and decided to suspend its plans to produce nuclear power.

In 2009, a Saudi royal decree announced that "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." In 2011, Saudi Arabia announced a plan for the construction of 16 nuclear power reactors over the next twenty years, at a cost of more than $80 billion, to generate about 20% of Saudi Arabia's electricity, while other, smaller reactors were envisaged for desalination.

According to the Kingdom's plan, a Saudi Arabian Atomic Regulatory Authority, a wholly independent regulator, will be established to oversee the Kingdom's civil atomic energy program

and ensure safeguards are in place for all the stakeholders (safety, transparency, compliance with international standards and regulations, etc.). In April 2014, the Kingdom entrusted the nuclear safety authority of Finland, Radiation and Nuclear Safety Authority (STUK), with the task of supporting K.A.CARE in designing and executing required activities to establish the regulatory body, its safety oversight functions and in developing safety regulations. Through this multi-year ambitious cooperation project, STUK will also provide training for the staff and assistance in the recruitment process. The Kingdom has also brought in Pöyry, a Finnish consulting and engineering company, to deliver strategic advisory and engineering services for nuclear and renewable energy.

Since its creation, K.A.CARE signed many cooperation agreements with domestic (such as SABIC), regional (such as Masdar from UAE) and international entities, such as the memorandum of understanding (MOU) inked in August 2014 with the Chinese National Nuclear Energy Company (CNNEC). More recently, K.A. CARE signed another MOU with the South Korean Ministry of Science, ICT and Future Planning (MSIP) focusing on the technologies to be utilized, joint human capability building and academic research activities. South Korean President Park Geun-hye met with Saudi Arabia's King Salman in early March 2015 in Riyadh, and the two countries agreed that South Korean firms will help build at least two small-to-medium sized nuclear reactors in Saudi Arabia, for an estimated cost of some $2 billion, according to official statements.

Deployment of nuclear energy can be made specific to each country's situation (endowment in energy resources, institutional structure, security concerns, etc.). While the progress of the Saudi nuclear program is awaiting further impulse to move forward, useful lessons may be drawn from the experience of neighbouring UAE. In 2008, the UAE have identified nuclear power-generation as a proven, environmentally promising and commercially competitive option which could make a significant base-load contribution to the UAE's economy and future energy security. The UAE Government formally endorsed a comprehensive policy statement as a reflection of its views on the potential establishment of a civilian nuclear energy program in the UAE.

The development of the nuclear power offers many benefits for the Saudi energy situation. Nuclear energy is an interesting option to accompany the expansion of renewable energy, because of the intermittency of supply of the latter. Nuclear energy is seen as a clean source of energy, with low carbon emissions, having an important contribution to economic development in terms of the acquisition of know-how and the creation of highly skilled jobs for the nationals (El-Katiri, 2012). When the UAE's first nuclear-power plant opens at

Barakah in 2017, an estimated 2,000 people will be working on the site, which will translate into 12,000 support workers[34].

However, the development of the nuclear energy in the region as a whole and more specifically in Saudi Arabia faces several challenges. The economics of nuclear power in the GCC in general poses the question of nuclear cost-effectiveness compared to oil- and gas-fired power plants in the region. There are important initial investment costs as well as a high level of long-run variable costs that could not be covered through electricity tariffs, unless the latter are raised significantly, but more likely through a substantial bill for governments in form of subsidies (El-Katiri, 2012). Looking at the UAE nuclear program as an example, estimates of expected long-term and variable cost components indicate that they lie above the existing tariffs. Thus, a significant bill will have to be picked up by the government and the size of the electricity market in Saudi Arabia (albeit three times the size of the UAE market) will not bring economies of scale, as it is the case in larger nuclear power markets like the US, Europe or Asia (El-Katiri, 2012).

There are also several well-known challenges requiring particular attention. Such risks include nuclear weapons proliferation, the physical security of nuclear material and facilities, the need to ensure high level of safety in technology design and facility operation and lastly, the public acceptance of the technology. Luciani (2014) argues that the strategic value of Saudi's Arabia nuclear program is high, notably for meeting the requirements of desalination and power generation for base load. He considers that nuclear energy from standardized plants is very likely to be competitive, if projects do not face delays in construction and with the prospects of these plants being used in excess 8000 hours per year.

[34] The National, 17 June 2013, <http://www.thenational.ae/news/uae-news/abu-dhabi-nuclear-plant-site-prepares-for-17-000-new-arrivals>.

Conclusion

There is no doubt that awareness is growing in the Kingdom, both in the ruling circles and within the population, about the need to address both the rising electricity demand and limiting the use (waste) of oil as feedstock for electricity generation.

The ongoing efforts to raise rationalization awareness and energy conservation by governmental and non-governmental agencies are progressively changing the endemic culture of profligate energy usage. However, economic and regulatory components of such efforts could certainly be accelerated and expanded further. Visible and advertised actions against energy waste are needed, such as the recent seizure of 150,000 air-conditioners violating specifications and energy efficiency standards. But economic signals on both, the investment and consumption components, will produce higher and long lasting results. On the investment side, favouring efficient electrical appliances through discounted prices and other similar measures are to be considered. On the consumption side, electricity prices for consumers will ultimately have to be raised. Though it is a socially sensible task, other oil producing countries have experimented variety of ways of adjusting electricity or fuel prices ("backward bills" rewarding in cash the most efficient users of electricity, caped level of electricity consumption at subsidized prices, etc.).

On the supply side, the oil-based electricity generation leads to a significant loss of revenues for the Kingdom, as the barrels burnt could be sold at a much higher international price. The Saudi government has already geared the future power generation capacities to use natural gas, instead of crude oil[35], but the electricity sector will be competing with the petrochemical and desalination sectors to get sufficient access to natural gas resources (quotas).

To ease the pressure on natural gas requirements for electricity generation, the Kingdom is also considering introducing renewable energy and nuclear in the Saudi energy mix. This is definitely a positive development for Saudi Arabia and the world, as the Kingdom's ability to maintain an idle oil production capacity is vital for the stability of oil markets.

[35] All the future generation projects will be using natural gas.

In the short term, the nuclear option seems to raise many issues that the Kingdom may need to respond to before moving ahead with significant nuclear deployment in the country. While the Kingdom could easily set and implement a training and education plan for nationals to become professionals and engineers able to run nuclear power plants, there are many other issues that are awaiting decision from the Saudi authorities, or have to be negotiated with other stakeholders for the Saudi nuclear program to move forward.

So far, Saudi Arabia has resisted any commitment not to enrich uranium as part of a prospective deal to buy U.S. nuclear technology for its projected power program. Washington has continuously insisted on a so-called "123 agreement" banning enrichment as a condition for cooperation. Such a condition was part of a deal with the UAE when Abu Dhabi announced plans to buy nuclear power plants. However, if Iran is allowed to enrich uranium should the current diplomatic negotiations lead to an agreement between Iran and the P5+1, the Kingdom would probably request the same right.

In January 2014, Saudi Arabia announced that the Kingdom will delay the completion of its clean-energy program by eight years. This includes the solar power component, to allow more time for the assessment of the technologies to be used[36]. However, as solar energy raises less complex issues than nuclear energy program, it is likely to be deployed as a first move towards diversification of the Saudi power mix. Indeed, deployment of solar energy does not have the safety and political challenges of nuclear reactors; it requires less complex regulation, less sophisticated technology, most of which is available on the shelf. Additionally, it does not generate waste that needs treatment and storage, does not mobilize huge investments and does not trigger fears of accidents.

In addition, the solar sector is witnessing a rapid cost decline. The cost of PV modules has been divided by five in the last six years, while the cost of full PV systems has been divided by almost three. For bulk power on the grid, PV electricity can already be competitive at times of peak demand, especially in areas where peak electricity is provided by burning oil products, with ample room for improvement. Still, clear and sensible regulations are an important condition in streamlining the procurement process, since they provide confidence to the market.

The decision by Saudi Arabia and its OPEC partners not to cut oil production has already impacted the Kingdom and the recently released 2015 Saudi budget shows a $38.6 billion deficit[37] projecting a significant decrease in oil-generated revenue. While Saudi Arabia has accumulated a significant amount of foreign currency reserves

[36] <http://www.bloomberg.com/news/articles/2015-01-20/saudi-arabia-delays-109-billion-solar-plant-by-8-years>.
[37] Petrostrategies, 5 January 2015.

during the last few years and could sustain low oil prices for some time, it is likely that new projects and energy policy avenues will be impacted by the new oil market environment as the cost of launching a new nuclear program may be deterring. In any case, a nuclear program breakthrough in Saudi Arabia would be a significant shift in a hydrocarbon dominated economy, though capturing part of the Kingdom's oil rent for the funding of such program is far from being straightforward and the issue fuels extensive discussion among the main Saudi stakeholders.

Regardless of the Saudi electricity mix structure in the future, the revision (upward) of retail and wholesale energy and water prices remain an urgent issue for the Kingdom's energy policy makers. A first step, bearing less social sensitivity, could be the restructuring of the inter-sector energy transfer prices, thus incentivizing investment in energy exploration and generation, leading to more efficient use of resources, producing more value for the main players, and ultimately improving the Saudi energy sector as a whole.

Appendix 1: Electricity tariffs in Saudi Arabia (in $)

<table>
<tr><th>Consumption categories (in Kwh)</th><th>Residential</th><th>Commercial</th><th>Governmental</th><th>Private educational establishments</th><th>Private Health establishments</th><th>Agriculture</th><th>Charities</th></tr>
<tr><td>1-2000</td><td>0.013</td><td>0.032</td><td rowspan="10">0.069</td><td rowspan="10">0.032</td><td rowspan="10">0.032</td><td>0.013</td><td>0.013</td></tr>
<tr><td>2001-4000</td><td>0.027</td><td>0.032</td><td>0.027</td><td>0.027</td></tr>
<tr><td>4001-5000</td><td>0.032</td><td rowspan="4">0.053</td><td>0.027</td><td>0.027</td></tr>
<tr><td>5001-6000</td><td>0.032</td><td rowspan="5">0.032</td><td rowspan="5">0.032</td></tr>
<tr><td>6001-7000</td><td>0.040</td></tr>
<tr><td>7001-8000</td><td>0.053</td></tr>
<tr><td>8001-9000</td><td>0.059</td><td rowspan="3">0.069</td></tr>
<tr><td>9001-10000</td><td>0.064</td></tr>
<tr><td>>10000</td><td>0.069</td></tr>
</table>

Source: SEC website, consulted 26 January 2015 <http://www.se.com.sa/SEC/English/Menu/Customers/Consumption+bills/TarifAndTax.htm>.

Appendix 2: Route and layout of the GCC grid interconnection

Source: http://www.gccia.com.sa/project.aspx?p=IP

References

Alyousef Y. and Varnham A. (2010), Saudi Arabia's National Energy Efficiency Programme: description, achievements and way forward, April.

BP (2014), Statistical Review of World Energy, June

Dii (2013), Desert Power: Getting Started: The manual for renewable electricity in MENA, Full Report

Electricity and Cogeneration Regulatory Authority (2014), Activities and Achievements of the Authority in 2013, Kingdom of Saudi Arabia, August.

El-Katiri L. (2012), "The GCC and the Nuclear Question", Oxford Energy Comment, December.

El-Katiri L. (2014), A roadmap for renewable energy in the Middle East and North Africa, Oxford Institute for Energy Studies Paper, MEP 6, January.

Fattouh B. (2013), "Summer again: The swing in oil demand in Saudi Arabia", Oxford Energy Comment, July.

Hagihara J. (2013), "Saudi Arabia's domestic energy situation and policy: focusing on its power sector", Kyoto Bulletin of Islamic Area Studies 6, March.

IEA (2014a), World Energy Outlook.

IEA (2014b), Medium-Term Gas Market Report.

IEA (2014c), Medium-Term Renewable Energy Market Report

IEA (2014d), Linking heat and electricity systems: Co-generation and district heating and cooling solutions for a clean energy future,

IMF (2013), Labor market reforms to boost unemployment and productivity in the GCC, Annual meeting of Ministers of Finance and Central Bank Governors, October 5.

IMF (2014a), Energy subsidies on the Middle East and North Africa: Lessons for reform, March.

IMF (2014b), IMF Country Report n°14/292, Saudi Arabia, September.

IMF (2015), "Learning to live with cheaper oil amid weaker demand", Regional Economic Outlook Update Middle East and Central Asia Department, January.

IRENA (2013), MENA Renewables Status Report

IRENA (2014), Pan-Arab Renewable Energy Strategy 2030, Roadmap of actions for implementation.

K.A. CARE (2012), Building the Renewable Energy Sector in Saudi Arabia, September

Krane (2014), "Navigating the perils of Energy Subsidy reform in exporting countries", Baker Institute Policy Report, Published by the James A. Baker III Institute for Public Policy of Rice University, Number 58, May.

Lahn G. and Stevens P. (2011), Burning oil to keep cool: The hidden energy crisis in Saudi Arabia, Chatham House, December.

Luciani G. (2014), "Nuclear power in Saudi Arabia", Oxford Energy Forum, May 2014, Issue 96, p. 24.

Matar W. Murphy F., Pierru A. and Rioux B. (2014), Lowering Saudi Arabia's fuel consumption and energy system costs without increasing end consumer prices, KAPSARC Discussion Paper.

Meltzer J., Hultman N., Langley C. (2014), Low-Carbon Energy Transitions in Qatar and the Gulf Cooperation Council Region, Global Economy and Development Program at Brookings, Report, February.

Nachet S. (2014), Saudi Arabia's Energy Challenges, Saudi Economic Journal, January (in Arabic).

Prince Abdulaziz Bin Salman Al-Saud (2014), A brief on Saudi Arabia's Energy Efficiency Program (SEEP), Oxford Energy Forum, May 2014, Issue 96, p. 4

Segar C. (2014), Saudi Energy Mix, IEA Energy, Issue 7 – 4th quarter.

The Cooperation Council for the Arab States of the Gulf (GCC) General Secretariat (2014), Desalination in the GCC: the History, the Present and the Future, Second Edition.

World Bank (2012), Renewable Energy Desalination: An Emerging Solution to Close the Water Gap in the Middle East and North Africa.