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Saudi Arabia energy transition: where does the kingdom stand?

28 June 2021

- **The development of renewable energies and energy efficiency are amongst the key pillars towards economic diversification** across the national "Vision Plans" of the Gulf Cooperation Council countries.
- **The Covid-19 pandemic came to crystalize the structural weaknesses of oil exporting countries.** Affected by a double shock – the Covid-19 and the oil price shock that resulted from the sudden stop in global oil demand- Gulf economies suffered massively from energy exports revenues loss, a conjuncture that brought to the forefront the need to push further for a sustainable economic diversification.
- **Benefiting from a privileged location, abundant resources (solar, wind), GCC countries, and more particularly Saudi Arabia, display a strong will to operate this energy transition** - the recent announcement of the Green Middle East and Saudi initiatives are a clear example of these efforts
- Even though, **we believe the oil industry will remain the key driver for the post-Covid recovery and mid-term economic development for the GCC economies.**
- In this paper we want to offer our readers with **a broad review on key themes and facts that currently define the promising prospects of the energy transition in the Kingdom of Saudi Arabia.**

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1. Foreword

Historically tied to its fossil fuel resources, the economic growth and development of the Gulf Cooperation Council countries[1] has been fully dependent on oil and gas production and revenues for decades. In recent years, the economic diversification agenda, embodied in the country-specific *Vision 2030/ 2040*[2] economic development plans introduced since 2008, have come to accelerate structural economic and social reforms. The renewable energy sector and energy efficiency are amongst the key pillars towards economic diversification: the rapid and sustained growth in domestic energy demand, the shocks in global oil and energy markets beside prospects for a post-oil era, have played in the decision process to embrace this shift.

The Covid-19 pandemic came to crystalize the structural weaknesses of oil exporting countries. Affected by a double shock – the Covid-19 and the oil price shock that resulted from the sudden drop in global oil demand - Gulf economies suffered massively from the loss of energy export revenues, a conjuncture that brought to the forefront the need to push further for a sustainable economic diversification.

Accordingly, on 27 March 2021 in the wake of the Covid-19 crisis, Saudi Arabia announced the launch of a Green Middle East initiative and a Green Saudi initiative as an engagement towards a more sustainable future in the region. These initiatives are set to apply several ambitious programs that pursue the reduction of carbon emissions by 60 % in the region by 2030 and the world's biggest afforestation mission (the plantation of 50 billion trees in the Gulf).

Despite the region's comparative advantages (geographical location, high solar irradiation, wind) and the current efforts to start materializing it, we believe the oil and gas industry will remain the key driver of the post-Covid recovery for the GCC economies. Indeed, in a moment when the fallout of the Covid-19 pandemic has resulted in the oil majors cutting long-term CAPEX directed towards hydrocarbon investments whilst announcing ambitious plans regarding renewables generation, GCC national oil companies (NOCs) will have the opportunity to expand their capacities through the investment in additional production. This represents an opportunity to increase market share and control over a commodity that is likely to maintain importance in the economic system in the coming decades.

With this paper we want to offer our readers a broad view on key themes and facts that currently define the promising prospects of the energy transition in the Kingdom of Saudi Arabia. In the first chapter we offer a global assessment of the GCC energy sector, a short recap on its natural resources endowments but also on its renewable energies potential. In the second chapter, we briefly address the history, the present and the mid-term prospects of the Saudi oil industry following the Covid-19 pandemic. In the third chapter, we will discuss the actual key positioning of OPEC's NOCs in reshaping the post-Covid oil market what leads us to emphasize the key role the oil industry will keep on playing in the Saudi economy over the long-term.

Finally, in the fourth and fifth chapters we will present the Saudi roadmap for the development of renewable energy within the frame of the Saudi Vision 2030 plan and a case study of green transition in Saudi Arabia: desalinization.

Lysu Paez-Cortez

[1] The Gulf Cooperation Council, GCC, is a regional political and economic union established on the 25th May 1981 between Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.
[2] All six GCC members have set development strategies plans with different target years, most of them fixed at 2030: Bahrain Economic Vision 2030 (2008), Kuwait Vision 2035 (Jan.2017), Qatar National Vision 2030 (Jul.2008), Oman Vision 2040 (Dec.2013) and Saudi Vision 2030 (Apr. 2016). The UAE has national initiatives such as UAE Centennial 2071, the UAE Vision 2021 and variants within its Emirates, i.e. the regional Abu Dhabi Vision 2030.

2. GCC energy sector: present and future

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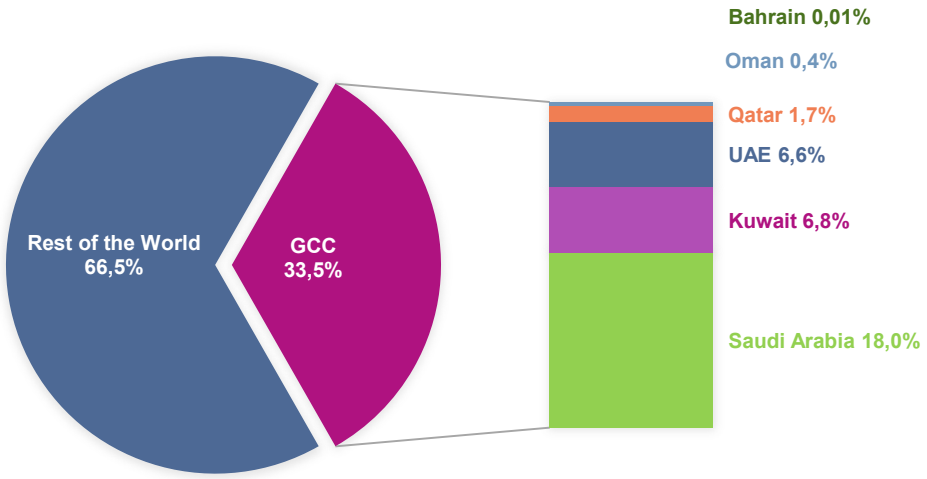
Abundant natural endowments and sustained investment

According to OPEC and EIA data, as of 2018 **GCC countries were holders of 33.5% of the world proven crude oil reserves**, equivalent to 497 billion barrels of crude (see Chart 1). The same goes for natural gas reserves: Qatar is the 3rd largest natural gas reserves holder in the world with 14% of world's natural gas endowments (24.5 trillion cubic meters) behind Russia and Iran, and the world's top liquefied natural gas (LNG) exporter (107Bn cubic meters in 2019), ahead of Australia and the USA.

CHART 1: Annual Proven Crude Oil Reserves



Sources : KAPSARC, OPEC, EIA

These resources, although abundant, are unevenly shared. Saudi Arabia (54%), Kuwait (20%) and UAE (20%) host the bulk of crude oil reserves but all GCC countries - notably Saudi Arabia - benefit from one of the lowest crude oil marginal production cost in the world, making the oil and gas business very profitable in the region. Over the past three decades, the GCC oil production has been growing steadily, as has been rising non-OPEC crude production lead by the US and Russia (see Charts 2 and 3).

Chart 2: GCC Oil Production (Thousands Barrels/Day)

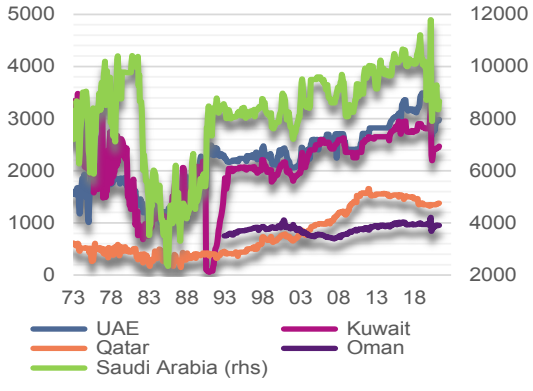
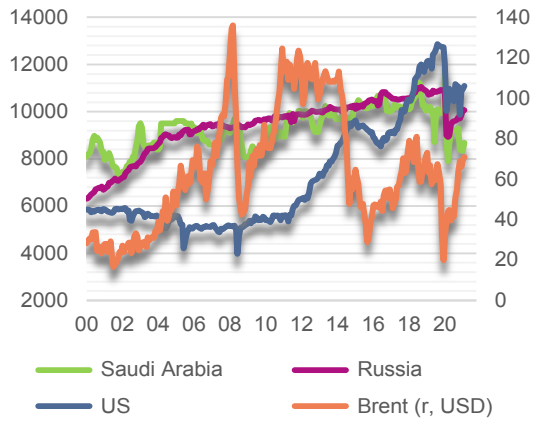


Chart 3: US, Russia and KSA Oil Production (Thousands Barrels/Day) vs. Brent



Sources : EIA, Natixis

Sources : Datastream

Beyond their natural endowments, and unlike many other oil producers, GCC countries (except for Kuwait) have known a rather stable political environment and benefited from extended peace. This geopolitical factor cleared the way for investments to ramp up the oil and gas production infrastructures. Such investments helped GCC countries develop their refining capacities, a crucial element for a region where crude oil is considered sour (indicating a higher than average sulphur content). The upgrade in refining technologies eventually reduced the price gap between crude oil produced in the region, normally associated to the benchmarks of the OPEC basket or Dubai's Fateh, and other European (Brent) and North American (WTI) benchmarks.

However, since 2014 and following the marked fall in global oil prices, questions over the sustainability of this financial windfall are more persistent. In the face of volatile and low oil revenues, GCC countries have accumulated widening deficits, revealing pressing needs for economic diversification. The domestic energy consumption growth and energy efficiency challenges also add pressure on the disposable oil production available for exports. Also, the imminence of energy transition and peaking global oil demand point towards the necessity for GCC countries to reduce their reliance on oil revenues and look for alternative resources. Renewable energies are a solid contestant to become an important new revenue stream.

An opportunity to seize: the promise of a renewable future

The region showcases a great potential for renewable energy and power generation. The possibility to leverage natural endowments such as the amount of sun or the presence of wind, technically translated as the level of solar irradiance and wind speed, respectively, vary from one country to another, but globally, opportunities are numerous.

Potential for solar photovoltaic technology (PV) is the highest in the region with suitable locations in all GCC countries, even though the UAE concentrate currently 65% of solar PV capacity in the region. Dust and high levels of humidity make the region less appropriate for concentrated solar power (CSP) technology, yet suitability of some parts of the GCC region compares with the best sites for this technology worldwide, notably in Saudi Arabia and Oman. Finally, and contrary to common expectations, the GCC region is also a good fit for wind energy. Technological improvements, such as high turbine towers and longer blades, are making wind farms economically viable in regions with lower wind speeds. Currently, the best sites are located in Saudi Arabia, Oman and Kuwait.

Given these promising features, GCC countries are quite ambitious regarding their renewable energy targets, especially the biggest markets, i.e. Saudi Arabia and the UAE. In fact, the UAE plan to convert 44% of its power generation capacity to renewables by 2050 while Saudi Arabia wants to produce 30% of its energy out of renewables and other sources, but one must specify that nuclear energy will play an important role in attaining this objective. The other countries present themselves as outliers with more modest targets, Kuwait aiming for 15% of electricity generation to come from renewables by 2030, the figure is at 10% for Bahrain by 2035 and 10% for Oman by 2025. A total of nearly 7 GW in renewable capacity is expected to be completed in the early 2020s. Solar PV accounts for the three-fourths of the project pipeline, CSP (10%) and wind projects (9%) coming after.

The last five years have been decisive for renewable energies in the GCC region. Plans have converted into operating projects and future investment outlook has increased. From 2016 to 2018, pioneering record-breaking bids in renewable energy auctions in Saudi Arabia and the UAE have pushed down costs and increased the technology competitiveness with other power sources.

In 2019, the 900 MW fifth phase of Dubai's Mohammed bin Rashid Al Maktoum (MBR) Solar Park received a bid from Saudi Acwa Power for a tariff of just 1.6953 US cents. As of 2018, total

renewable energy capacity in the GCC stood at 867 MW, accounting for only 0.6% of total electricity capacity, yet progressing four-fold from 2014. Renewable energy capacity consists mainly of utility-scale solar projects, solar photovoltaic (PV) and concentrated solar power (CSP) providing 94% of installed capacity and forming 91% of the project pipeline. The UAE hosts 68% of the capacity, followed by Saudi Arabia (16%) and Kuwait (9%).

Table 1: Installed renewable energy capacity in the GCC as of the end of 2018

	PV	CSP	Wind	Biomass and Waste	Total RE (inMW)	Share of RE in total electricity capacity
Bahrain	5	-	1	-	6	0,1%
Kuwait	19	50	10	-	79	0,4%
Oman	8	-	-	-	8	0,1%
Qatar	5	-	-	38	43	0,4%
SaudiArabia	89	50	3	-	142	0,2%
UAE	487	100	1	1	589	2,0%
Total	**613**	**200**	**15**	**39**	**867**	**0,6%**

Source: IRENA (2019)

Renewable energy costs are going through a downward path, incentivizing new investment. Well-designed auctions and favorable financing conditions add to the attractiveness of these projects. Local factors also play a role in making the investment landscape prosperous as taxation is low and land and grid-connection costs are minimal. These encouraging endeavors also affect the nature of the investment that go along the whole value chain, from research and development initiatives to project developers to manufacturing companies.

To leverage and sustain such pace of investment, the role of policy is key. Renewable energy deployment can bring many benefits in terms of energy and water savings but can also spur a wave of job creation in the GCC region. According to IRENA's[3] estimates the job creation potential of the sector at 220 500 jobs by 2030. However, policies in terms of training and development of human capital, the creation of local expertise and research center to guide industrial and investment policy will be decisive in attaining such figures.

When looking at resource savings, the estimates predict a cumulative 2 billion barrels of oil equivalent cumulative savings and 17% reduction of water withdrawal by 2030, a very important figure given that the region suffers from water stress.

Yet again, incentivizing policies to shift to renewable energy will be central. Among possible evolutions are the implementation of green building codes, encouragements for electric and public transport, setting fuel efficiency standards and addressing particularly energy-intensive industries. Reforms of the energy and water sectors are necessary, notably in terms of more cost pass-through to nudge users towards more responsible consumption habits. Finally, the off-grid renewable energy sources such as rooftop solutions look like an untapped solution and can be leveraged through favorable regulation.

[3] IRENA, International Renewable Energy Agency, founded in 2009, Abu Dhabi based.

3. Saudi oil industry: a long history and an uncertain future?

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The dawn of the Saudi oil industry

Faced with declining revenues from the pilgrimage of Mecca in the aftermath of the 1929 Great Depression, king Abdul-Aziz ibn Saud, the founder of the kingdom of Saudi Arabia, was in search for alternative revenues. World War I had finished to establish the centrality of oil as powering energy for warfare and the economy in general. In the meantime, speculations were rising over the suspected presence of oil reserves in the Arabian Peninsula. These combined factors eventually led to the discovery of oil in site Dammam No. 7 on March 3rd, 1938. This first discovery led to many others, eventually revealing one of the largest reserves of crude oil in the world.

The companies holding concession rights at the time of discovery were Standard Oil Company of California (Socal) and Texas Oil Company (Texaco). Explorations were undertaken under the name of a subsidiary, the California-Arabian Standard Oil (CASOC), founded in 1933. The company eventually changed its name to Arabian American Oil Company (Aramco) in 1944. In 1946, the ancestors of Exxon and Mobil Oil Company took stakes in the company. In 1950, the concession terms were reviewed to comprise a 50-50 profit-sharing agreement with the Saudi government. Under the leadership of emblematic petroleum minister Ahmad Zaki Yamani, Saudi Arabia would start negotiations that lasted from 1972 to 1976 and eventually resulted in agreement for total ownership of Aramco by the Saudi government. By 1980, payments to the four parent companies were completed and by 1988, the company became Saudi Aramco, a totally Saudi-owned company with the full responsibility for all domestic exploration and development projects.

Along with its ownership and governance evolutions, Saudi Aramco developed an impressive infrastructure and oil extraction, refinery, and transportation facilities. A landmark project marking the emergence of Saudi Arabia as a major oil exporter was the completion, in 1950, of 1 200 kilometers pipeline, named Trans-Arabian Pipeline Company (Tapline), connecting Saudi oil fields to a Lebanese port on the Mediterranean near the city of Sidon. Tapline eventually ceased operations by Saudi Arabia in 1975.

In 1951, the Safaniya Oil Field, the world's largest offshore field was discovered. In 1957, further discoveries confirmed the status of Ghawar Field as the world's largest onshore field. Saudi oil infrastructure eventually evolved to be centered over a main oil processing plant in Abqaiq, a set of pipelines feeding a network of refineries serving both local consumption and exports departing from oil terminals on both the Red Sea and the Persian Gulf, mainly carried by the tankers of Vela Marine International, a subsidiary of Saudi Aramco created in 1984.

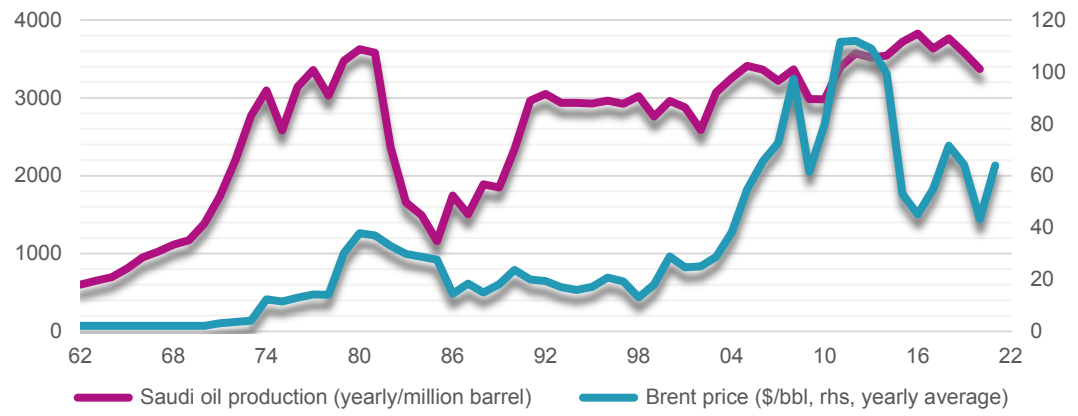
SAUDI ARABIA'S KEY OIL AND GAS INFRASTRUCTURE

Source: S&P Global Platts, EIA

Since the 1950s, when Saudi Arabia started to take an active role on its oil policy, the global oil market was shaped by a series of events that eventually influenced the kingdom's strategy. The first significant event was the formation of the Organization of Petroleum Exporting Countries (OPEC) in 1960, uniting Kuwait, Iran, Iraq, Saudi Arabia, and Venezuela with the objective of reducing competition between them and controlling prices. Since that date, pricing power would shift from international oil companies to OPEC members. This transition was clearly sealed when OPEC member countries decided to embargo countries supporting Israel in the Yom Kippur war in 1973, global oil prices increasing from an average of $2.48/bbl to $11.58/ bbl from 1972 to 1974.

During the 1980's, resulting from lower US and European consumption and the rise of North Sea crude oil production, oil prices survived a price moderation period. Saudi Arabia's reaction was to drastically cut its production, from more than 10 million barrels per day (bpd) in 1980 to less than 2.5 million bpd in 1985-86. The kingdom's attempt to defend prices eventually proved to be a failure and led the country into a 16 years-streak of budget deficits and piling debt. The Kingdom progressively restored its levels of production (see Chart 4) and took advantage of its low upstream lifting cost estimated at $2.8/bbl to gain market share and to impose discipline (via output cuts and production quotas) on its OPEC partners.

Chart 4: Saudi Oil Production (1962-2019)



Sources : NATIXIS,Thomson Reuters

Many geopolitical events will turn to be supportive for oil prices: the Iranian revolution of 1979, the Iran-Iraq War from 1980 to 1988, the Gulf War in 1990-1991, the fall of the USSR in 1991, the US invasion of Iraq in 2003, and the Arab Spring in 2011. On the other hand, the Asian financial crisis in 1997 and the Great Financial Crisis of 2008-2009 temporarily compressed global demand and stopped the long and sustained upward trend of oil prices. Most recently, the global Covid19 pandemic made oil prices collapse to multi-year lows on the back of an unprecedented demand shock resulting from the global lockdown measures.

Saudi Arabia's strategic positioning in today's oil market

In 2014, several factors led to a marked fall of global oil prices. Between mid-2014 and early 2016, oil price faced a 70% percent drop, one of the three biggest declines since WWII. It is also the longest lasting decline since the supply-driven collapse of 1986. Supply factors drove the plunge in prices. On the one hand, the rise of shale oil production and efficiency gains added a new chunk to the global supply. On the other hand, OPEC countries failed to reach an agreement to reduce production with Saudi Arabia even raising its production over the period. However, structural factors on the demand side also explain a big part of the story. Gains in energy efficiency and economic growth moderation both played in favor of a sustained oil price drop.

Price decline eventually came to a halt in 2016 when the then 14 OPEC member countries and 11 non-oil producing countries, including Russia, agreed on a 1.8 mb/d output cut as part of the Declaration of Cooperation (DoC). The agreement will be perpetuated through the Charter of Cooperation in 2019, setting a framework of discussion and agreement between what are now known as the OPEC+ countries. This framework allowed for a swift response (following a brief period of price war) to the coronavirus crisis impact on global oil demand. On April 15th, 2020, OPEC+ countries reached a historical production cut of 9.7 mb/d to be tapered gradually up until April 2022. Saudi Arabia even applied a voluntary 1 mb/d additional cut to support the market.

Saudi Arabia's oil market strategy is therefore lately characterized by the search for an equilibrium of price and market share preservation, taking the leads on necessary punctual cuts but also playing the compliance watchdog within the OPEC. The oil exporting kingdom also has to face international pressure to maintain oil prices at an affordable level. Finally, over time, Saudi Arabia aims to maximize inter-temporal revenue from its oil reserves in a context where peak oil demand is pointing at the horizon and is no longer a distant reality, and where alternative sources of energy are getting, day after day, cheaper and more efficient.

Saudi oil sector at crossroads: survival or revival?

In the short term, Saudi Arabia could take advantage of the post-Covid oil market environment and the return of global oil demand growth. The depressed global environment might see reluctant investors refraining from financing US shale oil production, leaving room for Saudi Arabia to increase production and gain market share without jeopardizing revenues and affecting prices.

Another imminent question regards the investment choices in the oil sector. With a production capacity currently estimated at 12.5 mb/d, the kingdom also eyes on the monetization of its 297.6 billion barrels of proven reserves, the risk to end up with stranded assets being increasingly high with the growingly pressing needs for an energy transition. Besides factors related to the energy transition, Saudi Arabia must consider other oil exporters capacity to increase production, but also the evolution of its own internal demand. Given the high dependance of the economy on oil, the country must be very careful of the effects its investment choices might have on the global revenue from oil.

While the need for diversification is less and less debatable, the way in which such transformation must take place is open for discussion.

In the case of a conservative bet hedging strategy, the oil sector will conserve its centrality in the economy and will allow for a smooth and relatively riskless diversification. In such strategy, competitiveness of the energy sector is enhanced and its resilience against potential risk of disruption due to the energy transition is increased.

The hedging strategy focuses on four pillars:

- Increasing Saudi Arabia's ability to compete in a low-price environment through lower production costs and higher energy production efficiency
- Decarbonizing oil and gas production to favor Saudi energy in a world with rising carbon prices
- Maximizing the country's oil export potential through an optimized domestic energy mix and more efficient domestic energy consumption
- Raising the share of petrochemicals and non-combustible uses of oil in the country's production portfolio

Under this prism, the oil industry becomes a sector of the future, lowering the risk to invest in non-viable new exports sectors, guaranteeing a lasting competitiveness for Saudi Arabia on global oil markets and streamlining the proceeds of the natural resources throughout time and generations.

4. OPEC NOCs likely to be critical in bridging the demand gap

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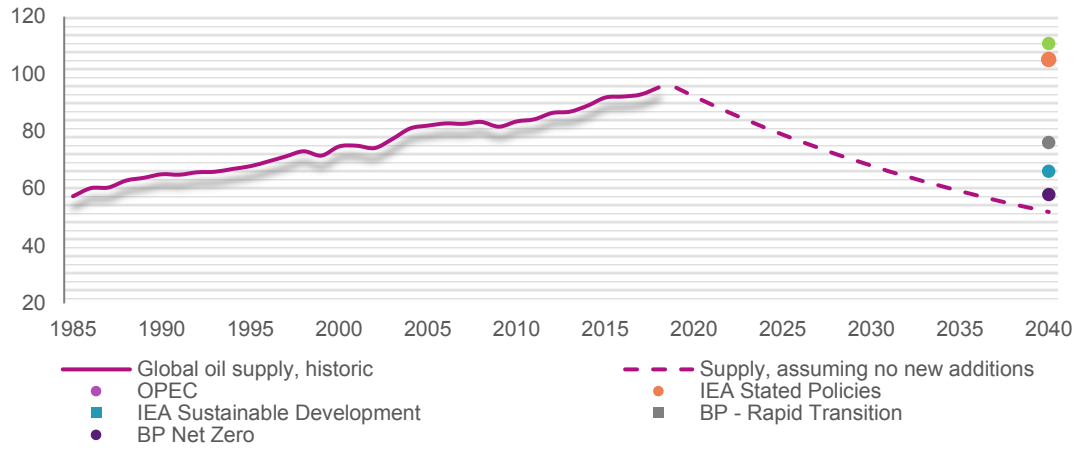
2021 is proving a transformative year for the future direction of the oil industry. The fallout of the COVID-19 pandemic has resulted in the oil majors cutting long-term CAPEX directed towards hydrocarbon investments whilst announcing ambitious plans regarding renewables generation. There is no escaping the green wave - recent weeks have even seen the US majors Exxon and Chevron, which have lagged the more ambitious transition plans of the European majors, facing shareholder disquiet on climate concerns. The IEA's recently published Net Zero Emissions (NZE) for 2050 study, whilst just one scenario, painted a somber picture for the oil industry. The IEA scenario sets out a potential pathway to zero net emissions out to 2050, with the objective to limit global warming to +1.5°C in 2100 compared with pre-industrial levels. Under this scenario, the IEA state that there would be no need for additional investment in new oil and gas fields other than those already sanctioned, with the NZE scenario assuming a contraction in oil and natural gas demand of 75% and 55% respectively. The oil major's ongoing "tobacco moment" is likely to increase the cost of capital for future hydrocarbon developments as capital providers face increasing pressure to be more carbon conscious, accelerating the transition to an integrated energy company model – with oil and gas divestments likely along the way.

Whilst decisions made by the oil majors today (currently 15% of total oil supply) look certain to cut the group's production (pre and post-pandemic, a combined $83bn has been removed from the capital budgets of majors that have published long-term guidance to 2025), what of future oil demand? Admittedly, demand estimates over the next decades vary dramatically, with this exercise requiring the incorporation of several high-level assumptions spanning economic, political and societal developments over the next two decades. Indeed, it could be argued that calculating a robust estimate is impossible under these conditions – that said, we have collated several estimates spanning a range of outcomes. On the high-end, we have OPEC's 110.6mn b/d estimate for 2040 as published in the group's 2019 world oil outlook. BP's net zero scenario, at 58mn b/d, provides the lower bound. We have also charted a "no-investment" oil supply scenario out to 2040, based on 2019 production levels – this omits 20mn b/d of "no-decline" oil production (Canadian oil sands and certain OPEC producers), applying a flat 4.0% decline rate on the residual wedge. This estimates a 2040 production level of 51.9mn b/d – below all 2040 demand estimates.

Projected oil supply assuming no investment vs various 2040 demand scenarios, mn b/d



Source : BP Statistical Review of World Energy, IEA, OPEC, Natixis

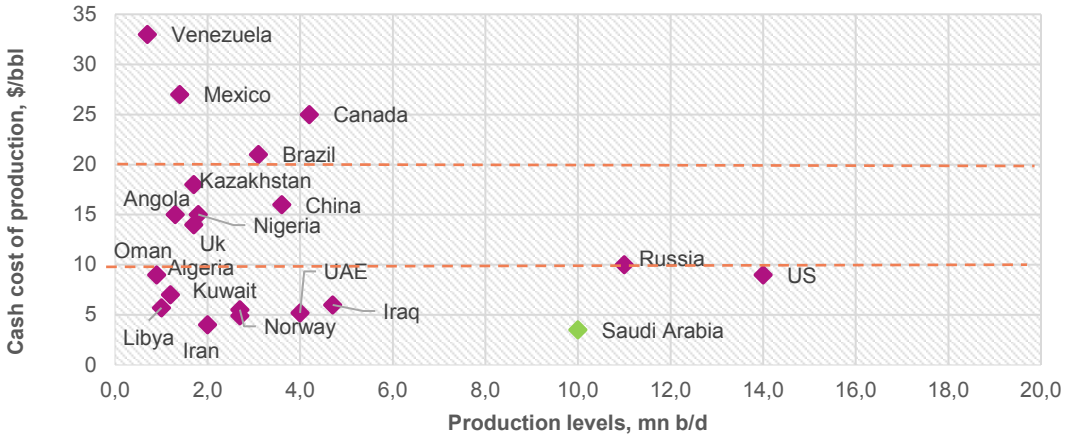
This analysis, whilst simplistic, provides us with a key piece of insight – whilst we can argue about the numbers, the geological realities of oil production, which is subject to incremental decline on a yearly basis, mean that new investment will be needed on the supply side, even as demand peaks, plateaus and eventually declines. **In our view National Oil Companies within certain OPEC member countries are well placed to deploy additional CAPEX and take advantage of this investment gap. Both Saudi Aramco and ADNOC are top of this list, and in ADNOC's case, already embarking on expansion plans.**

We base this view on two main factors:

Resource quality, extent, cost

Woodmac estimate that fourteen countries in the Middle East account for 43.6% of the world's known 2P (proven + probable) reserves, whilst making up just 3.6% of the total landmass. Three geological basins (Rub al Khalil, Widyan and Zagros) hold 1.28tn boe of remaining reserves, equivalent of 88 years of production at a level of 40mn boe/d.[4] These reserves are advantaged for several key reasons i) a favourable geological endowment – i.e. reservoir quality (thickness, permeability, porosity) and presence of largescale structural traps and ii) very low costs, relative to other hydrocarbon provinces. This is primarily driven by the location of major fields, which are typically either onshore or in shallow water. Lifting costs in the Middle East in aggregate average just $4/bbl, compared to a range between $8-14/bbl in other hydrocarbon provinces. These factors arguably feed into each other –good geology lowers costs, which when coupled with advantaged field location results in very cheap cash costs of production, as shown in the chart below.

Cash costs of the top-20 oil producers by volume, $/bbl



Source : WoodMackenzie

The nature of NOCs and importance to regional economies

The economies of many Middle Eastern countries remain closely intertwined with the oil market. Indeed, it could be argued that a NOC's key role is to deliver revenues to its government, as much as actually producing hydrocarbons. In at least 25 countries, the revenue collected by the NOC is equivalent to more than 20 percent of total government revenue[5]. Given the importance

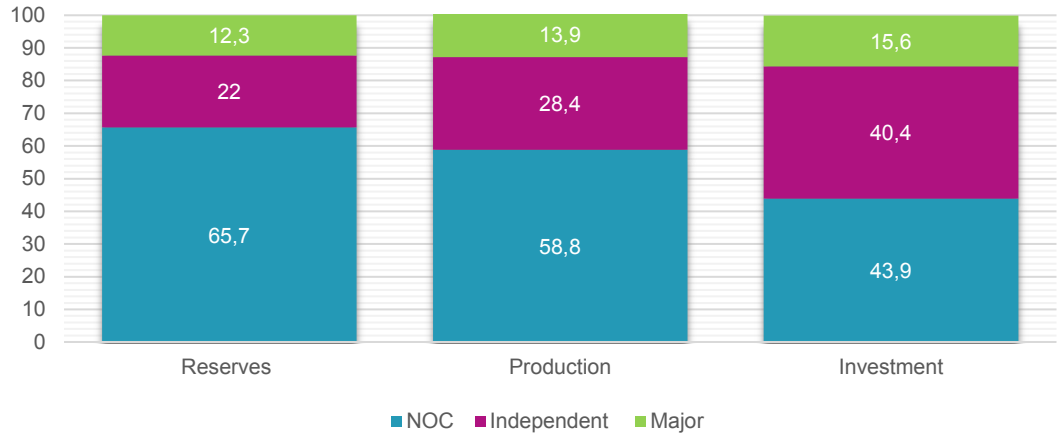
[4] Wood Mackenzie. Why are Middle East Resources so advantaged? *Report published 14/06/21.*

[5] Patrick R. P. Heller and David Mihalyi. Massive and Misunderstood: Data-Driven Insights into National Oil Companies (Natural Resource Governance Institute, 2019), 19-21, resourcegovernance.org/analysis-tools/publications/massive-and-misunderstood-data-driveninsights-national-oil-companies.

of the oil industry regionally, opportunities to expand are likely to be viewed favourably. NOCs, being state owned, are also not subject to the same pressure from shareholders regarding transition plans, and as such, can take a more nuanced view on long-lead time investments that public company shareholders will not stomach, given uncertainties embedded in the energy transition.

We therefore consider it likely that both capacity expansion opportunities will be available for NOCs as the oil majors pull away from upstream oil and gas investments and that for certain players, these opportunities will be taken. This is seen aligning the disparity between reserves (historically dominated by NOCs) and investments (dominated by the IOCs), which is shown on the chart below. For the NOCs that are able to invest in additional production capacity, this represents an opportunity to increase market share and control over a commodity that is likely to maintain importance in the economic system in the coming decades.

Reserves, production and investment by operator category, % share



Source : IEA

5. Saudi Vision 2030 take on energy transition

Highly ambitious objectives for an optimal energy transition

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Steered by the crown prince Mohammed Bin Salman, Saudi Vision 2030 is the cornerstone of the Saudi development policy. Launched in April 2016, the strategic plan aims to draw a winning way out of the oil rent through economic diversification. The master plan lies on three pillars: social development, economic diversification, and enhanced governance. Many flagship measures or quantified targets and key performance indicators symbolize the ambitious nature of the strategy.

From a social standpoint, Saudi Arabia wants to live up to its status of custodian of the two holy mosques raising yearly Umrah visitors to 30 million by 2030. It also aspires to increase spending on culture and entertainment and bring average life expectancy to 80 years. On the economic front stakes are high:

- To ensure a significant diversification by 2030 **increasing private sector's contribution to GDP from 40% to 65% and bringing non-oil exports in non-oil GDP from 16% to 50%**,
- Guaranteeing satisfactory rhythm of job creation **lowering the unemployment rate from 11.6% to 7%**
- Secure the sustainability of the kingdom's financial wealth through reasoned investments materializing with **the increase of the Public Investment Fund total assets to around SAR 7 trillion ($1.9 tn) by 2030**
- Saudi Arabia wants to modernize its state enhancing e-government and to develop a vibrant society through the encouragement of volunteering and community work
- On the energy sector, **the objective is to transform the kingdom's energy mix to make renewables and gas contribute 50% to the electricity supply by 2030.**

It is no surprise that the energy sector holds a key role in the development strategy of a country that has relied principally on its oil and gas resources for the past seven decades. Saudi Arabia wants to localize to the fullest the oil & gas industry and to reform the energy market to enhance its competitiveness. The country has a double objective: maximizing the value generated from its oil exports and increasing the efficiency of its domestic energy consumption.

Objectives set for the energy mix transformation seem rather ambitious. Saudi Vision 2030 plans a 50% contribution of renewables to energy mix - yet, as of 2019 these primary sources only represented 0.02% of the country's power generation. At the inception of Vision 2030, the objective was to produce 60GW of green energy by 2030. Accordingly, the National Renewable Energy Program raised in 2019 the renewables target from 9.5 GW to 27.3 GW by 2023 and to 58.7 GW in 2030. In addition, the National Industrial Development and Logistics Program, a Vision 2030 program, places the renewables sector as one of the priorities sectors for development along with military industry and some manufacturing industries. However, reports estimate that with current targets achieved, renewable energy will make only 12% to 14% of Saudi Arabia's electricity supply by the end of this decade.

The other challenge the Kingdom must face at the energy level is the reduction of its domestic consumption through the enhancement of its energy efficiency and its energy market competitiveness. So far, the figures are edifying: Saudi Arabia's domestic primary energy and power consumption doubled over the ten years to 2014 and energy intensity was at 2.5 barrels of oil equivalent per $1 000 of GDP, increasing by 1.5% year on year, while globally this figure was declining by 1% every year.

To turn around this trend, the country enacted aggressive energy efficiency policies across industrial, residential and transport sectors. Energy prices were also drastically adjusted in 2016 and 2018, with important overall rises, e.g. +240% for gasoline for the transport sector or +260% for electricity tariffs for the residential sector. Combined, these measures aim to lower domestic energy demand and to make the transformation of the energy mix a more achievable challenge.

The Saudi and Middle East Green initiatives

To back his country's ambition in terms of ecological transition, crown prince Mohammed Bin Salman presented last March 27 the Saudi and the Middle East Green initiatives, a holistic approach to climate change comprising energy transition, biodiversity preservation and reduction of carbon emissions. At the heart of these new initiatives is the flagship objective of the kingdom's future energy policy under Vision 2030 framework, **the generation of half of the country's energy from renewable sources by 2030.** Besides, the initiatives also plan to:

- Reduce carbon emissions by more than 4% of global contributions, through renewable energy projects and clean hydrocarbon technologies.

- Increase the percentage of protected areas to more than 30% of its total land area, representing roughly 600 000 square kilometers, in addition to various initiatives to protect marine and coastal ecosystems

- Plant 10 billion trees across Saudi Arabia in the upcoming decades, a 12-fold increase from the current tree cover

In tandem, Mohammed Bin Salman has rolled out his ambitions for the region in the fight against climate change. In addition to the 10 billion trees to be planted in Saudi Arabia, another 40 billion trees will be planted in partners countries in the Middle East, making the Middle East Green initiative the largest reforestation program in the world, twice the size of the Great Green Wall in the Sahel.

Regional cooperation is to take place also in the reduction of carbon emissions. The meagre 7% of clean energy production and the inefficiency of hydrocarbon energy production techniques do not help the Middle East to achieve its carbon emissions reduction targets. Saudi Arabia intends to transfer knowledge and share experiences with regional partners to achieve a 60% reduction of carbon emissions resulting from hydrocarbon production, hence raising the Middle East global contribution to carbon emissions reductions to 10%.

These initiatives address material problems in both Saudi Arabia and the Middle East. It is estimated that life expectancy was reduced by 1.5 years in the kingdom due to the pollution from greenhouse gases while desertification, through dust storms, costs the region an approximate USD 13 billion of losses. It also draws continuity with Saudi Arabia leadership on the environmental front over the last years. At national level, the kingdom established the Environmental Special Forces in 2019, raised the percentage of natural reserves from 4% to more than 14% and increased vegetation cover by 40% in the past 4 years. Saudi Arabia is also pioneering technological advancement in the efficiency of hydrocarbon production in terms of carbon emissions, and led, through its G20 presidency, the adoption of the concept of Circular Carbon Economy. The Saudi and Middle East Green initiatives cement the kingdom's ambitions in both energy and environmental transition.

A spectacular sustainable project: NEOM and "The Line"

The engagement of the Kingdom for a renewable energy powered and diversified future is embodied in the NEOM project.

Covering a surface 33 times the size of New York and located North-West of the country along the Red Sea, NEOM is the project of a smart, sustainable, cognitive city powered by 100% of renewable energy. Composed of five major developments (Neom Bay, Aqaba Region, Neom Mountain, Neom Industrial City and The Line), the project is set to mobilize 500 billion dollars in investment.

The Economist

Amongst these major developments, the star is definitely "The Line", a futuristic linear city built over 170km, totally powered by carbon-free energy, connected with a high-speed underground transportation system reducing commuting time to a maximum of 20 minutes and preserving 95% of the nature on its construction site. Neom city will also include a landmark touristic resort in a mountainside known as "the Vault" and is conceived to become a global technological hub. It will be subject to a distinct and freer jurisdiction. Presented in 2017, and with a first delivery phase due by 2025, no major construction work has been initiated so far.

The futuristic project balances outlandish features such as an artificial moon, drone-powered taxis, artificial rain and holographic teachers, and on the other hand, proposes interesting top-notch technological innovations such as NEOS, a powerful operating system expected to push smart city services to another level, and the promise of a 100% renewable energy run big agglomeration. So far, investors eagerness to involve in the project has been mixed. The US chemical company Air Products & Chemicals Inc. joined a Saudi firm in a partnership with Neom to build the largest green hydrogen-production facility in the world, for a USD 5 billion total investment (see next chapter for a detailed analysis of the nexus between desalination, low-carbon electricity and green hydrogen production and exports). However, this opportunity is worthy beyond the mega-city project, NEOM location being perfect for solar and wind energy production and ideal for export purposes. Investors will likely not take stake into greenfield projects that will have to rely on the Public Investment Fund, the Saudi sovereign wealth fund.

International actors have still in mind the failed projects of King Abdullah Financial District and King Abdullah Economic City and are cautious of the increasing competition with the UAE to attract foreign investments and workers. In any case, this massive avant-garde project reflects somewhat the ambition of the Kingdom to play the card of a greener and smarter future.

6. Greening of/greening by desalination in Saudi Arabia

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When the nascent green transition of a strategic sector has the potential to drive structural change in the economy

When examining potential avenues to be explored to address the environmental externalities of desalination, Saudi Arabia's case is worth highlighting. Not only does the country heavily rely on desalination to produce drinkable water (over 60%[6]) but it also runs a non-optimized power system both from an environmental and an economic standpoint. In 2019, Saudi Arabia generated 357TWh of electricity, 42% of which came from oil and 58% came from natural gas. It currently consumes nearly one-third of its oil production (consumption of 3,8 million barrels per day out of a total production of 11.8 million barrels per day in 2019[7]), of which around one-fifth is used for power generation purposes.

These issues are likely to further exacerbate in the coming years. The kingdom's population is indeed set to continue its growth from 4 million inhabitants in 1960 to 31.4 million in 2019 and 43.1 million in 2040, which means more desalinated water… and more electricity will be needed by then. Current forecasts estimate that Saudi Arabia will have to increase its installed generation capacity by as much as 80GWe (from 60GW in 2016 to 140GWe[8]) by 2040 to face incremental electricity demand. The bulk of the capacity needed to address such incremental demand is expected to be carbon-free, for the current government's energy infrastructure development plan provides for the commissioning of 50GW of renewable capacity (of which 41GW of solar CSP and PV assets) and 18GW of nuclear capacity.

In a threefold social, economic, and environmental perspective, **Saudi Arabia's dependence on desalination and fossil fuels for the supply of drinkable water and electricity can be addressed by using the prisms of "greening of" / "greening by" desalination**. While the former concept refers to the use of new technologies/processes with the specific aim of reducing the environmental impact of desalination[9], the later emphasizes the potential role desalination could play in the transformation of Saudi Arabia's economic structures towards a more climate-friendly (and economically sustainable) business model.

"Greening of" desalination thanks to low-carbon electricity generation

In the desalination sector, the rationale for the targeted increased use of renewable (solar) and nuclear assets does not directly respond to environmental concerns but rather to mere economic considerations. Indeed, government's stated ambition is to bring down desalination costs[10], given the high share of electricity costs in desalination assets' overall costs, while optimizing the use of hydrocarbon resources for the purpose of their exportation rather than domestic use. It is also worth recalling that despite the recent development of various RO plants in the Kingdom, Saudi Arabia still mainly relies on thermal technologies (MSF and MED processes accounting for over 80% of desalination capacity) to produce desalinated water, these technologies being more energy-intensive than RO (see section 1.1.1.). To this end, the government has launched the King Abdullah Initiative for Solar Water Desalination which

[6] Hereby making up for roughly 18% of the world's production of desalinated water.
[7] Source BP: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html
[8] http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/saudi-arabia.aspx
[9] We leave aside the issue of brine rejection which is thoroughly discussed in the study to focus on the indirect climate externalities of Saudi Arabia's desalination industry taking the angle of the country's specific climate drinkable water-energy nexus.
[10] As the abovementioned article from the World Nuclear Association highlights, "one of the main objectives of this initiative under King Abdullah City for Science & Technology (KACST) is to desalinate seawater at a cost of less than Riyal 1.5/m³ (US$ 0.40/m³) compared with the current cost of thermal desalination, which KACST says is in the range Riyal 2.0-5.5/m³ (US$ 0.53-1.47/m³), and desalination by RO, which is Riyal 2.5-5.5/m³ (US$ 0.67-1.47/m³) for a desalination plant producing 30,000 m³/d".

features the (now completed) construction of the world's biggest solar-powered desalination plant (60,000 m3/day) in Al Khafji.

Saudi Arabia is actively considering the use of nuclear energy and has entered into discussions with Chinese, French, Korean and Russian engineering and equipment providers to design and later develop its own nuclear fleet. The 2010 Royal Decree laying the foundations for the future construction of nuclear reactors states 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." Development of nuclear energy could take two, not necessarily mutually exclusive directions, with the Saudi government considering:

- **The deployment of large reactors** (installed capacity higher than 1,000MW) to meet the country's overall electricity mix objectives but also

- **The use of small units** (up to 100MW) aimed at directly powering desalination plants.

For what specifically concerns the deployment of the latter small units, discussions have been held with various providers, which eventually (2015-16) resulted in the signature of cooperation agreements with the Korea Atomic Energy Research (KAERI), Argentina's INVAP (Investigacion Aplicada) and China Nuclear Engineering Corporation (CNEC). Although there is little information available to shed further light onto these developing partnerships, it seems that KAERI's SMART reactors are well placed to address Saudi Arabia's specific needs in the desalination sector. Noteworthy is KAERI having designed an integrated desalination plant based on the SMART reactor to produce 40,000 m^3/day of water and 90MWe of power at less than the cost of gas turbine.

All in all, **Saudi Arabia's case evidences a genuine albeit lengthy change in energy paradigm for the powering of desalination assets. In the next few years**, despite the difficulties experienced in the abovementioned Al Khafji project which is now completed, after having incurred a three-year delay, **change is most likely to come from renewable sources, in particular solar energy**. Two factors are likely to fuel the trend:

- **The continuing decline of solar (both solar PV and CSP) energy's LCOE** (Levelized Cost of Energy[11]) which has been particularly notable in the Arabian Peninsula in the recent past, as evidenced by the then record-low price of the solar PV tender held in Abu Dhabi in May 2020 ($13.5/MWh) and the new record ($10.4/MWh) set earlier this year (April 2021) by the tender offer concluded in Saudi Arabia for the 600 MW Al Shuaiba PV IP project[12].

- **Saudi government's intention to accelerate the involvement of private companies in the desalination sector through the IWPP (Independent water and power projects) framework initially set out in 2002**. This is a key factor to highlight for the expected continuing drop of solar PV and CSP technologies' LCOE will further improve the competitiveness of solar-powered desalination plants vis-à-vis fossil fuel-powered facilities. The expected landing of solar PV project costs across the Arabian Gulf should contribute to improving the economics of new desalination projects in Saudi Arabia. According to Global Water Intelligence, the price of electricity charged to desalination plant developers in Saudi Arabia currently stands on average at $48/MWh, a level substantial higher than the recent record solar PV auction in Saudi Arabia ($10.4/MWh – see above).

[11] LCOE is a concept developed to measure the average net present cost (expressed in $/MWh) of electricity generation for a generating plant over its lifetime.
[12] By way of illustration, it is worth remembering that the average LCOE of the solar PV sector stood at $360/MWh in 2010 (source: IRENA 2018 renewable cost database).

"Greening by" desalination through large-scale green hydrogen manufacturing?

Taking a more forward-looking approach, the concept of "greening by" desalination is of particular relevance when applied to the Saudi economic context, for it illustrates how **the water-electricity nexus can be leveraged in such a way as to achieve both climate friendly and economically sustainable structural changes**.

Despite various economic diversification initiatives taken over the past 10 years (which are set to intensify in the wake of the recent - December 2019 - IPO of Saudi Aramco[13]), **the Saudi economy remains very dependent on oil rents**, as evidenced by the oil sector still accounting for roughly 87% of budget revenues, 42% of GDP, and 90% of export earnings[14].

This dependence raises the question of the sustainability of Saudi Arabia's economic model in the twofold context of mounting climate change awareness and gradual evolution of energy systems towards a lesser dependence on oil, particularly in the mobility sector. Observation of recent trends in this sector reveals a multiplication of technological and / or regulatory initiatives aimed at developing low carbon (or lesser carbon-intensive) energy substitutes for oil, hereby reducing the climate footprint of the various means of land, sea and air transport. In this field, let us cite the development of electric and fuel-cell vehicles[15] for land transport, regulatory incentives to switch to liquified natural gas (LNG) for marine transportation[16], exploratory developments by aeronautical companies for the propulsion of aircraft with hydrogen etc.

There is a growing consensus around the idea that **the share of oil in the means of transport (94% currently[17]) should reach a plateau in about 10 years before gradually declining thereafter** under the effect of the development of alternative vehicle fleets fueled by electricity, natural gas, biofuels and hydrogen.

Interestingly, IEA's recent NZE 2050 scenario recently shed light on the scale of the disruptions needed in the energy sector to enable the global economy to achieve carbon neutrality by 2050. In this prescriptive scenario, the IEA estimates such objective is achievable on condition, among other things, of drastically reducing the share of fossil fuels (oil, natural gas and coal) in meeting final energy needs (from 80% currently to 20% by 2050, in the IEA's modeling). **This modelled contraction in fossil fuels demand leads the IEA to consider as unnecessary the development of new projects other than those already approved, but also to forecast a sharp downtrend in prices (oil landing at $35/bbl by 2030 and $25/bbl by 2050). In parallel, the IEA's NZE scenario models the replacement of fossil fuels by the combination of low-carbon electricity (renewable and nuclear sources) and low-carbon fuels, in particular hydrogen[18].**

It is against such backdrop that the kingdom is currently exploring alternative strategies going beyond the mere diversification of Saudi economy, this with a clear "post-oil" perspective. The scheme being studied by the Saudi authorities considers the large-scale development of a value chain around the production of green hydrogen (namely hydrogen produced by green energy-powered electrolysis) taking advantage of the various seawater desalination and renewable energy production infrastructures (wind, solar PV) under

[13] As the World Bank emphasizes, "the completion of Saudi Aramco's IPO in December 2019 reflects the government's drive to leverage oil wealth to finance diversification, transforming the Public Investment Fund (PIF) into an activist sovereign wealth fund". http://pubdocs.worldbank.org/en/223911554825481995/mpo-sau.pdf.

[14] Source: https://theodora.com/wfbcurrent/saudi_arabia/saudi_arabia_economy.html

[15] Fuel cell vehicles are electric vehicles that use a fuel cell, sometimes in combination with a small battery or supercapacitor, to power its onboard electric motor; instead of requiring recharging, however, the fuel cell can be refilled with hydrogen.

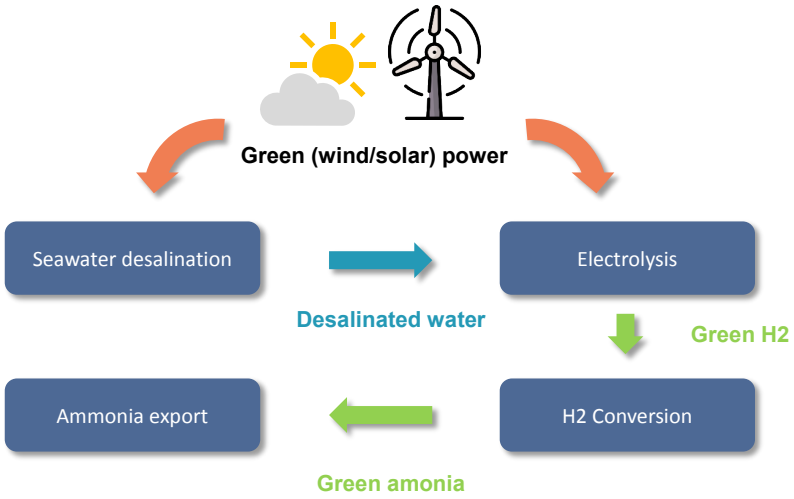
[16] IMO 2020 regulation states that "from 1 January 2020, the limit for sulphur in fuel oil used on board ships operating outside designated emission control areas is reduced to 0.50% m/m (mass by mass). This will significantly reduce the amount of sulphur oxides emanating from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coasts" (source: http://www.imo.org/en/mediacentre/hottopics/pages/sulphur-2020.aspx).

[17] Source: BP (https://www.bp.com/en/global/corporate/energy-economics/energy-outlook/demand-by-sector/transport.html)

[18] See our recent thematic report on the matter for more details: IEA's NZE scenario: is this the moment of truth for the energy sector?.

development in the kingdom. In this scheme, the exponential fall in solar energy production costs (see above) seen over the past 10 years would be leveraged to lower the cost of desalination and electrolysis and ultimately to enter into the mass production of a molecule able to compete with fossil fuels (oil, coal, natural gas) as an energy carrier but also as a feedstock for specific manufacturing processes (production of steel, petrochemical products, etc.). Upon undergoing a liquefaction process similar to that used for the maritime transport of natural gas but requiring much lower temperatures than for the latter[19] or transformed into ammonia, such green hydrogen would be sold in the international markets. In this context, **Saudi Arabia could eventually at some point find itself an exporter of a nearly perfect, carbon-free substitute for all fossil fuels across a wide range of sectors**. The underlying logic is to combine the different emerging water and power infrastructures so as to eventually develop a substitute for oil rent.

Considered value chain for green hydrogen in Saudi Arabia: from production to exports



Source: Natixis

Although it is still under development and has not yet been the subject of any official statement by the Saudi authorities, **this national strategy is beginning to take institutional form**. **This is illustrated by the recent admission (January 2020) of the national oil company, Saudi Aramco, to the World Hydrogen Council**, a global initiative of leading energy, transport and industry companies with a vision and long-term goal for hydrogen to foster the energy transition.

In addition, this strategy is starting to take concrete shape, in the form of industrial projects, which are already very ambitious. As one part of "Vision 2030" laid out by Crown Prince Mohammed bin Salman, plans were announced in 2017 to create the Neom (see above for general insights into the project) smart city entailing a $500bn business and industrial zone covering 26,500km2 between the Red Sea and the border with Jordan. Neom has a stated aim of being "built and powered completely by renewable energy" as it strives to lead the world in commercializing clean energy intensive industries including green hydrogen, produced from renewable electricity.

The first stage in this process came in early July this year when Neom signed **a $5bn deal with Air Products, a US industrial gas and chemical company, and Acwa Power, a Saudi Arabian power and desalination utility, to build the world's largest hydrogen project.** The production facility will be powered through the integration of more than 4GW of renewable power from solar and wind. The completed facility will produce 650 tons of green hydrogen daily, enough to run around 20,000 hydrogen-fueled buses, Air Products said. The fuel will be

[19] - 253 ° Celsius for hydrogen to compare with -161° Celsius for natural gas.

shipped as ammonia to end markets globally then converted back to hydrogen. Ammonia production is expected to start in 2025.

The launch of this project is illustrative of Saudi Arabia's ambitions in the production and export of green hydrogen. It is however probable that **the implementation of a more systematic approach in the mass production and export of the H2 molecule should depend on technological developments in the sector** (improved cost competitiveness of electrolysers vis-à-vis established processes such as steam methane reforming – SMR – this through lower unitary capex and improved operational efficiency).

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