ASSESSING ENERGY POLICY INSTRUMENTS IN RESOURCE RICH COUNTRIES: A CASE STUDY FOR LNG IMPORT IN SAUDI ARABIA

Maxime Schenckery, IFPEN- IFP School - Center for Energy Economics and Management, maxime.schenckery@ifpen.fr

Rami Shabaneh, KAPSARC, rami.shabaneh@kapsarc.org

Abstract:

Natural gas has been identified as part of Vision 2030 in Saudi Arabia to play an important role in diversifying the power mix away from oil. Studies have shown that if Saudi Arabia would meet its domestic gas production and renewable energy targets then it would be enough to meet its demand for power until 2030 (Matar and Anwer 2017). While developments are underway to ramp up domestic natural gas production, supplementing domestic supply with LNG imports could be an option to consider. Using a global gas model, this paper examines the issues and implications that come with opening up the economy for LNG imports and what specifications and market configuration are required if such a policy was adopted.

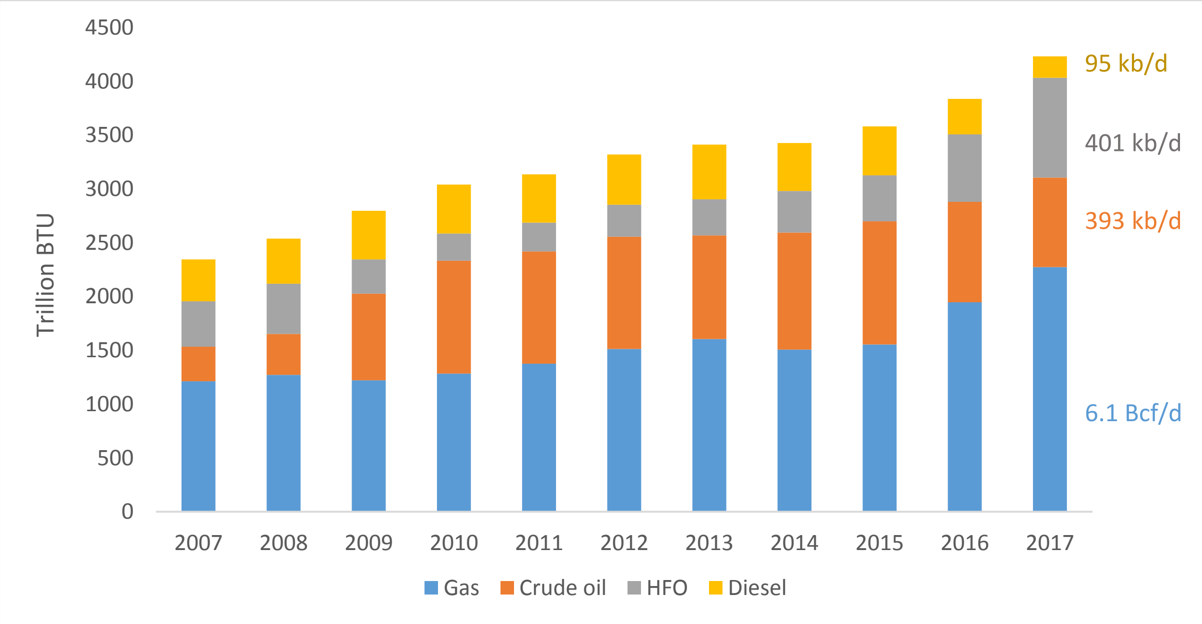
The paper reaches the following conclusions: i) LNG imports can provide a marginal benefit to Saudi Arabia's economy but it could also be a strategic fuel, used in a transition period, to support announced targets for domestic energy sources; ii)The electric load profile in Saudi Arabia is highly seasonal with peaks during the summer months for space cooling. This is counter-cyclical to major LNG importers and offers a value proposition for importing LNG during the summer when prices are lower; iii) An LNG import terminal for Saudi Arabia is best situated in the west coast to alleviate the western and southern regions from the high liquid fuel use; iv) Opening up the economy for LNG imports can further develop the gas markets in Saudi Arabia by introducing a gas benchmark price to create a conducive environment or roadmap toward further gas market liberalization.

1- Introduction

a. Saudi Arabia's power mix

Natural gas consumption in Saudi Arabia represents 37 percent of primary energy demand (BP Statistics 2018). At a sectorial level, the power sector is the largest gas consumer making up about two-thirds of total gas demand in the Kingdom followed by the industrial and petrochemical sectors. The growing need for power has strained domestic natural gas supplies. As a result, local utilities have used large amounts of liquid fuels for power generation to meet the remaining demand for fuel. As Figure 1 shows, depending on the availability of natural gas, liquid fuels – which consist of crude oil, heavy fuel oil (HFO), and diesel – can comprise almost half of the fuel used for electricity generation. In 2017, Saudi Arabia burnt through 1,958 trillion British thermal units (BTU) of liquid fuels, or almost 890 thousand barrels per day (kb/d), to generate power.

Figure 1: Yearly fuel consumption of power and seawater desalination by type

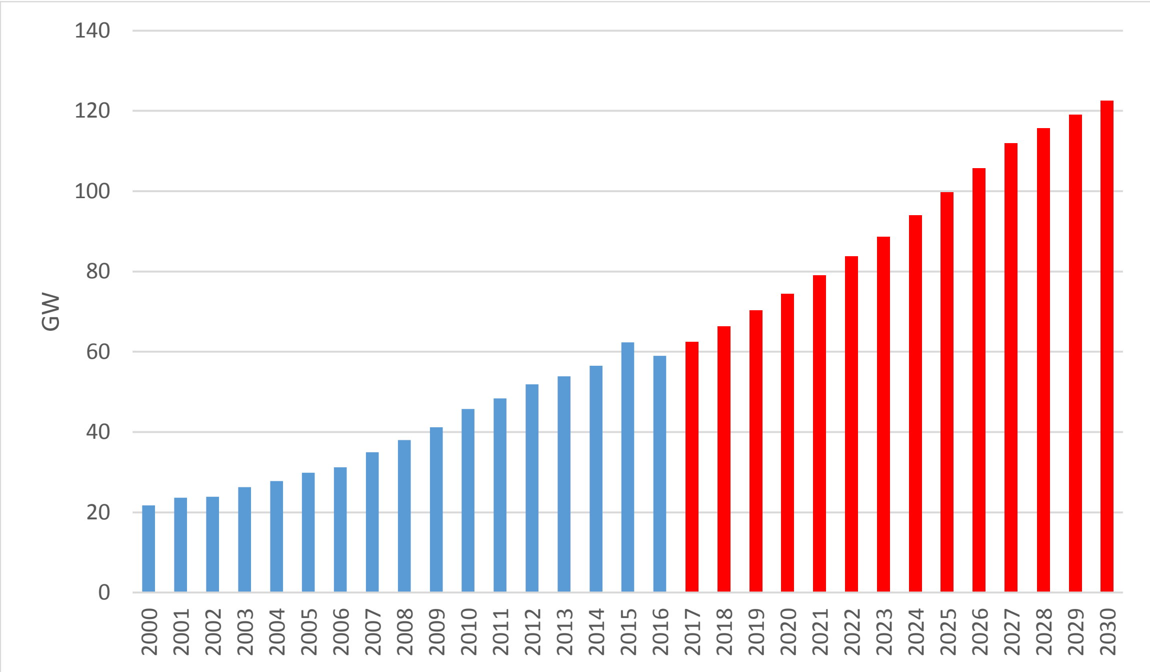


Source: ECRA, KAPSARC 2018

Despite sitting on the sixth largest gas reserves in the world (BP Statistics 2018), Saudi Arabia's production is yet to reach its full potential. Most of Saudi Arabia's gas supplies are sourced from associated gas from crude production. Due to the fast growth of gas demand in the country, Saudi Aramco has started to increase their production to non-associated gas fields. Between 2005 and 2012 gas production in Saudi Arabia grew at a rate of 4.5% per annum, but delays in developing new gas fields reduced supply growth to 3.5% per annum between 2013 and 2017 (BP Statistics 2018).

Meanwhile, rapid growth in power demand driven by population growth and industrial development has called for more crude oil and other liquid fuels to make up for the shortfall in gas supply. Historically low electricity tariffs – especially non-industrial tariffs - have also contributed to the high consumption in the residential sector. Although efforts are underway to temper power demand growth with fuel price reforms and imposing building and equipment efficiency standards, the Saudi Electricity Company (SEC) – Saudi Arabia's largest utility – expects peak load demand to double by 2030 as seen in Figure 2 (SEC 2017). With this expected growth in future power demand, keeping the status quo in the power mix implies a growing opportunity cost caused by an increased usage of crude oil and oil products.

Figure 2 Peak load demand expected to increase



Source: SEC

There are plans to double domestic natural gas production up to 23 Bcf/d from 2017 to 2030 which implies an annual growth rate of 5.5% per annum. While this target is plausible since Saudi Aramco raised output by 1.5 times between 2007 and 2017 at an annual growth rate of 4.1% p.a., the new gas supplies will not come from associated gas which has been traditionally the case. There is a shift toward developing more non-associated, more sour, and more unconventional gas fields which bring with it a set of challenges and higher costs. New and proposed expansions at Fadhili, Haradh and Midyan will accommodate over 3.5 billion cubic feet per day (Bcf/d) of raw gas supply over the next few years, but beyond that, new sources of supplies are required. Development of unconventional gas reserves are ongoing in North Arabia (Turaif), South Ghawar, and the Jafurah Basin. Baker Hughes has estimated that technically proven shale gas reserves to be around 645 trillion cubic feet – twice the shale reserves in the US (Elass 2018). Saudi Aramco is currently targeting 3 bcf/d of gas production from unconventional sources by 2030, more than a quarter of the forecast increase (Energy Intelligence 2018). In order to fully take advantage of its shale gas potential, Saudi Arabia will need to address technology transfer, water scarcity, and workforce concerns.

In the context of the difficulty and time taken to develop new domestic gas resource, LNG imports could become an interesting energy policy instrument to consider for Saudi Arabia. Under certain market configurations, LNG could add value to Saudi Arabia's economy by freeing oil barrels for exports (Blazquez, Manzano and Lester, et al. 2018). While presently there are no concrete plans to import LNG, this paper assesses how such a policy could play out, if it were to be adopted in the context of other policies and initiatives in the Kingdom including domestic energy market developments and energy efficiency measures.

b. Saudi Arabia's large seasonality for power demand

Residential demand accounts for almost 50 percent of annual power consumption due to the high air conditioning load during the summer months. Over 70 percent of power use in the residential sector is directed at space cooling (ECRA 2017). As can be seen in Figure 3, peak load demands in the eastern, central and western provinces are comparable as population density and industrial cities are concentrated in these provinces. The Southern region consumes almost a quarter of the three other regions. But they all have similar profiles in that they peak during the summer months starting from April through October.

Figure 3: Monthly average load variation in Saudi Arabia by region, 2017

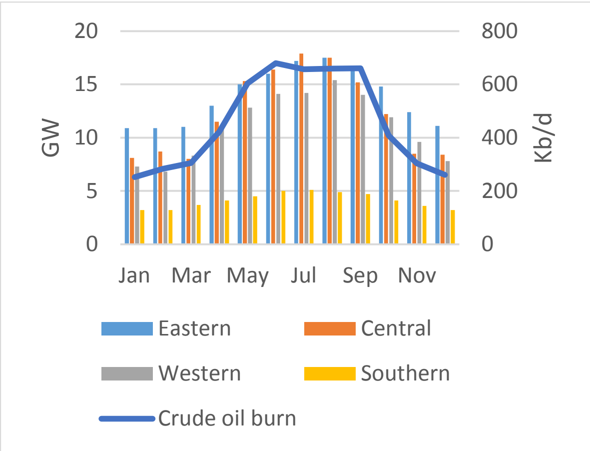


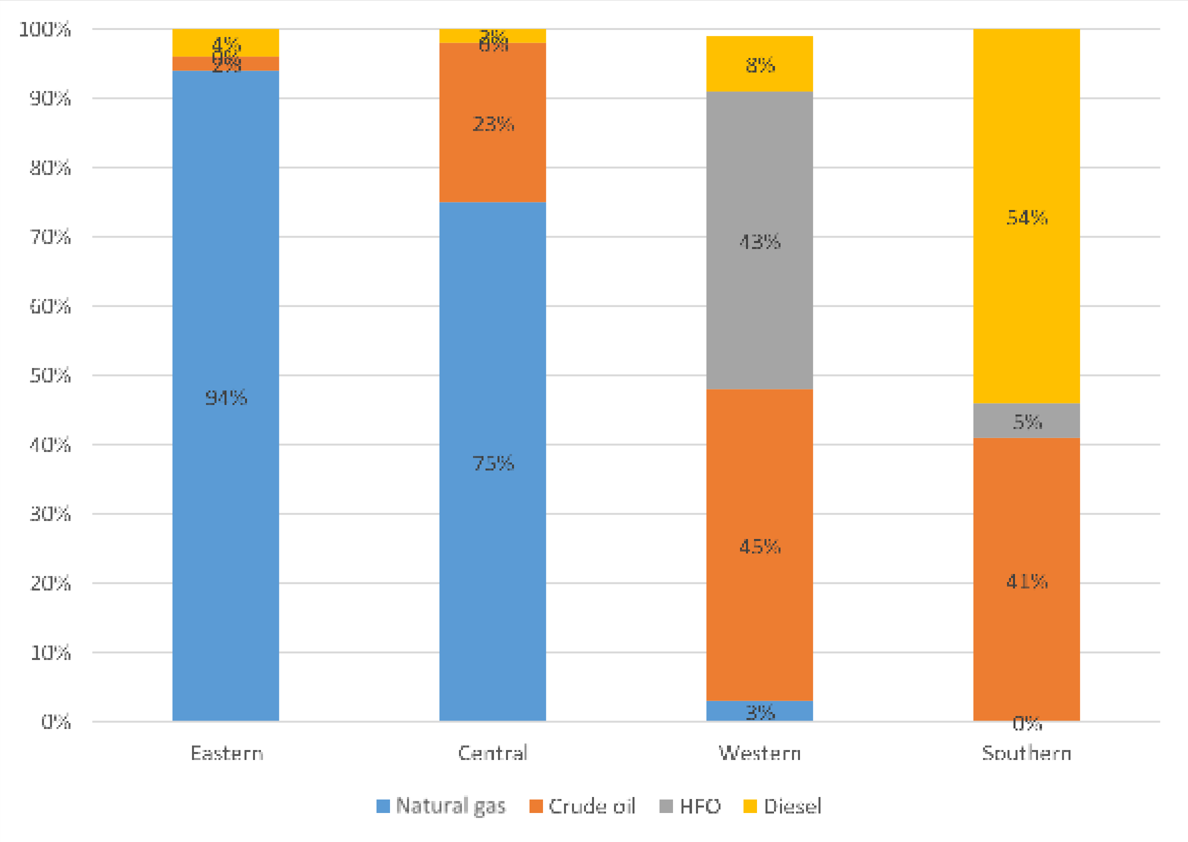
Figure 4 Map of Saudi Arabia with energy oil and gas infrastructure divided by region

Source: ECRA, Jodi data 2018

As mentioned earlier, crude oil makes much of the difference when gas is not available for power generation and so peaks during the summer month to meet air conditioning load but liquid fuel burning in power plants are not dispersed equally across the regions.

The Western and Southern regions burn the most liquid fuels as seen in Figure 5. The Master Gas System (MGS), a country-wide gas network completed in 1982, includes pipelines that transport gas from the eastern gas fields, where gas reserves are concentrated, to the rest of the regions. However, limited natural gas supplies, high industrial demand in the east and infrastructure bottlenecks limits the amount of natural gas transmitted on the MGS pipelines.

Figure 5 : Distribution of Annual Fuel Consumption by region, 2017



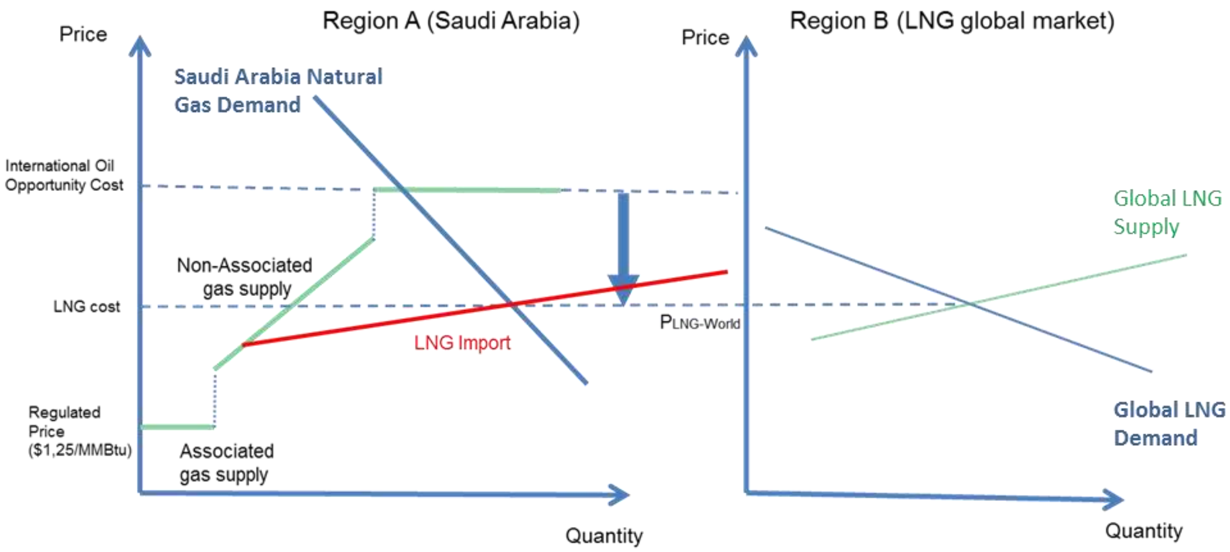
Source: ECRA

Given the greater intensity of liquid burning in the west, compared to the eastern part of the country, and to avoid infrastructure constraints on the MGS, an LNG import terminal along the Red Sea coast could be a potential solution.

2- Power generation supply curve

We model the natural gas market in all its components through the following framework. Figure 6 below shows two charts: Region A which represents Saudi Arabia's energy market equilibrium for power generation. While Region B represents the international LNG market equilibrium. The two regions could be connected by infrastructure to facilitate trade, [but currently are not]. As we see in Region A, currently there is less supply available relative to demand. Majority of the supply is made of associated gas supply (produced as a byproduct of oil) at a very low cost but in limited quantity. Shifting to non-associated gas raises the cost of the gas supply. The lack of sufficient gas volume forces utilities to resort to crude oil and oil products at a higher opportunity cost, the international price for crude oil.

Figure 6: Supply curve for power generation including international LNG trade



Without LNG imports (absent the ability to trade), the power market, in Region A, clears at the international opportunity cost of oil.

On the other hand if LNG imports were allowed, the price clears at the total cost of imported LNG. Domestic supply, in this case, will develop until their delivered cost equals the LNG delivered cost. A market reflecting the real price for natural gas is created. It reflects the international LNG markets supply and demand balance as well as the cost of domestic development.

The movements of prices in each region will depend on the relative elasticity (price responsiveness) of supply and demand, which will also determine the amount of trade that occurs (and infrastructure that is required). LNG import capability brings flexibility to Saudi Arabia energy system while enabling to guide the domestic development according to international market signal.

In this configuration, LNG import in Saudi Arabia should be seen not only as a cheaper alternative to oil but also as an energy policy instrument to improve energy security and adaptability to an uncertain energy transition future.

3- Scenarios specifications for Saudi Arabia integrated in the global LNG market

To determine the possible and optimal sources to procure LNG into Saudi Arabia, we use a partial equilibrium model that is specified as a linear programming problem (Nexant 2018). The model has a dynamic nature: it considers a long time horizon (2040) that is further decomposed using a quarterly time resolution. From a spatial perspective, the representation used in the model includes all the countries that produce, consume and transit gas. Each of them is modeled as a given node in the model. At each consuming node, there is an exogenously-determined demand level that is posited to be purely price inelastic.

The model decision variables represent the supply and trade flows of natural gas. Overall, the model mimics the decisions of a benevolent social planner that seeks to minimize the total cost of all the components of the global gas supply chain: including extraction, pipeline and LNG transportation and underground storage. The planner's optimization problem is also subjected to a set of linear constraints representing: the mass balance equation at each node and each time period, the infrastructure technical limitations or some contractual restrictions. As usual with that type of linear programming problem, the shadow variable associated with the mass-balance equation at a given note and at a given time period provides the marginal cost to supply gas at that node at that time. This marginal cost can be interpreted as the equilibrium price of natural gas that would prevail under perfect competition at that market at that time.

The calibration of the model is conducted using Nexant's proprietary database, Kapsarc data and authors' analyses regarding Saudi Arabia and the world energy features that typically provides the trajectory of future demand levels at the consuming nodes, the cost and capacities at the extraction nodes, the characteristics of the infrastructures. In order to allow for assess the potential of LNG imports into Saudi Arabia in the WGM, we create two cases for a supply deficit building up to year 2030: a 6.8 bcm (5 mtpa) case and a 30 bcm (22 mtpa) case summarized in Table 1. The former is our base case and it is based on a commonly sized import terminal that is within the range of neighboring Middle Eastern countries such as Kuwait and Egypt. The latter case is based on an assumption that Saudi Arabia replaces almost all of its liquid fuel usage in power plants with LNG. The second case also allows us to build a cost stack of multiple LNG supply sources to meet the highest potential demand for gas in the Kingdom.

As seen previously, the western coast of Saudi Arabia presents the best location for an LNG import terminal. An import node was created on the west coast of the country, namely the Jeddah port. It is also located along one of the main global shipping routes geographically next to the Suez Canal. Yanbu or any other port location along this coast is equally appropriate and does not change the results from the model. In addition, all LNG routes and distances were calculated from each export terminal that exists and planned into the Saudi receiving port (Voyage Planner 2018).

For the receiving and regasification terminal, two technologies are compared in terms of the inherent flexibility, speed of implementation and cost competitiveness: Floating Storage and Regasification unit (FSRU) and on-shore terminal. FSRUs are scalable and the investment in it is reversible without worrying about "stranded assets". (Songhurst July 2017). Given that LNG imports may only be a transitionary instrument. As a consequence, FSRUs are used to build our Saudi case.

WGM's cost assumptions for Kuwait's FSRU are used as a cost benchmark. In order to take into account lead time to plan, construct and deliver the FSRU along with the required on-land infrastructure, it is assumed that Saudi Arabia would start importing in 2021.

Table 1: Assumed characteristics and costs for the FSRU

Location	Nominal Capacity (mtpa)	Nominal Capacity bcm	Assumed start	Fixed Cost ($/mmBtu)	Variable Cost ($/mmBtu)
Port of Jeddah	5	6.80	2021	0.27	0.51
Port of Jeddah	22	30	2021	0.27	0.51

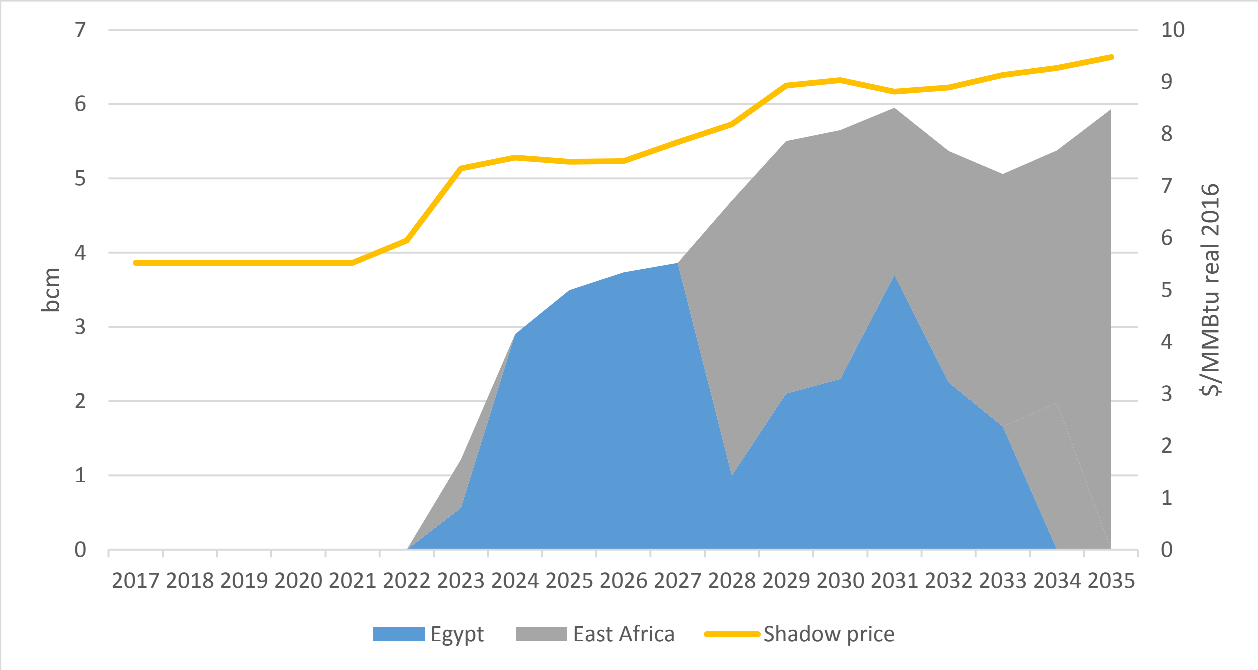
Source: KAPSARC

Other assumptions had to be taken into account in terms of LNG trade. Geographically, Saudi Arabia is surrounded by countries with large reserves of relatively inexpensive gas. However, geopolitical stance with Israel, Iran, and Qatar rules out gas imports from those countries and it has fed through in our assumptions. The civil war in Yemen has also forced the 6.5 MTPA Yemen LNG to declare force majeure in April 2015 and has remained offline since. However, no damage has occurred to the liquefaction units and we assume a return of exports by 2022.

4- Results of the simulation

In base case scenario of 6.8 bcm (5 MTPA), LNG imports into Saudi Arabia come mainly from Egypt and the Ruvuma Basin in East Africa (Mozambique and Tanzania) as seen in Figure 7 given their geographical proximity to Saudi Arabia. In addition, the timing of their development coincides with the start of LNG import in the Kingdom in our model.

Figure 7 Model simulation of LNG imports into Saudi Arabia under a 6.8 bcm (5 MTPA) scenario



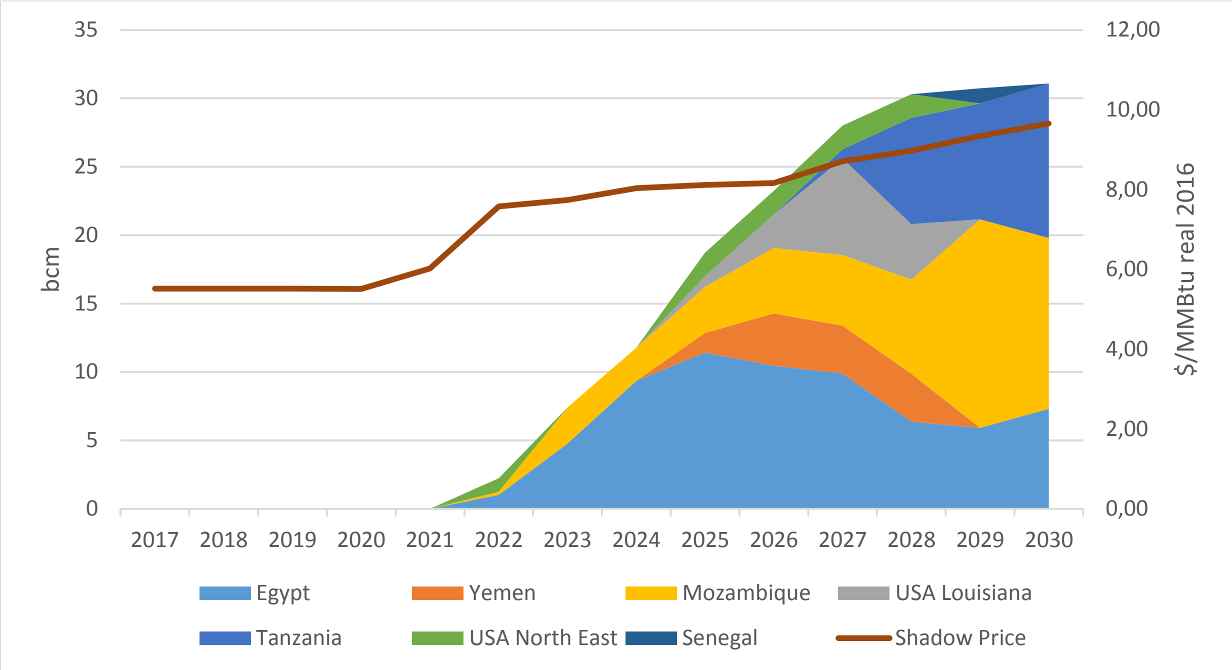
Source: Authors based on WGM - March 2018

The shadow price in Saudi Arabia increases from $7.3/MMBtu in 2022 to 9.5/MMBtu in 2035. The increase in price reflects an assumption of the model that natural gas resources like any natural resources are exhaustible and that the least expensive ones are tapped first. This delivered price includes the cost of gas, liquefaction cost, transportation and regasification. This also takes into consideration the structure of the contracts which are a mixture of spot price formula and oil priced indexed.

There are almost 72.5 bcm (or 53 MTPA) of LNG projects from East Africa that are slated to come online by 2035 according to the gas model's assumptions. This implies that the Ruvuma Basin would be a key supplier to Saudi Arabia if they chose to expand their imports further. Furthermore, even if LNG exports from Egypt are restricted over the long run (priority given to a growing domestic demand), other projects in the Mediterranean area could be potential suppliers to Saudi Arabia such as from Lebanon or Cyprus.

In fact, in the 30 bcm scenario (Figure 6), East Africa continues to play a significant role in supplying LNG to Saudi Arabia making up to 76% of Saudi imports. Other suppliers include Yemen, West Africa, and the US Gulf coast (Louisiana projects in particular, and also from the US Northeast).

Figure 8: Model simulation of LNG imports into Saudi Arabia under a 30 bcm (22 MTPA) scenario



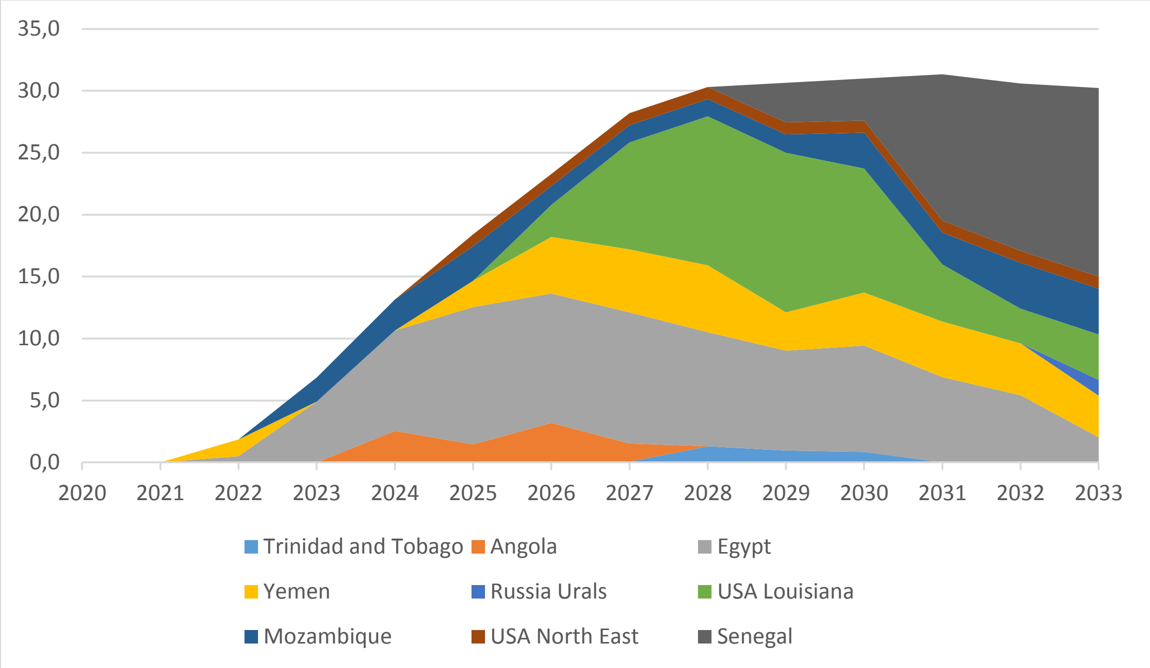
Source: Authors based on WGM - March 2018

Under this scenario, shadow prices for Saudi Arabia rises from $7.6/MMBtu in 2022 to $10.4/MMBtu in 2035. This does not show a significant difference in prices from our base case. This implies large volumes are available from the global gas markets for import into Saudi Arabia without moving excessively the cost of supply. The global LNG market provides some elasticity over the long term.

There is no doubt the Rovuma Basin is a world class reserve measuring up to an estimated 188 tcf (5.3 tcm) of gas resources (IHS Markit 2017). This is equivalent to the proven reserves of Nigeria or Venezuela (BP 2018). This makes the region one of the most promising new gas provinces, as the first gas discovery only took place in 2010. However, so far Eni's 3.3 MTPA Coral FLNG is the only project that has passed FID. Others are currently under evaluation and development. Many of the delays in East Africa projects can be traced back to the drop in oil and gas prices in mid-2014 which threatened the economics of remotely-located greenfield projects. In addition there are local institutional challenges which created many political hurdles as domestic usage of the natural gas is seen as a privileged instrument to accelerate the economic development (Schenckery and Shabaneh 2018). Thus a sanity check scenario was run in which East African projects were risked, with the exception of Coral FLNG, to understand what the likely alternatives of supply were.

In this case, as seen in Figure 7, most of the Saudi demand is being covered by West African and US LNG, but also LNG from the Russian Urals (i.e. Yamal LNG or Artic LNG 2) becomes a competitive option.

Figure 9: Model simulation of LNG imports into Saudi Arabia under a 30 bcm scenario with risked projects from East Africa



Source: Authors based on WGM - March 2018

The competitive nature of the global LNG market represented in the model and the implied elastic supply curve could enable Saudi Arabia to accommodate large fluctuations in natural gas demand using imports. As we showed in Figure 3, Saudi Arabia's load profile is highly seasonal. As such, it is counter-cyclical compared to the global LNG market where the peak demand for natural gas happens during winter when demand in the Northern hemisphere peaks for heating purposes.

In WGM, Saudi Arabia is displayed as having a demand profile for gas satisfying natural gas demand for all residential and industrial sectors. However, if Saudi Arabia opens up its economy to imports, it is expected that more gas would be procured in the summer for the power sector. This will reflect in its demand profile. Using data from ECRA for 2015 seasonal power load, we assumed that the same pattern will be experienced for natural gas residential demand. The table below defines the seasonal variation included in our model.

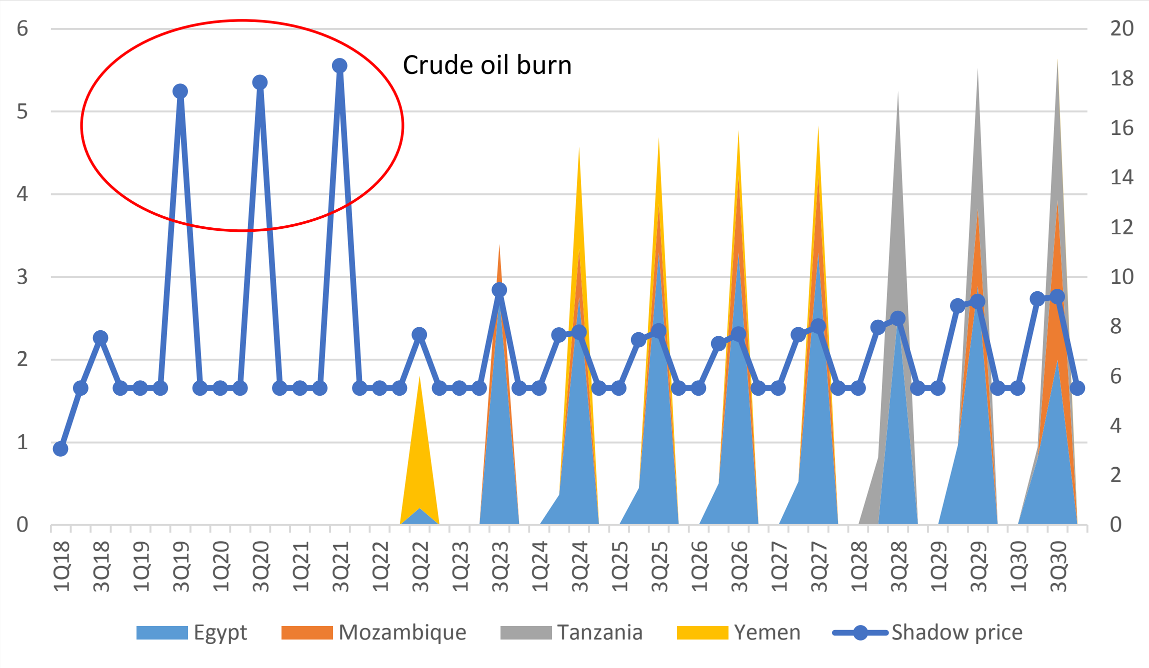
Table 2 Quarterly natural gas demand for Saudi Arabia integrated in WGM model for Saudi Arabia

Q1	Q2 (Apr, May, Jun)	Q3 (Jul, Aug, Sep)	Q4
19%	27%	31%	23%

Source: Kapsarc based on ECRA 2015

Running the base case scenario (6.8 bcm) with seasonality displays a more realistic picture of the current situation in Saudi Arabia. As figure 8 shows, price spikes during the summer months reflecting the higher opportunity cost of burning crude oil. However once LNG is allowed in 2021-22, shadow prices soften and drop down to reflect the long-run marginal supply of LNG.

Figure 10: LNG imports with a seasonal demand profile in Saudi Arabia



Source: KAPSARC based on WGM data

Another observation to note is that when we introduce seasonality, the model calls on Yemen to fill the void after exhausting supplies from Egypt and East Africa, in contrast to what we have seen in the first scenario with a demand without seasonality. This is due to supply mismatch from East Africa and Egypt with respect to Saudi Arabia's demand profile. In other words, LNG capacities from Egypt and East Africa alone are not able to meet all of Saudi Arabia's demand in the summer and the model had to call up on other sources.

It is clear from the figure above that Saudi Arabia only imports during the summer months while domestic supplies can fulfil its demand during the winter season. Thus, if Saudi Arabia does import LNG it would be sensible to only contract LNG volumes seasonally, similar to Kuwait (who imports only between April to October). This can open up opportunities in entering joint-ventures with winter-season importers to invest in LNG projects in new areas like East Africa, or with trading houses where volumes can be shared or swapped and therefore reduce costs.

5- Discussion

a. What does this mean to the power sector

EIA's (EIA, Table 8.1. Average Operating Heat Rate for Selected Energy Sources 2017) heat rate indicates a net advantage for natural gas power generation versus petroleum based one. According to literature, (Blazquez, Manzano and Lester, et al. 2018) this applies also to Saudi Arabia. We used EIA heat rate for 2017 in the calculations. In the table 3 we only consider crude oil and not heavy fuel oil or diesel despite the fact that as seen previously these liquid fuels are used in Saudi Arabia power generation industry. Conversion rate origins from BP (BP Statistics 2018).

Under the current regulated price framework, electric utilities purchase oil at $6.35/barrel ($1.11/MMbtu) and natural gas at $1.25/MMBtu in Saudi Arabia (APICORP February 2018). Within this framework, oil is more competitive than natural gas in power generation. In case of oil abundance and low price, power generation could be an easy outlet for spare oil production (if no carbon neutrality is required).

However, we can see from Table 3 upon a move toward a deregulated market and international pricing, LNG becomes more competitive than burning crude oil assuming a long term price for oil of $85/bbl.

Table 3: cost of electricity according to feedstock prices

Heat rate for crude oil power plant (MMBTu/Mwh)	10,83	source: EIA 2017 https://www.eia.gov/electricity/annual/html/epa_08_01.html	
Heat rate for NGCC (MMBTu/Mwh)	7,81	source: EIA 2017 https://www.eia.gov/electricity/annual/html/epa_08_01.html	
BBl to MMBTU	0,172	source: BP Statistical 2018	
2018 Regulated environment and opportunity cost of oil	oil at $6.45/bbl ansd gas at $1,75/MMBtu	oil at $85/bbl and gas at $1,75/MMBtu	oil at $55/bbl and gas at $1,75/MMBtu
Total cost of 1 Mwh from crude oil power plant ($/Mwh)	12,02	158,39	102,49
Total cost of 1 Mwh from natural gas combined cycle ($/Mwh)	13,67	13,67	13,67
US LNG (Tellurian fixed priced ie $8/MMBtu)	Oil at $85/bbl and LNG import at $8/MMBtu	Oil at $55/bbl and LNG import at $8/MMBtu	Oil at $35/bbl and LNG import at $8/MMBtu
Total cost of 1 Mwh from crude oil power plant ($/Mwh)	158,39	102,49	65,22
Total cost of 1 Mwh from natural gas combined cycle ($/Mwh)	62,50	62,50	62,50
LNG priced with standard (conservative) oil indexed clauses	Oil at $85/bbl and standard oil indexed contract for Asia (14%+1$)	Oil at $55/bbl and standard oil indexed contract for Asia (14%+1$)	Oil at $35/bbl and standard oil indexed contract for Asia (14%+1$)
Total cost of 1 Mwh from crude oil power plant ($/Mwh)	158,39	102,49	65,22
Total cost of 1 Mwh from natural gas combined cycle ($/Mwh)	100,77	67,96	46,09
2035 Market based price for LNG import in Saudi Arabia versus oil price at $85/bbl	Oil at $85/bbl and LNG at oil parity	Oil at $85/bbl and LNG scenario 1 - 6 Bcm	Oil at $85/bbl and LNG scenario 2 -30 bcm
Total cost of 1 Mwh from crude oil power plant ($/Mwh)	158,39	158,39	158,39
Total cost of 1 Mwh from natural gas combined cycle ($/Mwh)	114,21	74,21	81,24
2035 Market based price for LNG import in Saudi Arabia versus oil price at $55/bbl	Oil at $55/bbl and LNG at oil parity	Oil at $55/bbl and LNG scenario 1 - 6 Bcm	Oil at $55/bbl and LNG scenario 2 -30 bcm
Total cost of 1 Mwh from crude oil power plant ($/Mwh)	102,49	102,49	102,49
Total cost of 1 Mwh from natural gas combined cycle ($/Mwh)	73,90	74,21	81,24

Source: Authors' calculations

If the true opportunity cost of oil in the form of its international price is charged, then natural gas is always more competitive. In case of the oil price parity with natural gas prices, natural gas will still be attractive due to lower heat rates attained by a combined cycle power plant.

When looking at our global market based scenarios, LNG import in Saudi Arabia is competitive against oil at $85/bbl as well as at $55/bbl. Oil indexed contracts stay competitive against any oil prices due to the inherent better efficiency in heat rate. New schemes with a fixed cost like proposed by Tellurian remain competitive against a $35/bbl oil.

The LNG market has grown remarkably in the past decade and has seen new LNG suppliers coming into the scene, such as Australia, US, and Russia. Shorter term and destination-free contracts, especially from the US, are providing flexibility to buyers and an alternative to oil-linked long term contracts thus increasing the appetite for LNG in some markets. In addition, from the demand side, alternatives to fixed, onshore regasification terminals such as floating storage and regasification units (FSRUs) are also offering flexibility in seeding new markets and utilization of LNG.

Power cost using LNG import market price determined throughout our scenarios is always competitive against oil. If LNG is bought from the US or through oil indexed contracts, gas remains more competitive than crude oil in power generation. As calculated in the above table LNG is an acceptable option compared to burning oil for power generation. When looking at levelized cost, gas is also competitive compared to oil according to SEC (AlSaggaf 2018)[1]

b. LNG as a strategic fuel

Integrating Saudi Arabia into the global natural gas market provides an interesting feature and value beyond the apparent economic benefit. Due to the flexible nature of gas and the scalability of regasification technologies such as FSRUs, LNG can adapt (scaled up or down) with the current availability of domestic energy whether it would be gas or renewable technologies. It can also adapt with other national policies such as meeting environmental and air quality targets. Chartering an FSRU on a short to medium term basis, as opposed to building onshore regasification terminals, reduces the risk of stranded assets and can reverse this commitment to rent the FSRU in a matter of months. In this configuration, allowing for LNG imports can provide an insurance against changes or delays in domestic gas development, gas infrastructure expansions, or even renewable and alternative energy deployment. During this transition time, Saudi Arabia's energy policy could leverage on LNG flexibility to adapt to a transitioning energy system at a lower cost instead of relying on liquid fuels. Being part of the physical LNG markets can bring a tangible value in terms of diversification of Saudi Arabia's energy portfolio. Many of Saudi Arabia's crude oil and products partners are growing LNG consumers. Hence, with more destination-free contracts, Saudi Arabia may leverage on its trade experience to divert unwanted cargoes.

Saudi Arabia looks to reform energy pricing mechanisms in the energy sector. Introducing an international trading capability like LNG import, introduces market pricing into the power generation supply mix. Trade enablers like LNG import infrastructure could lead Saudi Arabia towards more resilient energy market based pricing. As more quantities of LNG come in at international prices, the delivered cost of LNG starts to feed through the domestic markets and facilitate a price benchmark for gas. This price can create a pathway to incentivize development of domestic gas markets.

Historically, low domestic gas prices created a situation in which demand outstripped supply and the government intervened with quota limit to different gas consuming sectors. Opening

[1] This report outlines the competitiveness of solar power generation against natural gas and oil. Assumptions on the future of solar power generation cost curve is an interesting object of research but is going further than the scope of this study.

up the economy to allow gas imports may put domestic natural development in competition with LNG to fulfill gas demand for power generation. In this case, domestic natural gas volumes will be developed until their cost equals Saudi delivered LNG price. This provides an interesting tool to avoid over investing in domestic natural gas especially non-conventional gas development.

6- Conclusions

Interestingly, when running the model with allowing Qatar to supply Saudi Arabia, given the geographical position of the receiving terminal on the west coast in the Red Sea, the model clears without any import from Qatar. All the free Qatari LNG flows to closer Kuwait, UAE, Pakistan and India. If the receiving terminal is positioned in the East coast (Dharam area) then LNG import flows from Qatar as the model optimizes total cost i.e. including associated LNG transportation cost.

If oil, diesel or HFO continue to be priced at current regulated prices for power generation, nothing will happen as utilities will continue to invest in power generation plants based on oil products. Neither domestic development of gas nor LNG import can be competitive. In addition, most of renewable energy based power generation will have fragile economic rationality if any. If strong economic assumptions such as domestic energy price at international energy prices are taken, demand will be curved down significantly reducing the need to develop new energy sources for Saudi Arabia.

In the meantime, LNG import creates a framework where Saudi Arabia navigates progressively towards more market pricing of energy while enabling the emergence of fuel competition in the domestic power generation market. But gas alone is not the only solution to displacing oil out of the power mix. Other options are on the table such as renewable technologies and nuclear. Energy efficiency initiatives have also recently started to take effect and thus natural gas may need to fight for its place in the power mix within a lower-than-expected energy demand. In addition, making natural gas infrastructure more efficient, such as adding seasonal storage, is also an option to consider assessing further the viability of LNG. At the extreme case, exporting piped natural gas in the East while importing LNG in the West may be seen as an interesting plot to investigate.

Despite its apparent disruptiveness, a limited import of LNG in the west part of the country and during summer could be a worthwhile and relatively easy to implement policy instrument to improve Saudi Arabia energy security and adaptability during the current transition era toward a more neutral CO_2 emission environment. Furthermore, the supply curve for the power generation industry is an interesting instrument to understand how Saudi Arabia could introduce market based energy pricing through international trade development.

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