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ENERGY GOVERNANCE IN SAUDI ARABIA: AN ASSESSMENT OF THE KINGDOM'S RESOURCES, POLICIES, AND CLIMATE APPROACH

Jim Krane, Ph.D.
Wallace S. Wilson Fellow for Energy Studies

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Abstract

Saudi Arabia's massive hydrocarbon endowment and ownership of Islamic holy sites have spawned a political economy unique in the world. The monarchical state that oversees these sites and resources has developed sophisticated structures of energy governance, including an ability to combine long-term planning with short-term market maneuvering. This paper explores established policy levers and practices, while assessing Saudi Arabia's emerging strategy for future participation in the oil business. Over the long term, the monarchy's survival hinges on its ability to find new niches in a business that has sustained it for nearly a century.

Introduction

Climate action and the global decarbonization agenda represent a fundamental strategic dilemma for Saudi Arabia. The kingdom's economy and patronage-driven political system face serious threats from policies aimed at reducing global oil demand, while its arid geography and extreme temperatures render it particularly vulnerable to increased warming. While climate change and the notion of peak oil demand pose major risks for Saudi Arabia's economy and long-term well-being, the kingdom has taken numerous steps aimed at preserving its economic future along with the future viability of oil itself.

Saudi Arabia is perhaps the world's purest example of a petrostate. More than 60% of its national budget, 75% of export revenues, and 40% of its 2016 GDP are supplied by oil exports (General Authority for Statistics 2017; OPEC 2017). Energy policy is therefore split between external concerns around oil exports and prices, and domestic concerns around providing sufficient supply for national development and the well-being of citizens. Saudi Arabia's external role, which involves its de facto leadership of the Organization of the Petroleum Exporting Countries—the OPEC cartel—is well known. As part of OPEC, the kingdom has aimed to preserve income for itself and other exporters by optimizing oil prices and supply, and protecting oil's long-term role as the world's primary transport fuel.

This paper focuses on the domestic side of the energy policy ledger, particularly the climate policy agenda that is beginning to shape Saudi behavior in the energy space. Saudi energy policy has long been profligate with resources, based around the notion of providing surplus production to Saudi citizens at heavily subsidized prices. In exchange, Saudis are expected to support the ruling al-Saud family. That formulation is beginning to change.

At first glance, Saudi Arabia and the global climate movement appear to be on a collision course. As the world commits to reduce the combustion of fossil fuels that intensify climate change, the kingdom has announced intentions to step up production of those fuels, lest its economy be destabilized and prodigious reserves be rendered worthless (Krane 2017). But climate change also represents a strategic opportunity for Saudi Arabia. The kingdom is not only a petrostate by dint of its hydrocarbon exports. Internally as well, Saudi Arabia is oil-dependent and oil-intense to the point that continued consumption growth threatens its long-term viability as an exporter (Bourland and Gamble 2011; Lahn and Stevens 2011; Krane 2015a).

The kingdom, which committed in Paris to a modest reduction to its business-as-usual carbon emissions, has begun treating the global climate regime as convenient political cover for reforming energy subsidies that have exacerbated its climate footprint and led it to become a hugely disproportionate oil consumer, the world's fifth largest. In 2016 and again in 2018, Saudi Arabia launched concerted policies to reduce domestic oil demand. While economic factors played the main role in those reforms, multilateral climate action probably also played a part; the kingdom's Paris pledge was directly linked to the success of its energy subsidy reforms.

At the same time, the Saudi national oil company has concluded several major investments into petrochemicals—a non-combustion use of oil and natural gas—that represent a "climate proof" niche in the hydrocarbon sector. The kingdom seeks to demonstrate to the world that it can build environmental credibility by joining a collective global action that runs counter to its national economic interests, even as it grapples for a new business line that can carry it beyond the age of oil.

The Saudi government, long associated with an obstructionist stance in international climate negotiations, has taken steps to engage on a more cooperative footing. While the Saudi delegation still acted to block progress in late 2018 climate talks in Poland, the kingdom appears to be preparing for a reduced, albeit long-term role, for oil in the global economy. Much of its shift is opportunistic. The kingdom's modest Paris goal, or Nationally Determined Contribution (NDC), calls for avoiding the release of 130 million metric tonnes of carbon dioxide equivalent by 2030. The NDC appears reachable under domestic policy changes already introduced. In return for meeting—and perhaps surpassing—its NDC, Saudi Arabia suggests that the international community treat it with special dispensation. If Saudi Arabia voluntarily curtails activities within its only serious economic sector, it requires the world's support in incubating a competitive replacement industry that "exceeds the loss of revenue from oil export," a demand alluded to in the Saudi NDC, the content of which is left unspecified (Kingdom of Saudi Arabia 2015).

This paper delves into these and other challenges facing the kingdom as it grapples with energy policy in the context of global climate action. First, I document the extent of Saudi Arabia's hydrocarbon endowment and the structure of the monarchical state that controls those reserves. The section then turns to examine the policy levers used to exploit the kingdom's resources, including recent changes in long-established energy governance. The discussion focuses on a broad array of events and trends influencing Saudi energy policy, highlighting challenging growth in domestic hydrocarbon demand, subsidies behind that growth, recent reforms to energy pricing, and the climate pressures facing the kingdom. The paper concludes with a review of strategic policies beginning to emerge in response to global climate action.

Domestic Energy Resources

The Kingdom of Saudi Arabia is the world's largest oil exporter and its premier strategic energy power. The kingdom has accrued that power not only from the size of its reserves, but also through its investments in spare oil production capacity and its willingness to deploy that capacity to balance markets during periods of stress. As such, Saudi Arabia has fashioned itself as the world's "swing supplier" of oil, acting to cut production when the market is in excess and raising output when supplies are tight.[1] The kingdom's energy policymakers describe Saudi Arabia as the world's "supplier of last resort," meaning that immense reserves and low unit costs—typically estimated at between $5 and $10 per barrel—ensure it can produce and deliver oil as long as anyone is willing to buy it (Blas 2017).

Saudi Arabia's importance to global oil markets stands behind its strategic and close relationship with the United States, which protects the kingdom based on the importance of its supply, its role in formation of oil prices, and the primary importance of these factors to the global economy (Collins and Krane 2017). Control over all oil and gas reserves and production in the kingdom is held by a single entity, the national oil company Saudi Aramco, which is the most valuable firm of any kind in the world measured by revenue (The Economist 2016). Today's Saudi Aramco is the offspring of the former Aramco joint venture launched by the original concession holder, Standard Oil of California (now Chevron), later joined by Texaco, Mobil, and Exxon. Aramco was completely nationalized between 1973 and 1980 and renamed Saudi Aramco.

Table 1. Saudi Arabia's basic energy indicators, 2017

Crude oil reserves	266.2 billion barrels
Natural gas reserves	8.04 trillion cubic meters
Oil production	11.95 million barrels/day*
Oil consumption	3.92 million barrels/day*
Natural gas production	111.4 billion cubic meters
Natural gas consumption	111.4 billion cubic meters
Coal consumption	0.09 million tonnes of oil equivalent
Electricity production	375.6 terrawatt-hours

Source: BP 2018

Note: * includes natural gas liquids

[1] Saudi Arabia's role in OPEC and the cartel's behavior and the extent of its influence on prices are the subject of much academic debate (Adelman 1982; Griffin 1985; Mabro 1992; Smith 2005). More recently, academics have focused on whether OPEC's market power has been undermined by U.S. shale oil, a topic covered below.

Oil

Saudi Arabia's 266 billion barrels of proven oil reserves (Table 1) are the second largest in the world behind Venezuela's, comprising roughly 16% of the world's total (BP 2018). At recent rates of production of around 10 million barrels per day (b/d), the kingdom's proven reserves can produce for 60 years (BP 2018). Saudi Arabia has more than 130 known oilfields, which include the largest onshore and offshore fields in the world. Most of the kingdom's oil and gas is located in the Eastern Province or just off its Persian Gulf shore. Saudi Arabia and Kuwait also have equal rights and shares of the 5 billion barrels of oil reserves in the Saudi-Kuwait Partitioned Neutral Zone. A single onshore field, Ghawar, is responsible for more than half of Saudi production. Ghawar, the world's largest oilfield, still contains reserves of 75 billion barrels, which is more than the total reserves of all but seven other countries. Safaniyah, the world's largest known offshore field, retains 35 billion barrels (EIA 2017; IHS Markit 2017). Saudi Arabia also harbors enormous unconventional oil and gas resources, mainly in shale and tight formations, which it has only recently begun exploring and exploiting. One report estimated potential shale reserves at 10 times the volume of the kingdom's proven conventional reserves (Parker 2018).

Outsiders often speculate over the true size of Saudi Arabia's remaining oil reserves. The kingdom has reported proven reserves near 260 billion barrels since 1990, when it inexplicably raised its official figures from 1989 levels of 173 billion barrels. Since then, some 100 billion barrels have been depleted without affecting reported reserves (BP 2018). Not all observers are comfortable with these estimates. Norwegian consultancy Rystad Energy estimates Saudi proven reserves at a far lower amount, just 88 billion barrels; "probable" and "possible" reserves— including those yet to be discovered—add another 188 billion barrels (Rystad Energy 2017). Since most of the kingdom's big fields were found at least 40 years ago, the long-term consistency in reserve estimates indicates that recent exploration activity is probably not the only source of reserve growth. Other factors may include "field appreciation," which leans on improvements in recovery and an understanding of reservoir capacity, and a loose criterion for estimating "proven" reserves, perhaps by adding in formations normally considered "probable" and "possible" (Krane 2017).

Saudi Arabia declares that its maximum sustainable oil production capacity is 12.5 million b/d, a level that Saudi Aramco determines it could sustain after a six-month period of capital and operational investment.[2] Independent estimates are generally smaller. The U.S. Energy Information Administration estimates maximum output at roughly 12 million b/d. In practice, the kingdom's oil production (not including natural gas liquids or NGLs) only breached 11 million b/d for a short period in November 2018, when output reached at least 11.1 million b/d (El Gamal 2018). For the first nine months of 2018, Saudi Arabia's average production of 10.2 million b/d slipped behind that of the United States, at 10.6 million b/d, and Russia, at 10.5 b/d (JODI 2018).

[2] The ambitious six-month timeframe for reaching 12.5 million b/d stems from Saudi Aramco's internal guidelines, according to an employee interviewed on condition of anonymity in 2016. See Krane (2017)

Of course, Saudi Arabia's advantage lies in the volume of its exports. About two-thirds of the crude oil produced in Saudi Arabia is sold outside its borders. In 2017, Saudi Arabia exported 7 million b/d of crude oil and petroleum products, making it the world's largest oil exporter (JODI 2018). Of these, 69% were destined for Asia, 18% for the Americas, and 10% for European markets.

Natural Gas

The kingdom's natural gas reserves and production are modest compared to its commanding stature in global oil markets. Saudi Arabia's proven gas reserves in 2017 were estimated at 8 trillion cubic meters (tcm) (284 trillion cubic feet, or tcf), ranking it in 6th place globally after Iran, Russia, Qatar, Turkmenistan, and the United States (BP 2018). Saudi Aramco produced 109.4 billion cubic meters (bcm) (3,869 billion cubic feet, or bcf) of gas in 2016, an increase of 4.4% from 2015.

As a matter of national policy, Saudi Arabia neither imports nor exports natural gas, although policymakers have not ruled out gas imports. For now, it chooses to remain self-sufficient and uses a rationing structure to allocate natural gas to domestic customers. Consuming sectors, such as power producers and industrial firms producing glass, aluminum, fertilizer, and petrochemicals, are given allocation quotas of natural gas at prices administered by the state.

Most Saudi output comprises associated gas produced in tandem with oil. Historically, gas production has depended on that of oil. Over the past decade, however, Saudi Aramco has worked to reduce this constraint by investing heavily in the development of non-associated gas fields. As a result, Saudi gas production has risen by nearly 60% over the decade to 2017, from 71 to 110 bcm (BP 2018). The investments have increased the average cost of gas produced, while providing a useful source of natural gas that does not fluctuate alongside oil production.

Other

Saudi Arabia, like other Middle Eastern countries, has geology that is believed to contain uranium. Geological assessments have described uranium deposits in the kingdom as "important," but open-source publications describing the extent of the ore deposits lack detail (Howari et al. 2016). In 2017, the Saudi Geological Survey signed an exploration agreement with a Chinese firm tasked to locate uranium ore deposits (World Nuclear Association 2017). Core samples taken during oil drilling have also turned up evidence of coal seams (Poinar et al. 2004). But coal is not produced commercially in the kingdom or anywhere else on the Arabian Peninsula.

The kingdom and surrounding region are also home to some of the world's most significant renewable energy resources, particularly solar. Average solar radiation in the country ranges from 4 to 7 kilowatt-hours (kWh) per square meter, with higher levels generally occurring away from the humid coastal regions. The highest levels occur in the

northwestern part of the country near the Jordanian border (Zell et al. 2015). Average annual wind speeds range between 6 and 8 meters per second (m/s), just above the minimum 6 m/s threshold for onshore wind viability. Consistent wind speeds of 8 m/s or above have been documented in the northern and mountainous western regions (K.A. CARE 2016). Solar and wind projects also benefit from state ownership of vast, empty and treeless tracts of land, as well as the ease of installing road access to these sites. On the downside, wind installations along the Red Sea and Persian Gulf coasts could threaten prominent flyways for migratory birds.

Electricity Mix

Despite its prodigious solar and nuclear potential, Saudi Arabia generated more than 99% of its electricity in 2017 using fossil fuels (Table 2). The kingdom's 88 gigawatts (GW) of generating capacity produced 376 terawatts (TW) of electricity in 2017, with just 0.04% of that power generated by non-fossil means, all using solar technology (EIA 2017; MEES 2017; BP 2018). The Saudi electricity sector has evolved quickly over the past decade, both in terms of growth—power generation increased by a yearly average of 6.4% since 2005—and in the fuel mix. Where oil-based liquid fuels once covered more than half of feedstock needs, by 2016 the kingdom's expansion in natural gas production and installation of gas-fired generation gave gas a slight edge in terms of power generated, along with a 60% share of installed capacity (ECRA 2016; MEES 2017).

Table 1. Power generation by source in Saudi Arabia.

Saudi power generation share by fuel, 2016	
Natural gas	50.7%
Crude oil	24.2%
Heavy fuel oil	16.5%
Diesel	8.6%
Renewables (solar)	0.04%

Source: ECRA 2017; BP 2018

The scant-known coal deposits in the region have not prevented some Middle Eastern countries from building coal-fired capacity. Dubai's giant Hassyan coal-fired plant, under construction in 2018, is the largest such project in the Gulf monarchies. Saudi Arabia has never proposed or promoted coal-fired power generation due to its lack of domestic stocks, preference for energy self-sufficiency, and competitive cost analyses that show coal compares unfavorably with existing sources (Matar et al. 2015).

The kingdom has also worked to diversify the fuel mix beyond hydrocarbons, and the King Abdullah City for Atomic and Renewable Energy (K.A. CARE) announced plans in 2013 to

develop 41 GW of solar power, 16 nuclear power plants producing 17.6 GW of nuclear power, and 9 GW of wind power by 2032 (K.A. CARE 2013). Those unrealistic and expensive plans have since been scaled back, only partly due to falling oil prices. Saudi Arabia now plans just two nuclear power plants of 1.4 GW each. The renewables target has been reduced to a modest 3.45 GW of renewables capacity by 2020 and 9.5 GW by 2023.

In 2017, the kingdom installed its first-ever wind turbine, while also launching bid rounds for a 400 MW wind farm and a 300 MW solar photovoltaic array (MEES 2017). The forthcoming wind installation is being constructed in the northwest, near the Gulf of Aqaba, where officials are confident it will achieve a 50% capacity factor, an unusually high level for onshore wind.[3] In 2018, Saudi Arabia announced that it would partner with Japan's SoftBank to finance an additional 200 GW of solar power capacity by 2030 at a cost estimated at $200 billion (DiChristopher 2018). Like the grandiose 2013 clean electricity plans, the SoftBank initiative was abandoned (Jones and Said 2018).

Characteristics of the Policymaking Environment

Governance Structure of the Country

The Kingdom of Saudi Arabia is an absolute monarchy that has been recognized as a sovereign and independent nation-state since 1932, when forces aligned with Abdulaziz al-Saud merged disparate tribal lands and placed them under al-Saud family control. Saudi Arabia is the only country named for the family that currently rules it, and it is one of the few to have largely escaped colonial domination. Political parties and electoral politics are illegal. Governance is based on traditional tribal-autocratic practices overseen by a dynastic ruler who draws on a mix of formal and informal institutions. Decision-making has traditionally been consultative,[4] bringing together royal family members to confer among themselves and with technocratic advisers. Informal consultative institutions also play an important role. Open, regular *diwaniya* or *majlis* gatherings, informal discussion sessions hosted by influential citizens, are obligatory among senior royal family members. These gatherings allow citizens to submit petitions and air requests for assistance (Royal Embassy of Saudi Arabia in Washington, D.C., n.d.; Wilton 1988; Anderson 1991).

Saudi Arabia's role in the global energy trade is secondary in importance to its founding role in the Islamic faith as the birthplace of the Prophet Muhammad and the site of Islam's two holiest shrines in Mecca and Medina. As such, Saudi kings since 1986 have assumed the title "Custodian of the Two Holy Mosques." Islam is closely integrated into the kingdom's laws and governance. Notably, however, the state supervises religious authorities, rather than the reverse (Anderson 1991).

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[3] Capacity factor measures the actual power output over time as a percentage of the maximum possible output. Details on capacity factor are from a Saudi energy official interviewed on the condition of anonymity in Dhahran, Feb. 21, 2017.

[4] Consultative practices had been reduced under the leadership of King Salman and his son, Crown Prince Mohammed bin Salman. See for example: F. Gregory Gause III, "Saudi Regime Stability and Challenges," in *Salman's Legacy: The Dilemmas of a New Era in Saudi Arabia*, ed. Madawi al-Rasheed (New York: Oxford University Press, 2018).

The kingdom's constitution is the Quran and the Sunnah, the religious teachings and practices of Prophet Muhammad. Article 8 in Saudi Arabia's *Basic Law of Governance* holds that governance is based on justice, consultation (*shura*), and equality according to Islamic sharia law. Article 5 establishes that the rulers must be sons of King Abdulaziz and the descendants of those sons. Since 2008, as the generation of sons readied to give way to the much larger generation of grandsons, appointment of a successor to the king—a crown prince—has fallen to an Allegiance Council of senior royal family members who vote on the king's candidates. King Salman, who acceded in 2015, is the sixth and probably last son of Abdulaziz to assume the kingdom's leadership. Salman has appointed his son, Crown Prince Mohammed bin Salman, as his successor. Mohammed bin Salman, a grandson of the founder, was approved by 31 of 34 members of the Allegiance Council, and he has assumed much of the daily governance from his elderly father (Al Arabiya English 2017).

The Saudi governance system has proven remarkably durable, and it benefits from extensive flexibility and adaptability. However, the high degree of concentration of power and the sprawling and informal nature of the Saudi bureaucracy have brought about a large measure of autonomy—even disarray—in day-to-day administration. While the king's powers are absolute and unchecked, his control is tempered by the lack of information on his economy and society, and the lack of control over civil servants providing—or thwarting—services to the public (Hertog 2010).

The kingship of Saudi Arabia includes numerous functions and titles that, in less centralized systems, are delegated to subordinates of the head of state. The Saudi king simultaneously serves as prime minister, oversees the use of sharia in the legal system and policymaking, and supervises national defense. The king and crown prince receive advice and assistance from their appointees in the Council of Ministers, which serves as a cabinet. The Council of Ministers consists of the prime minister (the king), the deputy prime minister (the crown prince, who currently happens to also hold the title of defense minister), as well as 21 other ministers who head departments and seven junior ministers of state (Royal Embassy of Saudi Arabia in Washington D.C., n.d.).

Advising the king and cabinet is the Majlis al-Shura, or Consultative Council, a legislative body of 150 members appointed by the king based on their expertise on particular areas of policy. The mandate of the Majlis al-Shura expanded in 2004 to include amending laws or proposing new legislation, in addition to its original discussion of regulations and matters of national interest. In 2013, King Abdullah appointed 30 women to the council after decreeing that women should hold at least a fifth of its seats (BBC News 2013).

Before 2015, two organizations were largely responsible for governing Saudi Arabia's oil and gas sector: the Ministry of Petroleum and Mineral Resources and a "supreme council" of advisers to the king. Established in 1960, the Ministry of Petroleum and Mineral Resources held oversight responsibility for the national oil company, Saudi Aramco. It also held (and still holds) partial policymaking responsibility for the oil, gas, and mineral sector. The ministry's main partner in energy sector governance was the Supreme Council for Petroleum and Minerals, which was founded in 2000. Members of the council included

royal family members and industry technocrats appointed by royal decree to four-year terms. The council held decision-making power over all matters related to petroleum, including production volume and export strategy. Saudi Aramco's operations were governed by decisions made within the ministry and the supreme council (Krane 2019).

After King Salman's accession in 2015, the kingdom restructured its energy governance. The king abolished the Supreme Council for Petroleum and Minerals and distributed its duties to three new organizations chaired by Crown Prince Mohammed bin Salman. One of these is the newly formed Supreme Council for Saudi Aramco, which assumed oversight over Saudi Aramco outside the purview of the ministry. In practice, however, the ministry and Saudi Aramco still coordinate closely, and Saudi Aramco executives regularly refer to ministry policies as guiding parameters for their operations. Two related and newly formed supreme councils, also chaired by the crown prince, overlap somewhat with energy affairs: the Council for Political and Security Affairs and the Council for Economic and Development Affairs. Further restructuring in 2016 expanded the oil ministry, renaming it the Ministry of Energy, Industry and Mineral Resources. The Ministry of Water and Electricity was broken up and replaced (Krane 2019).

Climate policy and negotiating strategy in Saudi Arabia is firmly fixed within the Ministry of Energy, Industry and Mineral Resources due to the importance of oil exports to the national interest, as well as the perceived threat of climate action to the Saudi economy. The energy ministry also retains a high level of technical competence and international diplomatic experience relative to most other arms of the Saudi government. Environmental policy within the kingdom also typically relates to energy, with an emphasis on the dual-purpose goal of improving efficiency of consumption. The Saudi Energy Efficiency Program, or SEEP, was created in 2012 to lead conservation efforts across industry, buildings, and transport. It has developed numerous regulations and efficiency standards, including fuel/energy efficiency labels attached to every car and most large appliances sold in the kingdom (al-Ragass 2017).

Existing Laws and Regulations Governing the Energy Sector

Saudi Arabia's legal system is unique, even among Muslim-majority autocracies in the Arab world. Islamic sharia law serves as the central guiding force for all legal and social matters and for criminal and civil cases. There is no written constitution other than the Quran itself and the historical precedent of interpretive enforcement, along with tribal traditions and customs that acquired force of law through the ages (Wilton 1988). Outside of Saudi Arabia, sharia principles have generally receded to supporting roles due to accumulating bodies of case law.

Saudi law is administered and enforced by a system of courts, overseen by a judicial council and guided by the *ulama*, an informal community of sharia scholars. Judges see themselves as ruling in accordance with God's will, rather than following the authority of the state. Much of the specifics of laws and the legal code remain unwritten (Brown 2012). In practice, secular and religious aspects of governance blend together. Saudi enforcement tactics often exhibit an ad hoc character, such as the 2017 detention of elites determined by

an anti-corruption committee to have engaged in corrupt practices. Many were held until they surrendered substantial sums. Evidence against the detainees was not made public, and human rights groups pointed out that the detentions targeted political rivals of the crown prince (Human Rights Watch 2017).

Articles 14 and 15 of the kingdom's *Basic Law of Governance* govern the energy sector. Article 14 states that "All natural resources bestowed by God, both under or above ground, of the country or in its territorial waters, or within its terrestrial and maritime limits, as well as the revenues of these resources shall be owned by the state as specified by the law." Article 15 includes a stipulation against foreign concession-holders, stating that "not any concession or any permission shall be given for the utilization of any of the country's natural resources, except as permitted by the law" (Ministry of Foreign Affairs, Saudi Arabia 2011).

Cultural Attributes and Informal Institutions in Policymaking

Saudi Arabia's politics are highly personal. Informal sources of influence such as *wasta*, or personal stature and connections, weigh heavily on government policymaking and responsiveness. The al-Saud family, with more than 7,000 princes, carries major influence, as do tribes historically allied with the family and its conservative religious backers. Tribal leaders maintain influential positions in the ruler's court (*diwan*) and those of provincial governors. Tribal influence is extended and maintained through marriage ties, particularly with the royal family.

Scholars have identified the social contract or "ruling bargain" as a key informal institution that governs the state-society relationship (Beblawi 1987; Beblawi and Luciani 1987). The unwritten social contract is portrayed as an exchange of citizen rights for government support and subsidies. Citizens acquiesce to al-Saud control of the state in return for generous welfare benefits and state-sponsored employment, along with a rising standard of living. However, Saudi citizens often say that no such compact exists. Recent research shows a gap in understanding between citizens and elites as to the shape of the state-society relationship (Krane 2016). The terms of the informal social contract were identified by scholars as a major impediment to reforms of social welfare benefits, including provision of subsidized energy.

Energy subsidies in the kingdom have their roots in age-old, sheikh-determined patronage practices that are among the longest-held principles of tribal rule, predating the discovery of oil and the founding of the modern Saudi state. The government began providing modern energy services in the 1950s. Current pricing practices arose during the oil boom era of the 1970s, amid the rent windfall from the 1973 oil embargo and nationalization of Saudi Aramco between 1973 and 1980. The kingdom's population was much smaller and poorer, and subsidized fuel, water, and electricity were initially seen as tools of poverty alleviation.

In the 1980s, Saudi Aramco built the kingdom's Master Gas System, capturing gas that had been flared off or vented when American oil companies operated the oil sector. Saudi Aramco used the gas to fuel the growing electricity sector. Prices for gas and electricity reflected the logic of the era. Since the surplus gas feedstock was essentially free and

otherwise too difficult to market overseas, executives concluded that consumers should only pay costs of building, operating, and maintaining the infrastructure. So-called "stranded" gas that had once gone to waste was used to develop the kingdom, improving lifestyles while shoring up political support for the ruling family (Krane 2019).

Sources and Control of Information in Policymaking

The Saudi state holds central authority over communications and media inside the kingdom, whether TV, print newspapers, or Internet news sites. Social media, hugely popular among Saudis, is subject to monitoring, censorship, and outright blocking, although this is rare. Users can be jailed or fined for statements deemed offensive or incendiary (Freedom House 2018). In practice, however, barriers to information access have fallen, and the state no longer has the ability to control access to media deemed undesirable. Saudis are among the world's top social media users and consumers—particularly of Twitter and YouTube—and policymakers have resorted to online messaging to improve services or respond to complaints (Global Media Insights 2018). For instance, employees of the kingdom's electricity and water regulator monitored Twitter to address complaints and defend increases in utility rates in 2016 and 2018 (Al-Shehri 2018). Saudi officials associated with unpopular economic reforms, including the energy minister, have come under personal attack on social media.

Recent Changes in Energy Policymaking

Saudi Arabia's energy policymaking landscape underwent a transformation in 2016 after King Salman's succession. At that time, the government reorganized ministries overseeing the energy, environment, and water portfolios. Prior to the 2016 restructuring, the Ministry of Petroleum and Mineral Resources, headed since 1995 by Ali al-Naimi, handled the upstream oil and gas portfolio. This ministry was tasked with producing sufficient oil for export and managing international market strategy.

Under Naimi, the Saudi oil ministry found itself frustrated in its attempts to confront fast-paced growth in domestic consumption of exportable oil and gas, demand for which was intensified by subsidized pricing. There was no government agency tasked with the crucial issue of demand management. Al-Naimi found his ministry working at cross-purposes with other energy-focused institutions, particularly the Ministry of Water and Electricity (MOWE) and its minister Abdullah al-Hasin. MOWE's mandate was to meet domestic demand for electricity and water, no matter what the effect on oil exports. Under MOWE, power generation expanded into a huge source of demand for crude oil, diesel, and heavy fuel oil. Power sector oil consumption reached 900,000 b/d during summer months. Despite the importance of crude oil exports to the Saudi economy and national budget, the Saudi Electric Company was still building new oil-fired power plants as recently as 2014 (MEES 2014, MEES 2016a).

In 2016, the Saudi government initiated a comprehensive reform to energy subsidies, raising prices for bulk industrial and transportation fuels, as well as retail prices on energy products and services (Table 3). Around the same time, MOWE was broken up, and al-

Hasin dismissed. The government gave oversight responsibility for water management to the newly created Ministry of Environment, Water and Agriculture (MEWA). At the top of MEWA's new mandate is the pursuit of conservation and protection of resources. The electricity portfolio was moved to a newly created energy "super-ministry," the Ministry of Energy, Industry and Mineral Resources (energy ministry). Appointed to replace the retiring al-Naimi was former Saudi Aramco CEO Khalid al-Falih, one of the kingdom's most prominent energy sector managers (McDowall et al. 2016).

The expanded energy ministry now oversees a combined portfolio including upstream oil and gas production and export market strategy, alongside domestic distribution and demand management. The energy ministry also handles the kingdom's participation in OPEC, as well as global policy toward refining and petrochemicals, the reform of subsidized prices on fuels and electricity, and Saudi climate policy. The changes aim to help Saudi Arabia streamline domestic energy use. The ministry can still ensure that internal needs are met while working to see that Saudi demand doesn't conflict with exports or the industrial strategy underpinning the kingdom's GDP.

The Saudi role in OPEC and OPEC's operating procedures have also undergone recent changes. The onset of U.S. shale oil production, which has added some 6 million b/d of oil production to world supply, has undercut OPEC's market power. The fast growth in U.S. output has also curtailed the autonomy of Saudi leadership in oil markets, forcing the cartel to collaborate with Russia in 2016 to impose production constraints sufficient to raise global oil prices. It is not just the supply of U.S. shale oil that inhibits OPEC, but the price elasticity of that supply. Without Russia's involvement, OPEC cuts would probably prompt an increase in shale production sufficient to nullify most of the resulting increase in price. But OPEC and Russia cutting production together can reduce global supply by a larger amount than shale can replace, as happened between 2016 and 2018, when very large production cuts forced oil prices up (Volkmar 2018). Ironically for the United States, one of the strategic downsides of the shale revolution has been to incentivize closer relations between Saudi Arabia and Russia, countries with a history of animosity dating to the anti-monarchy and atheist founding principles of the Soviet Union.

Discussion of the Energy Policymaking Process

Domestic energy policymaking in Saudi Arabia has undergone a thorough transformation since the early days of oil. At that time, profligate energy provision was based on poverty alleviation and basic industrial development. Today, energy policy recognizes the limits of domestic energy resources.

High Levels of Demand

Saudi oil demand is among the highest in the world, both in real and relative terms. Saudi Arabia was the world's 5th largest oil consumer in 2016 according to BP figures, despite a disproportionately small population, which the World Bank tallied as the world's 47th

largest. Within a few years, Saudi oil demand may well surpass that of the 4th largest consumer, Japan. Only India, China, and the United States consumed significantly more.

Saudi oil demand is particularly elevated on a per capita basis. The kingdom burned the equivalent of 44 barrels of oil per person in 2016, a figure comparable with neighboring oil monarchies—48 in Qatar, 45 in Kuwait, and 39 in the UAE—but far above levels in the developed world such as Germany's 10, Japan's 12, South Korea's 20, or the United States' 22.[5] A major factor in high levels of per capita energy demand is due to heavy use of air conditioning to cool buildings, the source of roughly 70% of electricity demand in the kingdom and surrounding monarchies. Low levels of prevailing efficiency in air conditioning equipment and building envelopes plays a role (Al Kanani 2017).

Since 1970, Saudi demand for primary energy has grown at the rate of 5.5% per year. Within that figure, oil demand has grown at a yearly average of 4.6% and non-oil energy by 9.6% (BP 2018). While demand growth has shown recent signs of slowing, official government forecasts project that primary energy needs will triple by 2030, rising from 267 million tonnes of oil equivalent (mtoe) in 2016 to 800 mtoe in 2030 (Government of Saudi Arabia 2016; BP 2017). Clearly, oil demand in Saudi Arabia is in dire need of reform, particularly given that domestic bulk sales, at around $6 per barrel, divert oil from export, sales of which fetch roughly 10 times that amount.

The kingdom's natural gas production has been part of the problem. Dependence on associated gas has left the kingdom vulnerable to fluctuations in the level of oil produced. Since Saudi Arabia acts as the world's market-balancing "swing supplier" of crude oil, fluctuations in output are frequent occurrences. Each time Saudi Arabia cuts oil production in line with OPEC, the kingdom's domestic supply of natural gas is reduced by a commensurate amount. Exacerbating these stresses, low domestic natural gas prices encouraged high levels of demand, particularly in the power generation and petrochemicals sectors. Rather than begin imports of natural gas, the kingdom chose to burn crude oil and refined products in lower-value applications that would have been better suited to gas.

As Table 3 shows, Saudi Aramco raised domestic gas prices by 67% from its longtime rate of US$0.75 to US$1.25 per million British thermal unit (mmBtu) in 2016. At the same time, the kingdom began developing previously idle reservoirs of non-associated gas. Non-associated gas has allowed gas output to increase independently of oil production, loosening the link with oil and OPEC quotas.

Energy Subsidies

Low prices have been a key factor in encouraging energy demand in the kingdom. Price affects demand in two ways: directly, by influencing choices in consumption of fuel, electricity, and water; and indirectly, through choices of energy-consuming equipment and

[5] These estimates use population figures from the World Bank and oil consumption data from BP (2017).

its efficiency, as well as how often it is used (Medlock III 2011). Roughly a third of energy demand in the six Gulf monarchies is attributable to subsidies (Krane 2015b). Since prices are set by the state, a large portion of the kingdom's energy demand—and its carbon footprint—can be ascribed to government policy.

Table 3. Energy subsidy reform: increases in energy commodity and service prices in Saudi Arabia since 2016

Product	2015	2016 /2017	2018	% change (2015-2018)	Current benchmark (US$) (source)	Saudi 2018 price as factor of international benchmark
Crude oil for power generation (US$/bbl)	$4.23	$5.87	$5.87	39%	$54.20 (2017 Brent)	11%
Natural gas (methane) (US$/mmbtu)	$0.75	$1.25	$1.25	67%	$4.69 (2016 NBP)	27%
Gasoline (91 octane) (US$/gallon)	$0.46	$0.77	$1.40	204%	$2.53 (2017 U.S.)	55%
Gasoline (95 octane) (US$/gallon)	$0.61	$0.92	$2.09	240%	$2.53 (2017 U.S.)	82%
Diesel (US$/gallon)	$0.26	$0.48	$0.48	88%	$2.65 (2017 U.S.)	18%
Water (residential) (US$/cubic meter)*	$0.03	$0.04	$0.04	50%	$0.61 (2018Tucson, AZ, U.S.)	7%
Electricity (residential, low consumption) (US$/kWh)	$0.01	$0.01	$0.05	260%	$0.13 (2017 EIA)	37%
bbl, barrels; mmbtu, million British thermal units; NBP, National Balancing Point; EIA, U.S. Energy Information Administration						

Source: Baker Institute of Public Policy; EIA 2018

Note: *Saudi 2016 price covers first 15 m^3/month only

Once provided, subsidized energy became understood as a customary privilege of citizenship (Krane 2014), or as others have argued, a fundamental right (Crystal 1990; Gause III 1994; Herb 1999). Subsidy policies were probably not originally intended to be permanent. Policymakers may not have realized that their benevolent policies would create a bloc of potential opponents, since subsidies create solidarity among beneficiaries

who organize to protect their interests. When their benefits are put at risk, recipients can rise up and threaten the political leadership. Welfare societies like those in the Gulf therefore maintain a constant potential for mobilization that raises the stakes of reform (Pierson 1996; Victor 2009).

In 2016, after years of pressure from Saudi technocrats, the kingdom began to reform subsidies (Table 3). The state raised prices again in 2018. Mindful of the outcry among Saudis over lost benefits, as well as the potential for unrest, the government began compensating lower- and middle-class households with cash payments tied to the loss in benefits.

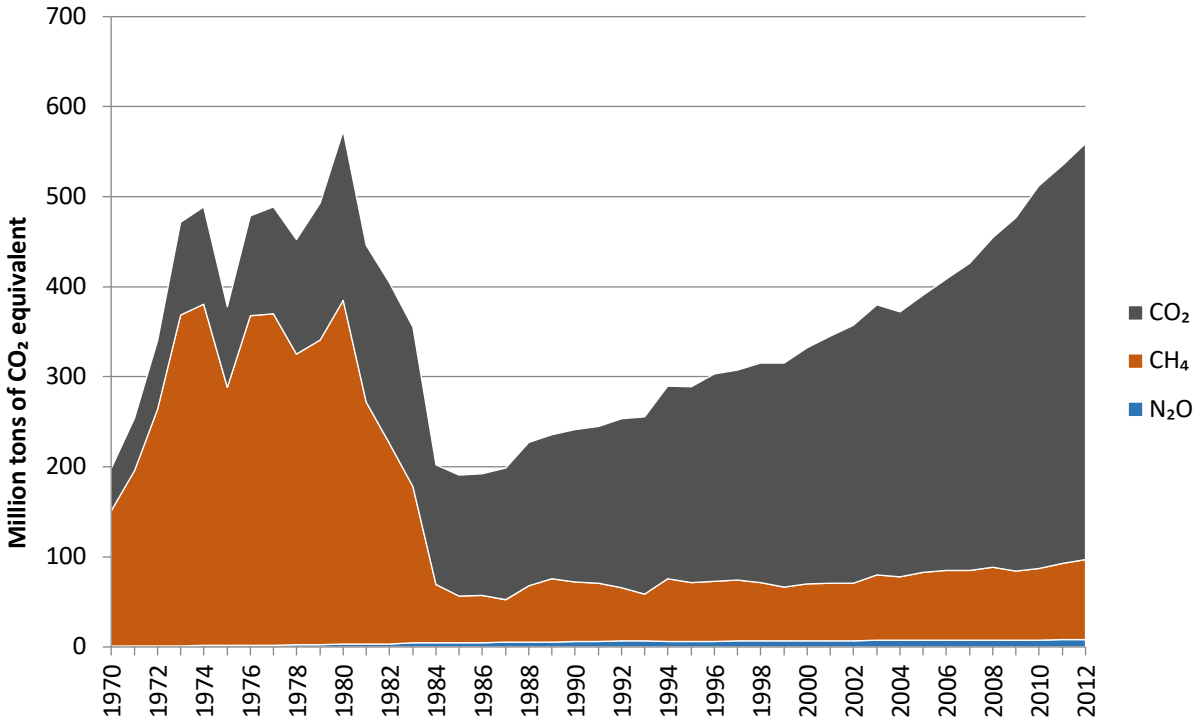
The pricing changes were beginning to affect consumption in 2018, and demand forecasts will probably have to be revised. For instance, forecasts in 2016 from Riyadh-based bank Jadwa Investment had depicted Saudi oil demand growing from 2.5 million b/d in 2015 to nearly 5 million b/d by 2030 if domestic prices were left unchanged, which would see about half of current Saudi production diverted to the domestic economy (Jadwa Investment 2016a). However, Saudi oil demand has flattened after the price increases of 2016 and 2018, with the kingdom undergoing a 1% decline in oil use in 2017 (Jadwa Investment 2018).

Meanwhile, Jadwa Investment expected the kingdom's electricity generating capacity and natural gas demand to continue to increase, as gas and renewables begin to replace oil in the power sector. Generating capacity required to meet demand was forecast to rise from 88 GW in 2017 to 94 GW in 2020 and 135 GW in 2030, with natural gas called upon to fuel most of that growth. Gas consumption is expected to grow from 14 billion cubic feet per day (bcf/d) in 2015 to 18 bcf/d in 2020 and 32 bcf/d in 2030 (Jadwa Investment 2016b) However, some of these forecasts were issued prior to major price increases in electricity rates in 2018, and they may be revised downward.

Saudi Climate Footprint and Policy

Energy demand growth has fed directly into increasing levels of greenhouse gas (GHG) emissions and the kingdom's disproportionately large climate footprint. Saudi Arabia is recognized as an important contributor to global climate change in several respects: as a major fossil fuel producer, supplier, consumer, and subsidizer. Saudi Arabia also stands to become an early and significant victim of climate change, since its arid geography and harsh summer climate are highly vulnerable.

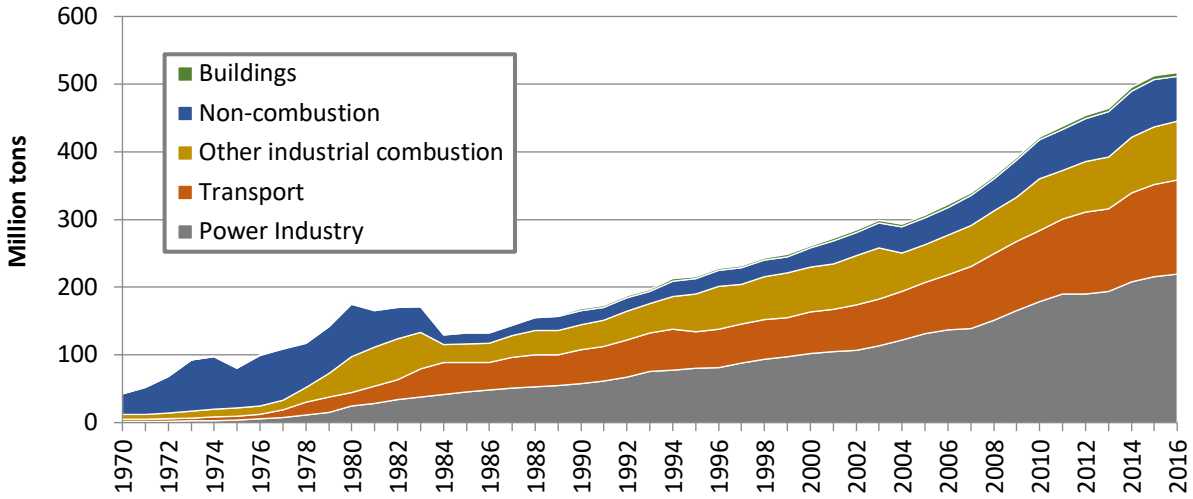
Figure 1. Saudi GHG emissions since 1970



Source: EDGAR (2017)

Historically, Saudi GHG emissions were dominated by natural gas flared and vented during oil production. Fugitive methane emissions peaked during the 1970s, a period when the kingdom's overall GHG emissions reached highs that were only surpassed within the last few years (Figure 1). At the time, Aramco was owned and operated by U.S. companies that had no interest in capturing natural gas produced in association with oil. The gas was either vented to the atmosphere—the source of much of the fugitive methane (CH_4) in Figure 1—or burned off at the wellhead, which accounted for a large portion of Saudi CO_2 emissions. The flaring and venting of natural gas were curtailed dramatically after the Saudi government took full control of the company in 1980, which resulted in the deep reductions in Saudi GHG emissions seen in Figure 1. The captured gas was fed into Saudi Aramco's newly established Master Gas System and used for the purpose of generating electric power (Krane 2014; Saleri 2018). In the post-nationalization period, the power sector has grown to become the largest source of emissions, followed by transport and industry. Since then, Saudi CO_2 emissions have grown nearly 6% per year, roughly the same rate as the country's primary energy demand (EDGAR 2017).

Figure 2: Saudi CO_2 emissions by sector since 1970



Source: EDGAR (2017)

Note: Fugitive (non-combustion) CO_2 from the oil industry was a major early source of emissions that has re-emerged in recent years, after dropping below 50% by 1979. The power sector now dominates carbon dioxide emissions, followed by transport and industry. Saudi CO_2 emissions have grown nearly 6% per year.

As befits a country with some of the world's highest levels of oil consumption and relatively high personal incomes, Saudi Arabia is a leading emitter of GHGs. The kingdom was the world's 9th largest carbon emitter in 2016 according to BP data, ahead of populous oil producers like Brazil, Mexico, and Indonesia, as well as developed states like Canada and Australia, but behind Iran, South Korea, Germany, and Japan. However, BP data only reflect CO_2 emitted from fossil fuel combustion and ignore other sources and types of greenhouse gases (BP 2017). When all GHGs are factored in, Saudi Arabia ranked as the 15th largest emitter in 2012 according to the most recent data collected by the EU's Emissions Database for Global Atmospheric Research (EDGAR). EDGAR GHG data rank the kingdom *behind* Brazil, Mexico, and Indonesia, as well as Canada and Australia. However, Iran remained a larger emitter in both instances (Table 4).

Table 4. Saudi Arabia benchmarked against selected countries in terms of GHGs, population, and economy*

Country	Crude & NGL export (thousand b/d)	2012 Population (million)	GDP (US$ bn 2011)	2012 GHG emissions (Million tons of CO_2eq)	Average annual growth rate of GHG emissions since 1970	2016 CO_2 emissions (Million tons)
USA	424	314	15,863	**6,125.0**	0.20%	5,350.4
Russia	4,858	143	3,602	**2,280.8**	0.60%	1,490.1
Brazil	532	200.5	3,032	**1,121.0**	2.82%	458.0
Indonesia	315	249	2,302	**823.2**	3.36%	531.4
Iran	1,371	76	1,271	**786.0**	2.49%	630.9
Mexico	1,333	121	1,972	**725.0**	2.57%	470.3
Canada	2,516	35	1,452	**717.5**	0.90%	527.4
Australia	281	23	967	**602.1**	1.65%	408.9
Saudi Arabia	7,442	29	1,444	**558.8**	2.50%	621.8
UAE	2,625	9	532	**225.2**	2.20%	288.0

Source: IEA, World Bank, and EDGAR

Note: *2012 data (most recent GHG emissions data available)

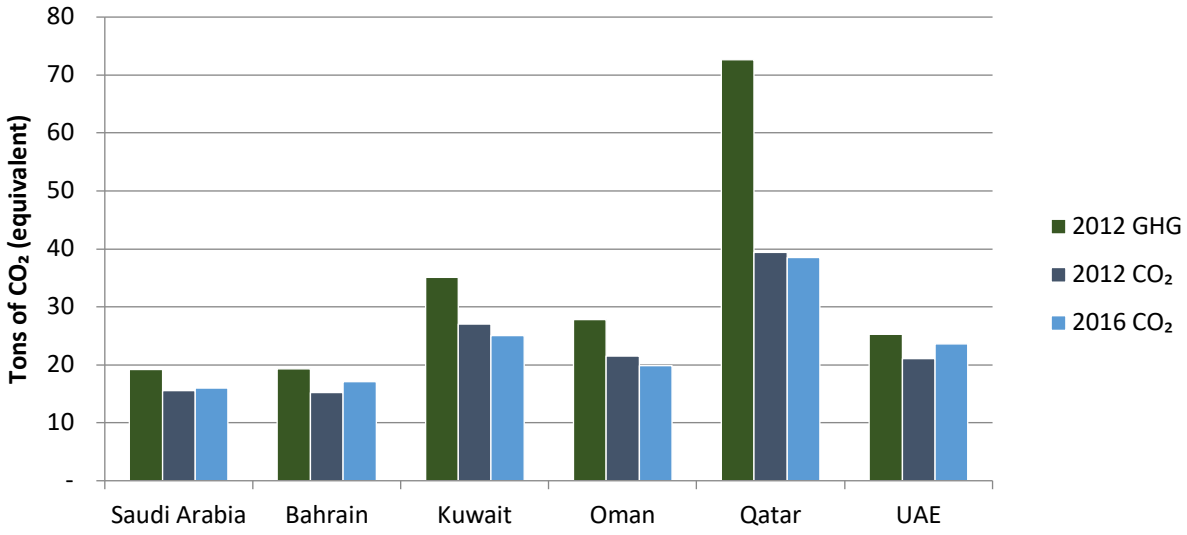
On a per capita basis, Saudi Arabia is the least prolific emitter among the six Gulf Cooperation Council (GCC) member states, far outpaced by Qatar and Kuwait, and even ranking behind the UAE, Oman, and Bahrain (Figure 3). The huge levels of per capita GHG emissions in the smaller monarchies are based on factors such as small populations relative to large-scale, energy-intensive industries. Qatar's natural gas sector, including its LNG and gas-to-liquids industries, is a major emitter of both carbon dioxide and fugitive methane.[6] Other factors include higher per capita incomes, larger home sizes, and lower electricity prices. Power is nearly free in Kuwait, and it is free in unlimited quantities for Qatari citizens.

Saudi Aramco has been identified as the world's highest current and historical emitter of GHGs among all commercial fossil fuel companies, when the firm's full tally of its production is accounted for at final combustion. Hydrocarbons produced by Saudi Aramco are responsible for about 4.3% of current global GHG emissions and about 3.2% of historical GHG atmospheric accumulations. Other major emitters include the Russian state-controlled Gazprom (3.8% of current emissions), the National Iranian Oil Co. (2.4% of current emissions), and Coal India (2.3%). By contrast, oil and gas produced by ExxonMobil, the former Standard Oil of New Jersey, is responsible for about 1.2% of current global emissions and 2.5% of historical accumulations. Chevron, the former Standard Oil of

[6] Fugitive methane constituted nearly half of Qatar's 2012 GHG emissions, or about 70 of 150 megatonnes of CO_2 equivalent, according to EDGAR's dataset (EDGAR 2017).

California, which discovered oil in Saudi Arabia in 1938 and held the original Saudi concession, is responsible for about 1.2% of current emissions and 3.5% of historic emissions, the highest share among historical emitters (Mayer and Rajavuori 2016).

Figure 3. Per capita GHG and CO_2 emissions in GCC countries



Source: EDGAR (2017)

Note: Saudi Arabia was at the low end of GHG emitters among the Gulf monarchies.

The GHG emissions attributed to Saudi Aramco and other state-owned entities are directly relevant to the economic well-being of their host countries and the funding of national budgets. These statistics show that carbon extraction and marketing are of integral—even strategic—importance for export states, governments of which can be expected to act to protect such industries, even to the detriment of the climate.

Saudi Climate Vulnerability

Saudi Arabia finds itself on the front lines of the climate changes that its resource exploitation has helped bring about. The kingdom is among the countries most exposed to risks of rising temperatures. Continued increases in summer heat could threaten year-round habitation on the Arabian Peninsula. For instance, a record high temperature for the kingdom of 53°C (127.4°F) was reached in the Eastern Province in 2017, surpassing the previous record of 52°C (125.6°F) in Jeddah in 2015 (Arab News 2017). Temperatures nearby have climbed even higher, reaching 54°C (129.2°F) in Basra, Iraq, and in Kuwait on July 22, 2016 (Samenow 2016). Heat index temperatures, which include humidity effects, have ranged even higher.

Table 4: Greenhouse gas emissions traceable to companies and government entities

Company	Current GHG emissions (% of global total 2010)	Historical emissions (% of global since 1854)
Saudi Aramco	4.3%	3.2%
Gazprom	3.8%	2.2%
National Iran Oil	2.4%	2.0%
Coal India	2.3%	1.1%
ExxonMobil	1.8%	2.5%
Pemex	1.7%	1.4%
PetroChina	1.7%	0.7%
British Petroleum	1.5%	2.5%
PD Venezuela	1.4%	1.1%
Royal Dutch Shell	1.3%	2.1%
Chevron	1.2%	3.5%
Abu Dhabi NOC	1.1%	0.7%
Sonatrach (Algeria)	1.1%	0.6%
Total (France)	1.1%	0.8%
Rosneft	1.0%	0.2%
ConocoPhillips	1.0%	1.2%
Kuwait Petroleum	0.9%	0.7%
Petrobras	0.9%	0.4%

Source: Mayer and Rajavuori (2014)

Note: Majority state-owned companies depicted in gray

Average warming in 2040 is projected to increase more in the kingdom than the global average. In a scenario where average temperatures rise by 3-4°C (5-7°F), three-quarters of the kingdom will suffer from excessive aridity by the end of the century (Climate Action Tracker 2018). In other words, inadequate climate action could subject the most populated areas of Saudi Arabia and the Gulf region to temperatures that are intolerable to humans within the current century (Pal and Eltahir 2016). While wealthy Saudi Arabia is better placed than many other developing countries to fund adaptation measures, financial wealth may be insufficient to fully cope with intolerable temperatures.

Opportunities Presented by the Economy's Oil Intensity

For now, the climate conversation in the kingdom is dominated by the threat of GHG mitigation actions to the Saudi economy. As the world's top oil exporter, Saudi Arabia is acutely vulnerable to any decrease in the global demand for crude oil and oil-based transportation fuels. However, the high oil intensity of the Saudi economy has also created opportunities for the kingdom to reshape domestic energy demand. Policy action to reduce oil demand has implicit environmental benefits, which can be touted externally to create goodwill in the international climate regime. The kingdom can accrue large reductions in carbon emissions simply by shifting to the consumption patterns of the developed world for crude oil, namely by reserving oil combustion for its most valuable service—in transport—and otherwise as a non-combusted feedstock for petrochemical production. The kingdom's power generation and water desalination processes can be performed at reduced opportunity cost and carbon emissions by using natural gas or nuclear and renewable technologies.

The very high carbon intensity of the Saudi economy also means that simple measures could provide big effects at low cost. Prices are the key variable. As prices are raised to international levels in line with current government plans, demand management tools can take effect (Kingdom of Saudi Arabia 2018). These demand-side tools include tightened performance standards for energy-efficient appliances, building standards for insulation and windows, and maintenance of HVAC equipment for optimal performance (al-Ragass 2017).

Burning crude oil to generate electricity and industrial output will quickly lose appeal if oil prices are rationalized in the kingdom. With oil selling at international prices near $70/barrel instead of the current in-kingdom rate of under $6/barrel, other forms of power generation, including solar and wind technologies, suddenly appear competitive. In short, a successful reform of energy prices in Saudi Arabia will push the kingdom in a more efficient and environmentally responsible direction.

Approach to Climate Talks

Saudi Arabia's past participation in UN-led climate negotiations has been well documented as obstructionist and adversarial. Depledge (2008) argues that Saudi Arabia joined the United Nations Framework Convention on Climate Change (UNFCCC) because it feared a successful agreement and wished to thwart, delay, or weaken it. The kingdom's confrontational stance was based on fears that the climate change mitigation policies would harm the kingdom more than climate change itself (Depledge 2008). Saudi qualms regarding "security of demand" for crude oil also arise partly from climate action, as U.S. diplomatic cables released by Wikileaks demonstrate (Smith 2010).

Saudi tactics documented by Depledge (2008) involved the following:

- Allowing its position to be determined and led by the national petroleum ministry
- Focusing on the damage of carbon constraints on economies, rather than the damage of climate change; offering worst-case scenarios as reference cases

- Highlighting skeptical views on climate science and downplaying the harmful effects of atmospheric carbon accumulations
- Employing negotiating techniques aimed at postponing or blocking progress
- Aligning with coal lobbies and other fossil fuel interests that oppose climate action
- Using financial incentives to convince delegations from poorer countries to back the Saudi position

Changes in Saudi Climate Strategy

More recently, as global resolve has coalesced around the desirability of GHG mitigation, the Saudi negotiating stance has grown more accepting of the scientific consensus and the need for climate action. Mohamed al-Sabban, the long-serving lead Saudi negotiator to the UNFCCC and Congress of Parties (COP) talks who was known for obstructionism, was replaced in 2012 by Khalid Abuleif, a Houston-educated engineer and adviser to energy minister Khalid al-Falih (Aburawa 2012).

Saudi Arabia has shifted its stance, at least in public, to one of support for climate change efforts. Al-Falih issued a statement at the time of the 2016 COP 22 in Marrakesh that expressed the kingdom's backing:

> "We view the Paris Agreement as balanced and fair, and this will pave the way to effective implementation in addressing our climate goals and sustainable development goals holistically," al-Falih said. "It is encouraging to note that the Paris Agreement has achieved the threshold for entry into force, and Saudi Arabia is determined to see it implemented" (Ministry of Energy, Industry & Mineral Resources of Saudi Arabia 2017).

The revised Saudi posture accepts the necessity of reducing GHG emissions, but mainly through efforts that protect the interests of oil-exporting states and do not affect demand for fossil fuels. Supported strategies include carbon capture and storage, and reductions to flaring and methane leakage. The Saudi strategy also shifts the focus to greenhouse gases such as methane and nitrous oxides, which are characterized by higher heat-trapping properties than CO_2. The Saudi brief also argues that fossil fuels should be retained alongside renewables in the future energy mix, given their complementary properties. The kingdom sees CO_2 emissions as a "harmful side effect" that can be mitigated with technological solutions (Ministry of Energy, Industry & Mineral Resources of Saudi Arabia 2017).

Along these lines, Saudi Arabia has begun hosting climate policy discussions, including a global forum on CCS, the Carbon Sequestration Leadership Forum, as well as the Global Methane Initiative, which aim to capitalize on Saudi success in reducing fugitive emissions. In 2014, Saudi Aramco joined the Oil and Gas Climate Initiative, a group of 11 national and international oil companies pledging $100 million each for research into low-emissions technology for fossil fuels. In January 2018, I attended a climate policy workshop hosted by the Riyadh-based King Abdullah Petroleum Studies and Research Center (KAPSARC) that was held at the U.S. Chamber of Commerce in Washington, D.C.

Measures to Reduce Vulnerability to Climate Action

More strategically, the kingdom is also positioning itself to continue to market oil in countries where climate action begins to limit unabated fossil fuel combustion. The most important of these strategies is Saudi Arabia's pursuit of non-combustion uses for crude oil as a hedge against stronger-than-expected climate action. A prime example is the kingdom's huge investments in petrochemical plants, both inside and outside the kingdom. Domestic investment includes the $20 billion Sadara joint venture with Dow Chemical, the largest single-phase chemical plant ever built. Internationally, Saudi Aramco and SABIC, the Saudi state-held petrochemical giant, have proposed joint venture projects in the United States, China, Malaysia, and India.[7]

To increase its competitiveness in petrochemicals, Saudi Aramco is investing in technology for direct conversion of crude oil into chemicals, bypassing the refining phase. In 2016, Saudi Aramco acquired from Novomer, the U.S. chemistry development company, technology for converting waste CO_2 into polyols and polyurethanes that can be used in finished products such as automobile seats and building insulation (Saudi Aramco 2016).

Discussions with Saudi energy executives in January and February 2018, on condition of anonymity, revealed further climate strategy approaches. For example, Saudi Aramco will begin highlighting the carbon intensity of its various grades of crude oil, which tend to be lower than competing global crudes, particularly the very heavy grades from Canada, Venezuela, and California (Gordon et al. 2015; Masnadi et al. 2018). Petroleum-based fuels can also exhibit lower carbon intensity than biofuels such as corn-based ethanol (DeCicco 2016), another factor that a Saudi campaign might point out. The kingdom also plans strategic investments in maximizing the efficiency of the internal combustion engine, so that oil-fueled transportation remains cost-competitive with electric vehicles and thus prolongs the lifespan of gasoline. From the Saudi perspective, an efficient hybrid vehicle is preferable to an all-electric vehicle that uses no petroleum.

The Saudi climate approach also leans on aspirations for renewable and nuclear electricity generation, but only within the kingdom. The interest in these technologies is due to strong economic rationales for policies that push oil out of power generation and reserve it for export. Most of the effort to replace oil-fired generation involves natural gas. But given the value of oil on export markets, a cost-competitive case could also be made for solar and nuclear power. As mentioned, the kingdom has announced and periodically scaled back plans for both. In 2017, Saudi Arabia produced just 0.04% of its electricity—or 135 GWh of a total of more than 375,000 GWh—from solar means, the only non-hydrocarbon source of electricity currently online in the country (BP 2018).

[7] Examples include an ethylene plant proposed in Texas in 2017 that would combine investments from SABIC and Exxon Mobil, as well as a Saudi Aramco-Sinopec-ExxonMobil integrated refining and petrochemical plant operating in Fujian, China, since 2009. In 2018, Saudi Aramco further announced a combined refining-petrochemical venture in India that would link it with three Indian firms. The Saudi company also announced joint ventures with Petronas, Malaysia's state-owned oil company, for an integrated refinery and petrochemical project in southern Malaysia.

Modest NDC Within Reach

As a participant in the UN climate talks and signatory of the Paris agreement of 2015, Saudi Arabia has issued a modest goal for in-kingdom GHG emissions reduction. The Saudi NDC calls for avoiding the release of up to 130 million tons of CO_2 equivalent by 2030. The reductions are to be measured against a business-as-usual emissions growth path (Kingdom of Saudi Arabia 2015). As currently written, the Saudi NDC is difficult to assess because it does not identify a benchmark year or a baseline level of annual emissions against which reductions can be measured. The kingdom's NDC document predicates achieving its target on the successful diversification of its national economy, an ambition for which the kingdom declares it needs international support (Kingdom of Saudi Arabia 2015).

The NDC outlines two future pathways for Saudi Arabia:

> Scenario 1: The kingdom meets its goal of avoiding 130 million tons (Mt) of CO_2 emissions by reserving oil for export and deploying export revenues to achieve economic diversification into low-emissions, high-value sectors in financial and medical services, tourism, and technology development in renewable and advanced conventional energy.
>
> Scenario 2: The kingdom falls short because diversification fails. Instead it accelerates energy-intensive domestic industrialization using oil and gas as sources of energy and industrial feedstock. Under this scenario, Saudi Arabia would continue expanding investment in refining, petrochemicals, cement, mining, and smelting. The NDC speculates that these energy-intensive industries would bring about slower economic growth, leaving the kingdom unable to finance its low-emissions aspirations.

A key difference between the two scenarios is the point of combustion of Saudi oil. In Scenario 1, the kingdom meets with some success in reducing growth in domestic oil demand, which allows exports to be maintained at levels relatively close to the current 13% of global crude markets. Scenario 2 envisions oil and gas diverted into the domestic economy, where combustion and emissions are tallied. Neither case appears to portend a significant reduction in global CO_2 emissions, but rather a shift in where the emissions take place.

As described, the NDC rests on the unlikely alignment of four prerequisites. First, Saudi Arabia must achieve sufficient economic growth; second, it must succeed with economic diversification; third, the government must reform domestic energy subsidies; and fourth, foreigners must make capital investments and transfer technology to the kingdom.

Independent assessments of the Saudi NDC have not been charitable. The climate research consortium Climate Action Tracker (CAT) classifies 32 countries,[8] covering 80% of global emissions, into six categories based on NDC ambitions and the credibility. CAT ranks Saudi Arabia as "critically insufficient," the lowest category. Joining the kingdom at the bottom of

[8] The European Union is aggregated as a single country.

the list are the United States, downgraded after the Trump pullout from the Paris agreement; Turkey and Chile, both in the midst of a major expansions of coal-fired power; and Russia and the Ukraine, where NDCs imply increases in CO_2 emissions, rather than decreases (Climate Action Tracker 2018).

CAT describes the Saudi NDC as a pledge that has little to do with climate policy. Rather the emissions gains are a natural side effect of economic advancement that the country is already pursuing. In other words, the Saudi plan approximates the Environmental Kuznets Curve. Under this paradigm, economies mature and environmental degradation is supposed to wane alongside increases in wealth and health concerns regarding pollution. Overall energy use and carbon emissions typically plateau or even reverse as an economy matures, although the evidence is mixed (Galeotti et al. 2006).

Energy-Climate Policy Synergy

Saudi Arabia is far from alone in proposing a climate goal that dovetails with ongoing trends or aspirations. The Paris agreement pushed governments to choose the route to decarbonization that fit their national circumstances. As in Saudi Arabia, climate benefits may be secondary to other savings in local pollution or industrial diversification in other countries.

In the United States, hydraulic fracturing produced a surplus of natural gas that has displaced higher-carbon coal. Meeting the Paris mandate—at least before President Trump—meant not only reduced carbon emissions but also cheaper electricity prices. For China, the climate rationale is secondary to a pollution-driven push for renewables and natural gas. In Western Europe, largely bereft of hydrocarbons, investment in wind and solar can be rationalized on reducing pollution as well as dependence on Russian natural gas.

For Saudi Arabia, decarbonization effects are useful byproducts of otherwise sensible economic policy. In fact, Saudi Arabia can leverage its Paris commitment in two useful, self-reinforcing ways. Not only does its energy subsidy reform produce a positive climate side effect, but participation in Paris also provides a useful source of blame for the domestic audience, shielding the ruling family. Therefore, climate action is both a key driver of the Saudi reforms, as well as a beneficiary and an enabler. Saudi citizens may continue to protest higher prices on electricity, water, and gasoline, but the state can argue that the policies are necessary to maintain the exports underpinning the generous welfare state, to keep the government budget solvent, and to meet Saudi Arabia's international environmental commitments signed in Paris.

NDC Overshoot

The kingdom has embarked on a policy direction that, if fully implemented, may well accomplish or even overshoot the 2030 goal of reducing 130 Mt of carbon-equivalent emissions. In other words, the kingdom's NDC may be achievable without all the prerequisites.

Forthcoming research from KAPSARC in Riyadh finds that the kingdom could meet this goal simply by rationalizing prices of bulk fuels used in industry and power generation.[9] Levying international prices on crude oil, diesel, and heavy fuel oil used in power generation and industry is supposed to take place by 2023 (Kingdom of Saudi Arabia 2018). The changes would drive the Saudi power generation sector away from liquid fuels accounting for just under half of electricity generated.

The huge increase in price—in the case of oil from $6 to somewhere around $60 per barrel—would incentivize industry and utilities to shift to natural gas. Gas-driven power generation employs more efficient turbines and results in about half the carbon intensity of oil-based generation. Renewables like wind and solar would be rendered cost-effective, which would further reduce growth in the Saudi carbon footprint. Oil-based liquid fuels burned domestically would instead be exported, with carbon emissions registered elsewhere.

Data collected by EDGAR show the Saudi power generation sector alone produced roughly 250 Mt of carbon emissions in 2016 and the industrial sector produced another 86 Mt. Total Saudi emissions have grown by an average of 5.6% per year since 1970, with the power sector emissions growing 11% per year (EDGAR 2017). Saudi reforms of fuel prices would act like a carbon tax, incentivizing the reduction of the business-as-usual carbon emissions scenario.

The kingdom may accrue further emissions reductions from reforms to energy prices charged to residential and commercial customers. Deregulation of fuel prices could reduce CO_2 emissions from the electricity sector from 160 million tons per year to as low as 72 million tons, if fuel prices *and* electricity prices were deregulated. Higher prices would encourage investments in energy efficiency as well as lower electricity demand by altering consumer behavior (Anwer and Matar 2017).

As mentioned, partial reforms of retail energy prices have taken place since 2016. These have affected transportation fuels, electricity, and water prices. Demand growth has slowed or even reversed in some areas. For instance:

- Diesel demand dropped by 10% in 2016 from 2015 levels.
- Electricity demand in 2016 declined for the first time in the 16-year history of the Saudi Electricity Company (MEES 2016b). Peak load dropped 2.3% over 2015, and the average per-customer consumption was down by just over 5% (ECRA 2017).
- High-octane gasoline prices have approached levels in the United States, driving Saudi motorists toward lower-octane blends. Anecdotal reports show reduced sales of high-performance luxury cars and high-consumption SUVs.

Saudi Arabia is not a unique case in this regard. Subsidy reductions in several high-income oil and gas-exporting countries would bring CO_2 emission reductions that exceed their

[9] Information based on conversations in 2018 with David Wogan, author of the forthcoming paper "Pragmatic policy pathways to meet Saudi Arabia's contributions to the Paris Agreement," KAPSARC discussion paper, forthcoming 2019.

Paris climate pledges (Jewell et al. 2018). Having participated in the Paris process and declared a modest NDC, Saudi Arabia now finds itself in the unexpected position of having an opportunity for early compliance.

A number of possible responses suggest themselves. First, Saudi policymakers might consider improving the country's standing in the climate regime by clarifying its NDC so that compliance can be measured and verified. Second, it might also intensify its NDC for the 2020 iteration of the UNFCCC. Possibilities include moving up the compliance deadline from 2030 to 2025 or increasing the carbon reduction target. Either of these options would improve Saudi credibility in the climate regime and perhaps remove the "critically insufficient" label from independent assessments.

Given the Saudi history of obstructionist behavior at UNFCCC gatherings, the kingdom's willingness to define, exceed, and then recalibrate its 2015 NDC could generate sufficient goodwill for Saudi negotiators to extract concessions in future climate summits. At the same time, the kingdom will reap the associated benefits of streamlining its energy and fiscal balance. By contrast, for oil-importing states, meeting the Paris mandate appears far more difficult. Countries with leaner energy intensity lack the "low hanging fruit" options that present themselves to oil exporters. For them, compliance means retiring profitable capital equipment such as coal-fired power plants before the end of their useful lives, or imposing Pigovian penalties that price externalities, such as cap-and-trade schemes or carbon taxation.

Conclusion

Over time, climate action such as that enshrined in the Paris agreement poses a transformational threat to Saudi Arabia. The kingdom's geopolitical stature and strategic power is bound up in its long-held role as the world's oil supplier of last resort. The demise of oil's importance would impose more than just economic damage on Saudi Arabia. Oil's decline would also restrict the flow of rents that the al-Saud family deploys for political survival. But, as this chapter outlines, climate action also provides opportunities and convenient political cover for energy policy changes in the kingdom, including modifications that are quite beneficial to the kingdom's economic and environmental sustainability.

Domestic public reaction to the revamping of the Saudi energy social contract presents an obstacle. The public reaction to the subsidy reform has been negative, albeit muted. For further reforms to proceed and full rationalization of energy prices to be reached, the Saudi public must understand and accept the changes being pushed by the monarchy.

Global oil demand is not going to disappear overnight, and Saudi Arabia's chief economic sector will continue to provide for the kingdom in coming decades. Oil remains the world's dominant transportation fuel. Alternatives are emerging in the form of electric vehicles and fuel cells, along with hybrid vehicles that improve the efficiency of oil use. Oil substitutes are also gaining viability, including ethanol and other plant-based biofuels.

Whether or not oil substitutes can succeed in displacing petroleum depends on technology and, even more, on changes in government policy.

Even when world oil demand starts to decline, one would expect the kingdom to remain among the surviving exporters, given unit costs of production that remain among the lowest in the world, at $5 to $10 per barrel. Low oil prices are deeply damaging to the Saudi social contract and patronage system that oil exports have maintained. The fact that Paris provides the kingdom with an impetus for economic diversification is one of its key benefits.

In the midst of so much uncertainty, the Saudi bet on non-combustion uses for oil, primarily in petrochemicals, currently accounting for less than 10% of oil demand, appears prudent. Non-combustion uses for crude oil should be less affected by climate action. Saudi exposure to climate and demand risk could be further reduced by diversifying its overwhelming dependence on oil. In that sense, climate action could push the kingdom to take further action in line with the international climate strategy in its own self-interest. Saudi Arabia's role in climate negotiations may have evolved, but it remains far from amicable. The kingdom's interests remain tied to internal combustion engines and jet turbines. It is difficult to imagine Saudi policymakers embracing the UNFCCC climate agenda with the enthusiasm of more energy-agnostic countries that meet their fossil fuel needs through imports. In the end, as the Saudi NDC predicts, it may be the developed importing countries that help the kingdom navigate the energy transition through targeted investments that aid the strengthening of a non-oil economy.

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