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HAVING IT BOTH WAYS:
GCC OIL FACES PEAK DEMAND

BY ANTOINE HALFF AND ROBIN MILLS
DECEMBER 2021

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EXECUTIVE SUMMARY

Global efforts to address climate change offer difficult choices for the oil- and natural gas-reliant economies of the Gulf Cooperation Council (GCC). While swings in commodity prices over the decades have led to calls for economic diversification, some countries are now planning in earnest how best to adjust to the prospects of peak oil demand as the world strives to meet Paris Agreement and Glasgow Pact goals and an increasing number of nations commit to net-zero carbon emissions by midcentury. The issue is no longer simply about volatility and cyclicality of the oil market but rather a secular, structural, irreversible decline in global oil consumption, and the choices facing producers to support their hydrocarbon-reliant economies are fraught with risk.

This paper, part of the work by Columbia University's Center on Global Energy Policy on oil and gas and the energy transition, examines two broad actions being taken by petrostates to remain relevant in a decarbonizing world: demand defense and demand creation.

Demand defense involves many tactics, including price and volume policies that drive out high-cost competitors and ensure maximal use of the generally lower-cost oil reserves held by GCC states. These states can, for example, encourage the development and deployment of technologies such as carbon capture, utilization, and storage that may make continued use of fossil fuels during the transition more palatable. They can also adopt oil and gas production techniques that generate a smaller carbon footprint, such as curbing gas flaring and venting practices to reduce methane emissions, and electrifying offshore installations. In addition, they can attempt to support demand by investing in improved vehicle fossil fuel efficiency to cut the environmental impacts and the cost of travel.

In addition, GCC countries can look to create new demand for their oil and gas reserves, tapping into new or growing businesses and regions. Petrochemicals for products with anticipated demand growth such as plastics and other non-metallic materials is an area of intense focus. Investing in new energy creation, such as hydrogen production, is also being considered through pilot projects. And while most oil producers have a keen interest in capturing existing high oil demand in China and India, others are looking to emerging economies, mostly in Africa and parts of South Asia, which still face energy poverty. With the right infrastructure investments, these regions could create substantial new demand as fossil fuels substitute for unsustainably harvested biomass, which can result in better—if not zero-carbon-ideal—health, environmental, and climate impacts.

The routes GCC countries take in adjusting their economies to peak oil demand have major implications for the region as well as for the pace and scope of the global clean energy transition, including the following:

- Policies encouraging higher oil demand, if not offset elsewhere, are likely to draw strong opposition from environmental organizations and financial institutions.
- Countries that are large oil and gas exporters will want to preserve markets for both these fuels as much as possible. Major oil producers with natural gas export potential

may look to develop sales of the fuel due to its perception as a greener alternative to energy sources such as coal, at least during the transition to full decarbonization—though natural gas too is under growing environmentalist challenge.

- Increased use of fossil fuels will lead to higher carbon dioxide emissions, particularly in the near term, and potentially necessitate a faster decline in overall emissions thereafter. This could expose oil producers to trade restrictions or even boycotts.
- Extended use of fossil fuels and the related climate damage is likely to harm a number of leading oil exporting countries directly through drought and desertification, flooding of low-lying coastal areas (including important energy facilities), loss of fisheries, and heat waves and near-intolerable summer weather, and indirectly via political destabilization and refugee flows.
- Because of these geopolitical and environmental risks, any actions to foster oil demand would have to be accompanied by robust and realistic measures to offset increased emissions or reduce them in other sectors, along with a clear communication campaign. Such a campaign would need to tout the benefits of new oil use in, for example, producing products with environmentally superior characteristics and reducing energy poverty in lower-income countries.
- Investments in refineries, petrochemical facilities, and improved internal combustion engine vehicles are tantamount to doubling down on an oil-fueled future. Stranded-asset risks loom large. Major GCC oil exporters may seek to privatize a portion of their resources as well as hedge against peak oil demand by investing profits in nonoil technologies such as biomaterials; battery technologies and related minerals; electric vehicles, charging stations, and associated retail; and wind and solar power.

INTRODUCTION:
OIL'S ROLE IN THE ENERGY TRANSITION

Few countries face the challenge of decarbonization more viscerally than Persian Gulf oil producers. Global warming is by definition a global threat, calling for shared, urgent preventive and adaptive steps. At the 21st Conference of the Parties, each of the participating countries committed to doing its part to avert catastrophic outcomes and cut its own greenhouse gas (GHG) emissions.[1] For Middle Eastern oil and gas exporters, however, the threat of climate change hits home in a very personal way. For these fossil fuel-dependent economies and, first and foremost, for the Gulf monarchies,[2] the cure to climate change is in many ways as problematic as the disease. A measure of this challenge was recently provided by the projections of the International Energy Agency's (IEA's) May 2021 report[3] on reaching net-zero carbon dioxide emissions by 2050: a near-80 percent reduction in oil consumption by midcentury with a concomitant fall in revenues, a drop in oil prices to $35 per barrel by 2030 and around $25 per barrel by 2050, and a fall in per capita earnings in oil and gas producers from $1,800 recently to $450 by the 2030s.

The Gulf group of oil producers account for an oversize share of the world's primary energy supply. These states are the world's premier oil suppliers. The largest among them, Saudi Arabia, is both (pandemic times apart) the world's number one oil exporter and, along with Russia and the United States, part of a small group that may be dubbed the "G3" of oil, the top three oil producers.[4] Collectively, Arab Gulf states hold 48 percent of the world's oil and 38 percent of its gas reserves. Their economic and geopolitical ascent since the mid-20th century has been predicated on the rise of the global oil economy, which they have enabled and from which they have profited more than any others. The transition to a lower-carbon fuel mix directly challenges their dependence on fossil fuel exports, threatening the basis of their economies and political systems. Seen from Riyadh, Abu Dhabi, or Kuwait City, the prospect of "peak oil demand" resulting from climate policies and technological change can easily seem as devastating as climate change itself.

This transition is a matter of when, not if. Signs of global warming are everywhere. Catastrophic weather events pinned at least partly to it—from heat waves and droughts to forest fires, floods, and hurricanes—have become frequent occurrences worldwide, a frightening fact of life rather than part of a remote, dystopian future. At the same time, low-carbon solutions are now within reach. Solar and wind energy and green electricity are steadily becoming more cost competitive, and advances in technology look increasingly capable of bringing decarbonization at scale.

This suggests that an engineered peak in oil consumption may occur from a mix of market, technology and policy forces without too much damage—climate effects notwithstanding—to consuming-country economies, unlike after the oil price shocks of 1973 and 1979 when declines in world oil consumption came hand in hand with considerable economic stress. Decarbonization momentum is building on the supply side, where renewable energy (solar, wind, and supporting systems such as batteries) can replace not just oil and coal but even natural gas in power generation. And it is also building on the demand front, with electric

vehicles offering for the first time since the mid-20th century the prospect of a ground transport system not primarily run by oil. For the Gulf countries, the challenge of a looming decline in oil demand seems further compounded, at least in the short term, by the rise and continuing resilience of US tight oil production, which competes with Gulf countries for what market growth remains in the oil sector itself.

No wonder that calls for the economic diversification of the Gulf countries have been rising, not least from the Gulf capitals themselves.[5] Such calls have a familiar ring.[6] Past periods of low oil prices have regularly produced similar appeals for diversification from multilateral lenders such as the International Monetary Fund and others. The oil market crash of 2014 and subsequent period of relatively low oil prices naturally rekindled these appeals. Unlike in the past, however, the problem for so-called petrostates is not just the volatility and cyclicality of the oil market but rather the prospect of a secular, structural, irreversible decline in global oil consumption.

With such concerns compounding the impact of the oil market downturn, Arab Gulf leaders have embraced the diversification agenda with unprecedented resolve.[7] Plans for "national transformation" have been put forward;[8] these are not new or unique, but concentrate more than ever on post-oil and climate-compatible economies and are pursued with more vigor than previously in at least some of the GCC states. Revealingly, one of the first public statements made by Saudi Crown Prince Mohammed bin Salman (MBS) after his father ascended to the throne in early 2016 was a call to end the kingdom's "addiction to oil."[9] This call echoed one made earlier by Sheikh Mohammed bin Zayed, the de facto ruler of nearby Abu Dhabi. "In 50 years, when we might have the last barrel of oil, the question is: when it is shipped abroad, will we be sad?" Mohammed bin Zayed asked rhetorically in 2015. His answer: "If we are investing today in the right sectors, I can tell you we will celebrate at that moment."[10] Of course, the timing of peak oil demand matters: 2025 would be an emergency, and even 2040 is not far away in investment and policy cycles, while 2065 would allow a more measured adjustment.

But while Gulf Arab producers talk the talk, are they walking the walk? Their actual policies often seem to belie their rhetoric. Arab Gulf investment in oil and gas continues even as it slows in other sectors.[11] Saudi and other officials have gone on the record to push back against the idea of a quick end to the oil economy.[12] Despite MBS's self-declared indifference to oil prices,[13] Riyadh has clearly taken a keen interest in shoring them up, leading the Organization of the Petroleum Exporting Countries' (OPEC's) campaign to do so in both 2016, in the wake of the 2014–15 oil price crash, and 2020, during the COVID-19 pandemic. Unprecedented steps taken by the kingdom to make up for shortfalls in oil revenue, namely Saudi debt issuances and securitizations, and the IPO of 1.7 percent of Saudi Aramco,[14] while revealing short-term budgetary pressures, also hinge on the assumption of the continued relevance and profitability of the Saudi oil sector in the longer term.

Are Saudi Arabia and its Gulf neighbors doubling down on the oil economy or planning their exit? Does their continued investment in the oil sector betray a shallow commitment to diversification or signal the elusiveness of an effective exit strategy? Or is the opposition between their commitment to hydrocarbons and to the energy transition a false dichotomy?

The authors argue that there is no absolute contradiction between continued Gulf commitment to the oil sector and adaptation to a changing energy system. For petrostates,

economic diversification simply cannot happen overnight. Gulf producers will also continue to need oil revenues to finance the high cost of economic diversification. Last but not least, next-generation oil derivatives such as advanced plastics, nonmetallic materials, and petrochemicals are required to implement the green economy, such as electric vehicles and carbon-efficient infrastructure.

While some commentators have emphasized the urgency of the need for the Gulf countries to transform their economies (the IEA[15] and Chatham House[16]), other publications have laid out the near impossibility of a full transition away from oil, even within a few decades (Diwan, Herzog,[17] and Fattouh and Sen[18]). Others still have argued that leading oil producers can continue to focus on that sector even in a carbon-constrained world (Goldthau and Westphal[19]). Rather than killing the goose that lays the golden eggs, there is a strong case for responsibly leveraging the oil sector itself to support the decarbonization agenda both at home and globally. Economic diversification and continued investment in the oil sector can work hand in hand.

There are at least three ways in which decarbonization warrants continued development of the Gulf's oil sector. First, even in the event of a rapid energy transition, oil will likely continue to account for an important share of the global fuel mix for decades to come. While Gulf countries are often seen as losers of the energy transition, they may in fact come out on top, at least for a while.[20] Few countries can produce oil at a lower cost than the Gulf monarchies, particularly Saudi Arabia, the UAE, and Kuwait. The IEA net-zero report sees OPEC's market share (dominated by the GCC members along with Iran and Iraq) rising from 37 percent recently to 52 percent by 2050, albeit of a much smaller total.

Furthermore, few countries can do so with a smaller carbon footprint.[21] Saudi, Kuwaiti, and Emirati crudes come with relatively low GHG emissions, making them more attractive than other types of crude in a decarbonizing global economy. If jurisdictions such as the European Union (EU) impose border carbon tariffs on imports or set a limit on their GHG intensity, the GCC could realize premium pricing for its remaining oil and gas exports. (The difference between the cleanest and dirtiest upstream production is estimated at about $8/barrel [bbl] for a $50/ton carbon tax.[22]) McGlade and Ekins[23] indicate that although nearly 40 percent of Middle Eastern oil reserves would be unburnable by 2050 in a 2°C scenario, this is a function of the Middle East's long reserves life. Its production of about 430 billion bbl during 2015–50 would still be far more than that of any other region and almost half of total world production in that period, as it gains market share from producers with higher carbon footprints, higher costs, and shorter reserves lives. Recent advances in satellite-based detection of methane emissions independently confirm that Gulf countries rank among the oil and gas producers that can boast the lowest methane footprint, a decisive advantage in the context of the EU's Methane Strategy.[24]

While concerns over stranded assets and investor pressures for cleaner fuels may undermine private investment in international oil projects, Gulf countries are set to keep playing a key role in ensuring oil supply security during the transition. Their market share is likely to rise (after falling during the response to the US shale oil surge), and their absolute production levels could continue increasing for some time even in an overall shrinking market. Saudi Aramco sees its market share at about 12.5 percent in 2020 rising to 20 percent by 2050, while its

petroleum liquids output increases at an average annual rate of 0.7 percent between 2015 and 2050.[25] The peak oil demand narrative comes in different versions: depending on a wide range of factors, the decline in oil consumption could be sudden or gradual and associated with higher or lower oil prices. In any event, continued investment in the oil sector will be required to offset declining rates and ensure an orderly transition to a cleaner fuel mix. As the lowest-cost producer and one with very low Scope 1 and Scope 2 emissions (i.e., GHG emissions directly and indirectly associated with the production process), the Middle East could end up as the last man standing of the sector. Gulf producers certainly have every incentive to ensure that is the case, if only to smooth their own transitions.

Second, just as the oil industry will continue to play a role on a global scale through the energy transition, so too will it be instrumental in the transformation of Gulf economies at the local level. Oil-addicted economies cannot and should not go cold turkey. The oil sector is their economic lifeline, and it alone can fund their transitions to a more diversified and cleaner model of economic development and activity. The national transformations of the Gulf countries are capital-intensive and potentially destabilizing projects for which no other sectors in the petrostates can foot the bill. The oil sector itself is thus needed to plan its own succession, as it were. The key for oil-producing countries will not be to forego oil revenues but to use them in a new way—to leverage their oil incomes to support, rather than choke off, the non-oil sector.

Finally, the transformation of oil demand brought by the energy transition and the decarbonization agenda will be qualitative as well as quantitative. Not only will oil consumption go down in terms of volume but the uses of oil and the types of products made out of crude (the product slate) will also evolve. New modes of consumption are already emerging. As the cliché goes, the oil sector must not be the problem but part of the solution. The oil industry can help advance the diversification agenda through self-transformation. This entails both ways of reducing its carbon footprint, such as advances in carbon capture and utilization, and new types of products and uses, such as hydrogen, advanced plastics and nonmetallic materials for use in electric vehicles, and other applications. Not surprisingly, Gulf countries are taking a keen interest in these frontier markets. Some of them are already pursuing investment opportunities in this space. For its part, Saudi Arabia has promoted the "circular carbon economy" as a central part of its climate response.[26]

While media and expert commentary on the Arab Gulf countries has focused generically on their need to reduce their oil dependence, diversify their activities, and retool their economies to spread their risks and better suit the decarbonization agenda—and on the difficulty of doing so—this paper focuses in detail on the incumbent fuel and reviews the current policies being pursued by Gulf countries and the future options available to them in the oil sector itself. After taking stock of the momentum toward peak oil demand, the paper reviews how Arab Gulf countries can protect their oil sector and leverage their competitive advantages even as they adjust to a changing global energy system.

Many of these strategies are already being implemented by Gulf countries. They fall, broadly speaking, into two main categories: on the one hand, defensive moves to protect oil's established markets in a lower-carbon economy and, on the other hand, demand-creation strategies to open up new frontiers to oil consumption and tap new opportunities as they

arise from the energy transition itself. In describing these efforts, this paper discusses how the opposition between protecting the oil sector and diversifying the economy is more apparent than real. For Arab Gulf exporters, the choice is not between doubling down or quitting. Rather, Gulf petrostates can have it both ways and leverage their competitive advantages in the oil economy to advance global change and make oil part of the solution.

This is not to say that such an approach is free of difficulties or potential pitfalls. While there is a possibility for Gulf countries to preserve a role for their main industry in a decarbonized—or decarbonizing—economy, success is far from assured. The oil industry's track record as an engine of economic development is not encouraging: its history offers more case studies of the "oil curse" than of successful, diversified economic development. Should Gulf countries collectively emerge as the last man standing of oil, there clearly is a risk that their very success, far from enabling their national transformations, might defer, undermine, or disincentivize them. Finally, the successful development of new oil products such as advanced plastics and nonmetallic materials will likely use as feedstock the lighter fractions of the oil barrel, leaving substantial volumes of heavier by-products that refiners would then seek to dispose of at distressed prices, potentially making it more difficult for cleaner fuels to compete, and thus interfering with and undermining the global energy transition.

Over the last year, the COVID-19 pandemic has further exacerbated the Gulf producers' conundrum. On the one hand, the fall in oil demand caused by global lockdowns and the attendant oil price crash, along with ambitious green recovery plans in large energy consumers, have reinforced the urgency of the imperative of economic diversification and reduced dependence on oil revenues. On the other hand, the revenue collapse has heightened the short-term challenge of funding Gulf producers' national transformation plans and emphasized their need to maintain their cost and carbon advantages in a shrinking and increasingly competitive oil market. The twin needs of continued oil competitiveness and economic diversification are more acute than ever. The risk of mishandling these seemingly conflicting but complementary goals has never loomed larger.

PEAK OIL DEMAND: THE EMERGENCE OF A MAINSTREAM NARRATIVE

The question of peak oil demand has replaced that of peak oil supply in recent years.[27] A range of forecasts by major agencies and oil companies show a peak in oil demand between the early 2020s and 2035[28] (although some scenarios from ExxonMobil, Equinor—formerly Statoil—and the US Energy Information Administration show no peak by 2040 or 2050). Even Saudi Aramco's IPO prospectus mentions a "levelling off" of growth around 2035 with a plateau by 2040.[29] Recent views from BP and the IEA, expressed in the aftermath of the first stage of the pandemic, suggest that 2019 could already have marked the all-time maximum for petroleum consumption, though signs of strong rebound in some sectors of oil consumption have since challenged these findings. The fast-growing and increasingly wide acceptance of the idea of peak demand has far-reaching implications for oil-producing companies and countries. Oil-exporting countries of the Persian Gulf, in particular, are being challenged to prepare for an expected decline in global oil consumption—a daunting task given their dependence on its export revenues.

The COVID-19 outbreak has further solidified expectations that oil demand may come to an inflection point sooner rather than later. The pandemic has brought home the fragility of our shared ecosystem and strengthened the resolve of both the private and public sectors to combat climate change. Since the onset of the pandemic, many of the world's leading economies have embraced ambitious net-zero targets. As former Schlumberger chief executive officer Andrew Gould recently put it, "The global health crisis . . . triggered increasing attention on climate action and the environment. The European Green Deal is channeling significant investment and bringing needed regulation towards green finance, lower emissions, increased use of biomass, and new energy sources such as hydrogen. A new US administration is bringing change aimed at overtaking the EU and China in clean technology."[30] In the private sector, many oil companies have similarly pledged to reduce their climate footprints and achieve carbon neutrality by midcentury, if not sooner, and have come under increasing shareholder and legal pressure to do so.[31] Oil major BP has gone a step further by pledging to reduce oil and gas production by at least 1 million barrels per day (bpd) of oil equivalent, or 40 percent, by 2030 from 2019 levels, and to dramatically reduce the role of incumbent hydrocarbon fuels in its overall portfolio of assets.[32] The IEA's May 2021 report, as discussed in the introduction, provides a dramatic accounting of the changes that reaching net-zero carbon by 2050 could have for oil and gas and the whole energy system.

Officially, Gulf producers do not dispute the need for decarbonization. Gulf countries are signatories of the Paris climate agreement of December 2015, are increasingly embracing renewable energy at home, have even taken on leadership roles in the promotion of clean fuels and efficiency, and have been increasingly outspoken in promoting agendas of national transformation. Their very acknowledgement of the climate threat can be seen as a sign of the times and a reflection of its seriousness. Their response to it has not been entirely one sided, however, and has combined the ambition to remain relevant and viable in a lower-carbon world, the desire to distance themselves from the opprobrium increasingly associated with hydrocarbon fuels, and an understandable will to preserve if not increase the oil revenues that

to this day make up their economic lifeline.

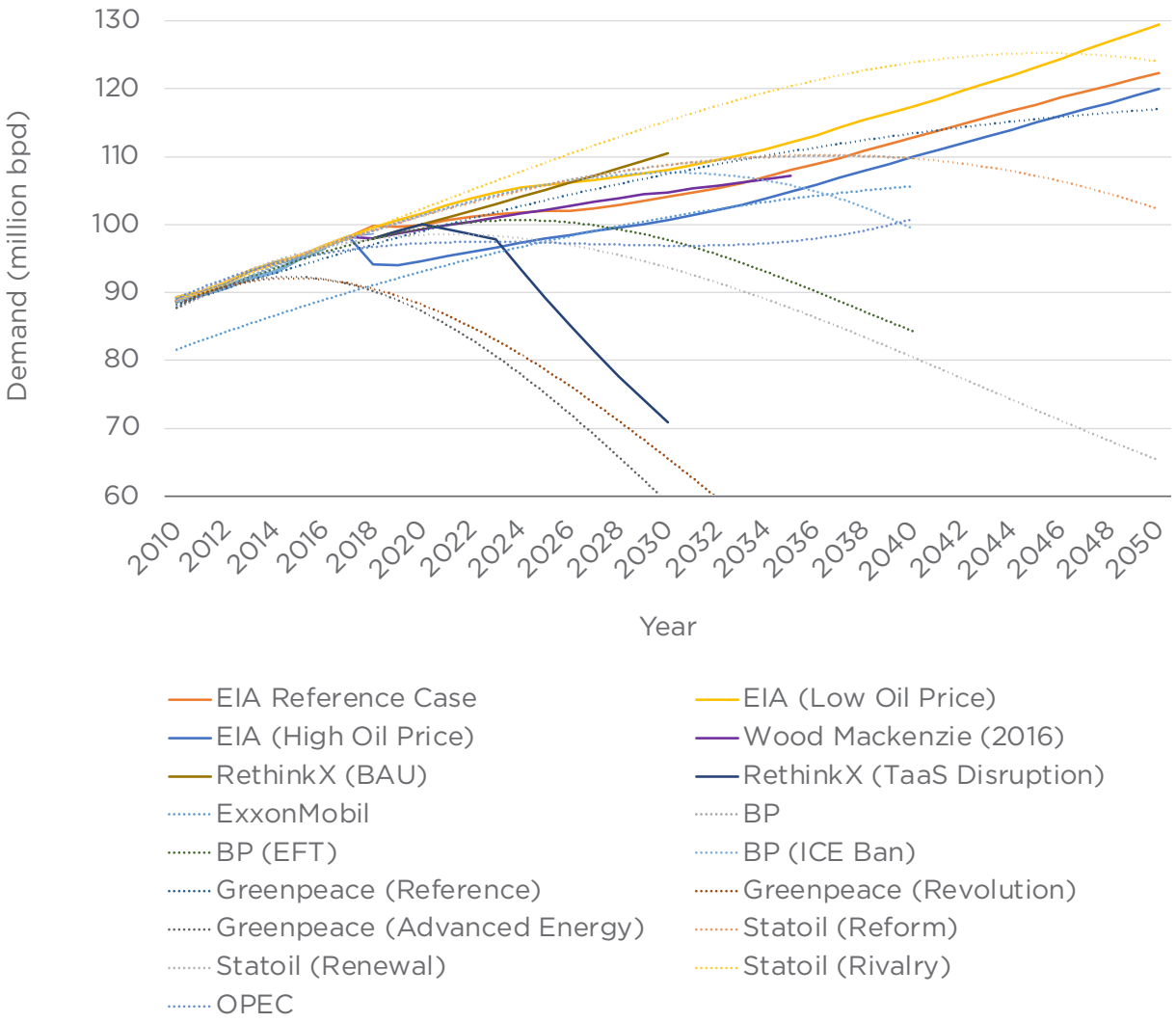
Until peak demand came to prominence, peak supply postulated that oil supply would quite imminently go into a decline due to a lack of geological resources and/or the greater technical difficulty and cost of producing from unconventional resources. This falling supply would presumably be accompanied by sharply rising prices as demand for oil was expected to keep growing, fueled by population growth and economic development in China and other emerging and industrializing countries. To this day, most of the economics literature on oil and extractive industries continues to hinge on resource scarcity: the idea that oil and mineral resources are finite, nonrenewable, and destined for depletion. The widely used Hotelling rent model, named after American economist Harold Hotelling (1895–1973),[33] calculates commodity prices by walking backward from the theoretical future point when resources will have run out. Likewise, Hubbert's peak, named after American geologist M. King Hubbert who predicted in 1956 that onshore Lower 48 US oil production would head into decline in the 1970s,[34] also revolves around the central tenet of production-induced depletion. The implication for oil producers is that the value of their reserves will appreciate over time: to optimize their revenue, producers must rein in supply and leave as much of it as possible for future generations.

Peak supply has always had its critics—even at its zenith around the time in July 2008 when oil prices reached record highs of $147/barrel for US benchmark West Texas Intermediate.[35] Throughout oil history, technological innovation has repeatedly pushed back the expected time when the world would start running out of oil.[36] Support for the prediction of imminent peak supply collapsed entirely around 2014, along with oil prices, under the twin impact of the US shale boom and the increasing affordability of renewable fuels. The view has now been made obsolete by technological advances, notably in light tight oil production, and the realization that a vast oil resource base of various types is available at reasonable cost and is much larger than long-range demand projections.

In contrast with peak supply, peak oil demand postulates a fall in oil demand because of key factors including the rise of non-oil technologies (electric vehicles and others); growing efficiency of use; maturing and more service-oriented, slower-growing economies; demographic shifts to slower population growth and aging populations; and environmental and climate policies.

Figure 1 shows various prepandemic long-term oil demand forecasts from government agencies, oil companies, consultants, and nongovernmental organizations.[37] Some represent differing scenarios of environmental policy goals. Many forecasters refrain from providing a single forecast of long-term oil demand but resort instead to a scenario approach, highlighting a range of possible demand outcomes based on different sets of assumptions. For example, the IEA in its flagship *World Energy Outlook* has presented a choice of two scenarios, dubbed the Stated Policies (previously New Policies) and Sustainable Development scenarios.[38] Shell, BP, and Equinor, to name a few oil companies that publish long-term oil market outlooks, also adopted the scenario approach, which Shell pioneered in the 1970s. (Note that the absolute level of demand varies because of different forecasters' definitions of *oil*.) There is a wide range of forecasts of the level and timing of a peak. Aggressive environmental scenarios show a peak around now, while others have no peak by 2050.

Figure 1: Prepandemic oil demand forecasts



Note: Divergences in historical data are due to forecasts' different definitions and publication dates.
Source: See note 39.

These forecasts have been derived on the basis of various assumptions about energy and feedstock demand in the different sectors of the economy, the price of oil, gains in the efficiency of oil use, and the technological and cost development and deployment of competing technologies such as electric vehicles. Some scenarios are in the group of advocacy or at least illustration—what would be required to meet certain climate targets—while others are bottom-up constructions based on the growing competitiveness of non-oil

technologies. Ironically, even as a consensus has emerged in principle over the ineluctability of peak oil demand, that looming inflection point has in practice become more elusive. Oil demand growth bounced back from the oil price crash of 2014 and resumed a robust pace of growth, and with it greenhouse gas emissions, until late 2019, when concerns over economic growth, rather than any environmental achievement, took the wind out of its sails.[40] Oil demand and associated GHG emissions swung into reverse with the onset of COVID-19 in 2020 but look set to resume their growth once the economy recovers. Despite the pandemic's steep blow to the global economy, the resulting loss of oil demand was in fact less severe than initially estimated. The International Energy Agency's forecast of demand suppression in its *Oil Market Report* of April 2020 substantially overshot, leading the IEA to subsequently shave the loss estimate as reported data trickled through. Pockets of oil demand in certain sectors and geographies—bunker fuels for marine transportation, petrochemical feedstocks, and air and road freight demand—proved surprisingly resilient throughout the pandemic. By the end of 2020, oil demand in China and other developing economies had swung back to levels well over those of the previous year, and by early 2021, some analysts predicted that global oil demand would swing back over 100 million bpd by July 2021.[41] As the world's carbon budget (the amount of permissible emissions giving a reasonable certainty of keeping global temperature rise below a benchmark such as 1.5°C or 2°C) gets ever closer to exhaustion, the climatic imperative to change course becomes ever more pressing. With each passing year, the required downward demand slope becomes steeper—and thus more challenging to achieve.[42]

Although the specific level and timing of a peak in oil demand are difficult to pin down and remain a matter of debate, the very notion that such a peak will occur sooner or later at some point in the relatively near future—within the next 30 years—has gained broad acceptance, with only a few notable exceptions.[43]

Of course, excepting changes in storage, which are immaterial in the long term, supply has to equal demand. The distinction between peak supply and peak demand is therefore that peak supply would be accompanied by high and rising prices and economic damage, while in most—though not all—narratives, peak demand would be accompanied by a tendency toward falling prices (depending on the strategic behavior of producers) and strong growth in alternative non-oil technologies and would be compatible with overall robust economic growth.[44]

Nevertheless, demand would of course be expected to fall faster than the trend during recessions, and prices could be very volatile as periods of oversupply intersperse with brief reversals in demand decline, times of underinvestment in a sunset industry, and consequent supply shortfalls. Typical field declines with moderate reinvestment around 3 percent annually would lead to a shortfall of some 50 million barrels per day by 2040 if demand remained flat from 2020 or almost 10 million bpd even versus the IEA's sustainable development scenario. Substantial continuing investment by low-cost producers is therefore likely to be required. In the more recent scenario of the IEA's net-zero report, no new oil or gas field would need to be approved for development from 2020 onward, and by implication there would also be no new exploration; however, currently approved projects would continue, as would reinvestment in existing fields (likely including infill drilling and improved/enhanced recovery).

In the early phases of peak demand, it might be hard to discern the moment of the peak or even that a turning point has been reached, but the underlying secular trend of falling growth would probably be visible for some years beforehand. This would go along with key developments at the margin: for instance, the expansion of truly mass-market electric vehicles and actual, effective bans on oil-fueled transport in some key areas.

Meanwhile, on the supply side, the US shale boom has replaced the scarcity concerns of yesteryear with a perception of endless abundance. Compounding the supply-side effect of the shale revolution, peak demand expectations carry far-reaching implications for oil-producing companies and countries.

IMPLICATIONS FOR PRODUCERS: THE NEED FOR SELF-REINVENTION

While climate change poses an existential threat for mankind, the prospect of peak oil demand associated with climate policies and a changing fuel mix constitutes in its own right another form of existential threat for both oil companies and oil-exporting countries. Faced with the reality of global warming and the prospect of an announced energy "transition" intended to cut GHG emissions and decarbonize the economy, oil companies and petrostates are compelled to transform and reinvent themselves to suit the needs of a cleaner fuel mix and prove their continued relevance as enablers of the transition to a lower-carbon energy system. They can only do so, however, by playing to their competitive advantages, which more often than not are inherently tied to skill sets, assets, and relationships acquired and nurtured over many decades in the very oil sector from which they now must distance themselves.

On the corporate side, investors are increasingly demanding that oil companies account for the risk of stranded assets and other climate impacts and are calling on them to factor the energy transition into their strategic plans.[45] To address those demands, investor-owned companies can gradually reduce or even liquidate their oil businesses by curtailing or altogether ceasing reinvestment, as BP recently pledged to do, and either shrink into dividend plays or reinvest in gas (which may eventually face a peak of its own) or in renewable or other energies.[46] This can be a challenging prospect given the required transformation of core competencies. Companies can also opt to engage in joint ventures or make acquisitions of leading-edge new-energy, high-tech companies (in electricity distribution; electric vehicles; batteries; next-generation renewables; advanced biofuels; carbon capture, utilization, and storage [CCUS]; hydrogen; or other related fields) to gain exposure to noncarbon energy and overcome their skill deficits in those spaces.[47]

For most leading national oil companies (NOCs) and oil-exporting states, the challenge is even more acute. Their very businesses and economic models rest on the possession of large, long-life, low-cost oil and gas resources. They cannot easily, or perhaps at all, diversify completely into other industries in the next 10–30 years. Even if they manage large-scale diversification, this will come with heavy demands on their systems of employment, economics, and politics.

For petrostates as for oil companies, concerns over the long-term viability of their financial lifeline compounded the more immediate shock of the 2014 oil price collapse and the subsequent, protracted down cycle in global oil markets, further prolonged by the effect of the COVID-19 pandemic. The 2014 price crash itself came on the heels of the "Arab Spring" of 2011 and was succeeded by further unrest in several regional countries in 2019.[48] While down cycles in the oil market have often spurred calls for economic diversification in Gulf countries, never before had their concerns reached such a fevered pitch as in the last few years. The Gulf monarchies, which rank among the most oil-revenue-dependent petrostates, managed mostly to escape the political turmoil that swept through the Middle East and North Africa region during the Arab Spring. Since 2014, these petrostates have been among the most forward leaning in acknowledging the need for reinvention. All Gulf governments have issued plans of national transformation that boldly call for diversification, developing a non-oil private sector

spanning manufacturing and services, growth in domestic employment, innovation, reduced oil and energy subsidies, and so on.

Several years after their publication, however, there is considerable daylight between these visionary blueprints and their execution. While significant progress has been achieved on many levels, on others the results have fallen far short of expectations. It would be hard, in particular, to overstate the scope of the transformation intended for Saudi society and politics under King Salman and MBS, which so far has yielded results more on the social[49] than the economic side.[50] The UAE's economic diversification began earlier and has proceeded further, though it continues to encounter new challenges alongside successes.

In many ways, it is in their traditional, core oil sectors that some of the most striking developments in Gulf countries have recently taken place. For Gulf petrostates, national reinvention means first and foremost the reinvention of their oil sectors. Even if they ostensibly entail a call for economic diversification and for the end of their "addiction to oil," their national transformation plans do not advocate forsaking the oil sector altogether but rather reimagining or repurposing it. And while the rhetoric has focused on the non-oil sector, the oil sector has not stood still.

In retooling their oil sectors to face the shift to a lower-carbon economy, Gulf states such as Saudi Arabia and Abu Dhabi,[51] and to a lesser extent Oman, Kuwait, and Qatar, can adopt—and indeed have largely embraced—a two-pronged approach: on the one hand, a defensive strategy aiming to protect their existing markets and businesses and to encourage growth and/or prevent declines in those markets, referred to here as "demand defense," and on the other hand, an effort to create and promote alternative oil products and markets whose development they hope will offset demand attrition in more traditional sectors, referred to here as "demand creation."

On the supply side, Gulf countries led by Saudi Arabia also appear to be well positioned to win the last-man-standing contest. By engaging in a seemingly ill-timed price war at the onset of the COVID-19 pandemic, world top oil exporters Saudi Arabia and Russia compounded the impact of the demand shock, sending prices into a tailspin and driving capital away from higher-cost competitors. The combination of surging supply and plunging consumption pushed oil inventories through the roof, testing storage capacity limits, and at the peak of the lockdowns, briefly sent New York Mercantile Exchange futures prices into negative territory. Whatever the intent of Riyadh and Moscow in starting a price war may have been, the market crash helped slash upstream spending by oil and gas companies[52] and likely longer-term investment in non-GCC oil and gas, pressured the US into openly endorsing OPEC production cuts,[53] and forced a broad restructuring of the governance regime of the oil market. This has left low-cost Gulf producers well positioned to emerge from the downturn relatively unscathed and enjoy the benefit of both recovering oil prices and an expanding market share.[54]

By pushing top producers Saudi Arabia, Russia, and the US to openly join hands for the first time in a shared bid to shore up the market, the price collapse may have to some degree driven a wedge within OPEC and the Gulf alliance, whose role in the governance of the oil market seems somewhat eclipsed by the G3. While Gulf countries share many similarities in terms of the central role of oil in their economies and export and fiscal revenues, they differ

significantly in production volumes and market share. In some ways, Saudi Arabia's market management interests may now be more closely aligned with those of Russia and the US than with those of Kuwait or the UAE. Media reports in November 2020 that Abu Dhabi may have been considering leaving OPEC, less than two years after Qatar's own departure, seem telling in that respect.[55] Brought closely together in managing the oil market in the five decades since the first oil supply shock of 1973, Gulf countries may find themselves growing apart in the era of peak oil demand and the aftermath of the COVID 19 demand shock. Nevertheless, Saudi Arabia and its Gulf neighbors have abundant reserves, low production costs, and a common interest in ensuring the long-term role of oil in a lower-carbon economy through demand-defense and demand-creation policies even as they undertake steps to diversify their respective economies.

DEMAND DEFENSE

Gulf states can play an important role in shaping the trajectory of global oil demand and the impact and modalities of decarbonization. So far, much of the debate about the impact of peak demand on Gulf producers has taken a decline in oil consumption as an exogenous, uncontrollable event. What has been much less considered is the responses of their oil sectors, in particular their flagship national oil companies; how they can retain and gain market share even with overall declining demand; and how they can influence the level and timing of such a peak in demand—for example, by ensuring that the peak is delayed, that peak demand is higher, or that the postpeak fall in demand is slower. More importantly, what has been lost in the discussion is how these developments can call into question the very dichotomy between peak oil demand and the continued preeminence of the Gulf countries as leading oil producers.

For Gulf producers, dealing with the energy transition can mean fighting for oil's continued relevance as much as preparing for the post-oil economy. Fighting for oil doesn't necessarily mean pushing back against climate policy or denying its urgency but rather riding the decarbonization wave as smoothly as possible and looking for opportunities for oil to support and benefit from the decarbonization agenda—just as Gulf producers have supported and benefited from the growth of the global oil economy over the last 85 years.

Price and Volume Policy

OPEC has, of course, frequently used changes in output to influence prices, generally in a bid to raise the overall level of prices while avoiding sharp spikes that would negatively affect oil demand. Historically, concerted action has typically relied on a sharp price decline, which has overcome members' tendency to "cheat" on quotas, as in 1998, 2008–9, and 2014–16. But success in raising prices to high levels has generally come when markets were already tight and there was robust demand with little countervailing extra supply, as in 1973–4 and 2007–8. OPEC has also less obviously served to restrain members' long-term production growth plans and prevent any single member from making a dash for market share.

One form of long-term price defense lies in the suggestion that in response to limits on fossil fuel/oil consumption imposed by climate policy, major oil exporters could increase production in the short term, accepting lower prices but driving out high-cost competitors and ensuring maximal use of their existing reserves. Arguably, though perhaps for different reasons, OPEC acted in this way in 2014–15. Fattouh and Dale[56] argue that because of short-term revenue needs, most OPEC states are simply not able to follow such a policy today. Depending on their market share and cost of production, some OPEC member countries may be more inclined to do so than others, however. While Saudi Arabia's price war with Russia at the start of the COVID-19 pandemic has been lambasted by some analysts and commentators as a spectacular blunder or even a suicidal move, it may also be seen as a savvy step to bring downward price pressures to a boil and durably sideline high-cost producers.

Such an approach could be seen simply as a variation on the usual OPEC revenue maximization problem, which consists of trading off lower prices today against higher prices in the future and allowing for a discount rate. With different discount rates and resource endowments, optimal production levels are different for each OPEC member. OPEC policy in the face of peak demand could be viewed similarly but with a much higher price elasticity of demand. Then the Fattouh and Dale conundrum of short-term revenue needs could be represented by a higher discount rate applied to future revenues (though this seems inconsistent with many OPEC states' current easy access to borrowing at low rates).

Instead, OPEC countries from 2016 to 2021 have followed the opposite policy of trying to prop up short-term prices at the cost of both slower demand growth and loss of market share. This may have been partly motivated by the belief that the competition from shale oil would be relatively short lived and, as US shale growth eventually slowed or reversed in the 2020s, that OPEC would regain this market share. The belief that peak demand, if it arrived, would not be soon—more likely in the 2040s or afterward—may also have played a role. OPEC's ability to pursue such a policy until the COVID-19 outbreak hinged on cooperation with Russia, removing the risk of Moscow's further taking market share at its expense, and on political weakness in several OPEC members (notably Venezuela, Libya, and Iran), which has led them to take on much of the burden of overall adjustment involuntarily.

While the pandemic has dealt this approach a setback, which was further exacerbated by the Saudi-Russian price war, demand will eventually bounce from its COVID-19 lows. In April 2020, at a meeting of the Group of Twenty hosted virtually by Saudi Arabia, OPEC, Russia, and other producers, the group agreed on the steepest supply cuts in oil history in a bid to shore up prices. Washington joined Riyadh and Moscow in endorsing the agreement, with then president Trump pledging that the US would help Mexico "pick up some of the slack" to smooth the deal's progress.[57] As of late February 2021, prices were back above their pre-COVID-19 levels, fueling speculation that a new "supercycle" might be in the offing,[58] in which demand growth and prices move durably above their long-term averages.

It nevertheless remains the case that the approach of production curbs carries obvious risks in the context of imminent peak oil demand. New competitors—for instance, relatively high-cost new deepwater developments, enhanced oil recovery, and shale in areas outside the US—could be facilitated. Even as investors, spooked by the recent price collapse and heightened uncertainty around the demand outlook, stayed away from the oil sector, investment into the research, development, and deployment of electric vehicles and other non-oil technologies has been encouraged, as has consumer adoption. Demand decline could begin earlier and from a lower peak.

Even before the COVID-19 pandemic, the scenarios of Equinor[59] showed a demand peak around 2030–50, with the earlier date giving cumulative world oil demand from 2020 to 2050 as 1,185 billion bbl and the later date giving 1,309 billion bbl. At pre-COVID-19 production rates, the GCC states with Iran and Iraq would produce just 345 billion bbl of this by 2050,[60] or barely 40 percent of their current reserves, leaving more than half (plus future additions) to be produced in a world well beyond peak production and likely with lower prices or never to be produced at all.

Countries highly dependent on oil imports have concerns about possible geopolitical or cartel-related reductions in supply and price volatility (usually when prices rise sharply). This has historically been the case for the US, Western Europe, and Japan, and China and India are now in a similar situation. Indeed, the Indian oil minister complained in February that OPEC's production restraint was leading to high prices, and he instructed state refiners to look for alternatives to Saudi crude.[61] Such concerns have led these oil-importing countries to pursue a variety of policies such as the promotion of alternatives including coal, natural gas, renewables, nuclear power, biofuels, synthetic fuels, and electric vehicles; high fuel taxation; vehicle efficiency standards; and public transport. Thus a potential rising market share for OPEC or the Middle Eastern countries creates further reasons for importing countries to cut demand.

Oil's image as a reliable fuel can be bolstered by policies from oil exporters such as clearly communicating future supply policies, avoiding price spikes via the deployment of spare production capacity and storage, working with major importers to develop cooperative relations and build trust, investing in refineries and other oil-consuming industries in importing countries (to give the exporter a stake in a continuing reliable supply), and working with importers to resolve conflicts and avoid supply disruptions in major producing areas. Recent tensions in the Gulf, including a September 2019 missile/drone attack on Saudi Arabia's giant Abqaiq oil processing center, work in exactly the opposite direction. Yet the brief price reaction to the Abqaiq attack was surprisingly benign. Riyadh's deft management of the crisis, the swift recovery of Saudi production, and the dexterity with which national oil company Saudi Aramco reallocated supplies and kept exports running through the disruption helped reassure the market that even a nightmare scenario such as the attack on Abqaiq, the world's largest crude processing facility, could be absorbed.

Climate Policy

For an extended period, some major oil exporters, echoing the approach of some international oil companies, have followed a policy of delay and inaction on climate policy as a method for protecting their perceived interests. That policy has since undergone a sea change.

More recently, some exporters, the UAE being a notable example, have taken a far more constructive position toward climate policy, seeking to support climate action and to guide it in favorable directions (for instance, through support for CCUS). Saudi Arabia's "circular carbon economy" is intended as a paradigm for continuing climate-compatible hydrocarbon use, which was a major part of its net-zero carbon ambition by 2060 presented around the COP26 talks of November 2021.[62] Such policies could be extended and pursued in collaboration with other fossil fuel-intensive states.[63] Successful deployment of CCUS on stationary facilities would have a positive impact on future gas demand but may not do much for oil (except in reducing emissions from upstream production, refining, and petrochemicals). To the extent that it reduces the carbon footprint of oil sands and heavy oil, upstream CCUS might even be seen as defending a competitor to conventional oil.

However, CCUS and other forms of climate action, especially those that target non-oil emissions (coal, fugitive methane, and land-use change) create "carbon space," slowing the rate of using up the remaining carbon budget. That would allow a larger continuing use of oil.

Saudi Arabia in particular has long boasted of the small carbon footprint associated with its oil production, the fruit of policies that drastically curb the flaring and venting practices still so common outside of the GCC. Riyadh argues that its small footprint makes its crude a contender in a lower-carbon economy. Qatar likewise targets providing among the world's lowest-carbon footprint liquefied natural gas (LNG) via efficiency, methane abatement, CCUS, and other methods.[64] The growing momentum of methane policies in the US and Europe gives credence to this view and could give Saudi, Qatari, and other regional crude and natural gas a competitive advantage, securing their long-term places in a lower-carbon fuel mix.

In October 2020, the European Commission unrolled its Methane Strategy, a set of policies that includes tariffs on oil and gas imports deemed to come with a large methane footprint. In the US, after the Trump government's rollback of Obama-era methane policies, the Biden administration has put methane removal and other green policies at the top of its agenda. On day one of his administration, one of the first executive orders signed by President Biden mandated the Environmental Protection Agency to deliver new methane rules by September 2021.[65]

Renewed policy support for methane abatement comes at a time of great advances in the capacity of new remote sensing technologies to detect, measure, and attribute methane emissions. This newfound transparency opens the possibility of benchmarking fossil fuel producers and ranking their output by methane intensity.

Saudi Arabia has long argued that its crude oil not only enjoys some of the world's lowest production costs but also record low methane emissions. Earth-observation company Kayrros has been tracking methane emissions worldwide since 2019.[66] Its findings support Riyadh's claim. While hundreds of superemitters were detected in Turkmenistan, Russia, Algeria, the US, and other countries, virtually none were found in Saudi Arabia and its GCC neighbors.

Aside from methane abatement, biosequestration, carbon dioxide (CO_2) mineralization, direct capture of carbon dioxide from ambient air (or direct air capture [DAC]),[67] bioenergy with carbon capture and storage (CCS), or some equivalent technology is needed in most climate models to achieve the 1.5°C or 2°C targets. Large-scale deployment of carbon-negative technologies would allow the continuing use of oil in applications where CCUS is not feasible (for instance, aviation). Some recent research suggests DAC costs could be reasonable[68] in comparison to zero-emission technologies, falling in the range of $94–$232 per ton of CO_2 (equivalent to $40–$100 per barrel of crude oil, $0.84–$2.06 per gallon of gasoline,[69] or $200–$500 extra on a London-New York return economy class flight,[70] a stiff but not impossible level for carbon taxation[71]).

In June 2019, Occidental Petroleum partnered with Carbon Engineering, a Canadian start-up, to build a 0.5 million ton per year DAC plant, using the CO_2 for enhanced oil recovery, to be operational by 2022.[72] The financial viability of this is greatly assisted by California's low-carbon fuel standard, which credits trade at $160 per ton, and the recent 45Q tax credit of $35 per ton offered in the US for CCUS. Carbon Engineering CEO Steve Oldham has put the project's cost at much less than $200 per ton.

However DAC's feasibility on a large scale[73] and at reasonable cost is yet to be demonstrated. Major oil exporters could, for a relatively small investment, assist in the demonstration of DAC. This could be particularly interesting for those with mature fields (such as Oman, Qatar, and

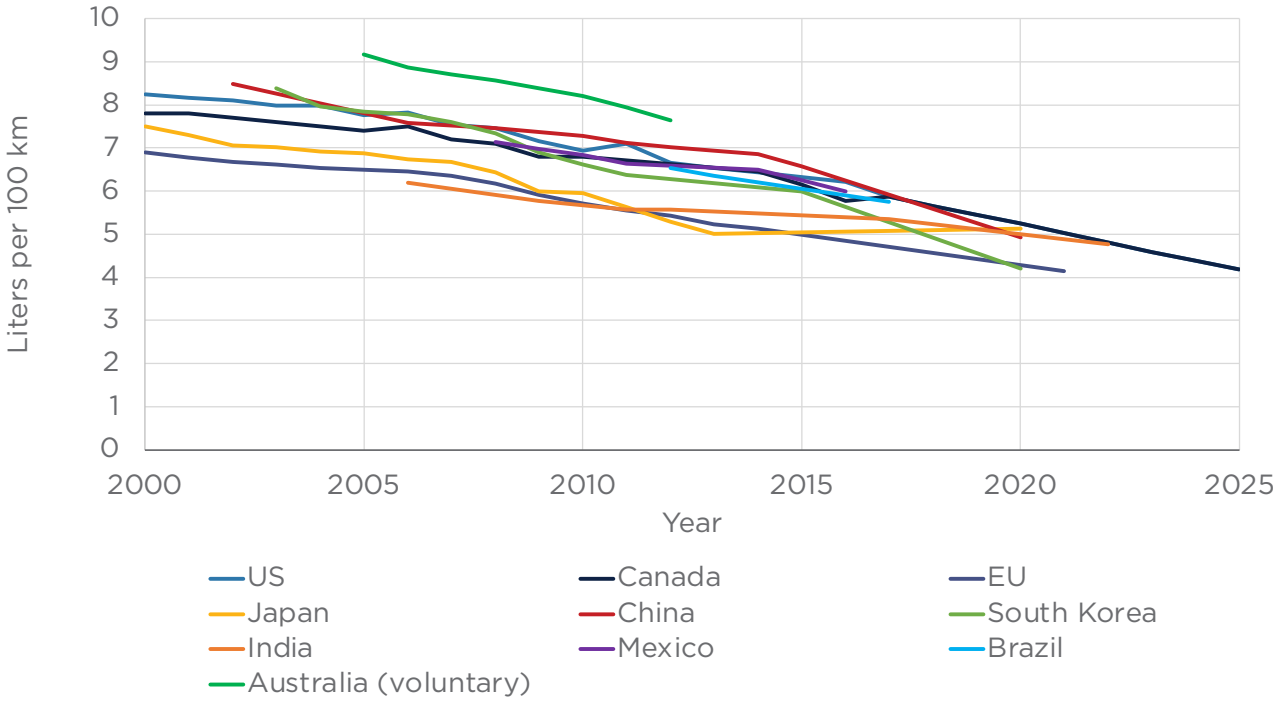
Bahrain) or where the injected CO_2 would replace natural gas for reinjection (as in the UAE, Algeria, and Iran).

Transport Fuels: Efficiency and Mobile CCUS

Improved vehicle fuel efficiency has generally been seen as decreasing oil demand. However, by reducing the effective cost of travel and its environmental impacts, it has served to maintain growing demand for oil in the long term. This becomes more salient when comparing an internal combustion engine (ICE) running on gasoline or diesel (or natural gas) with an electric vehicle.

Fuel efficiency has been promoted by government policies including efficiency standards (Figure 2) and fuel taxation. EU standards, for instance, will result in a gain in overall light vehicle fleet efficiency from 6.9 liters per 100 kilometers (km) in 2000 to 4.14 liters per 100 km in 2021. This also raises the cost of vehicles.[74] The Volkswagen emissions scandal of 2015[75] and growing concern over diesel-related pollution in major European cities has made it increasingly unlikely that mileage targets can be reached using diesel engines.

Figure 2: Efficiency standards, cars (normalized to Corporate Average Fuel Economy standards)



Source: Data from Lew Fulton and Sheila Watson, eds., "Vehicle Efficiency and Electrification: A Global Status Report," Global Fuel Economy Initiative, 2020, https://www.globalfueleconomy.org/media/791561/gfei-global-status-report-2020.pdf.

One leading NOC, Saudi Aramco, is investing in the competitiveness and cleanliness of ICEs. Similar efforts have not been identified for other major NOCs, whether from the Gulf or elsewhere.

Saudi Aramco's research center in Detroit is developing, in partnership with Mazda, compression ignition engines that run on gasoline (instead of diesel, as usual),[76] with a potential improvement from 30 to 40 percent efficiency (equivalent in the example above of 6.9 liters per 100 km falling to 5.2 liters per 100 km, the EU standard in 2013). It has a research partnership with FAW Group Corporation, one of China's largest automakers, and Chambroad Petrochemicals on cleaner engines and fuels.[77] Another design Aramco is researching uses opposed pistons for a truck engine with almost twice the mileage of a conventional gasoline engine[78] and is able to run on gasoline or diesel. These engines are also intended to be simpler to manufacture and lighter and smaller than traditional engines.

Of course, these engines still have to demonstrate that they can meet emissions standards and offer reliability, good performance, and reasonable cost. Major oil exporters could also invest in more conventional methods of improving fuel efficiency (incremental engine improvements, reducing weight and drag, reducing auxiliary consumption, hybridization, etc.), which have boosted mileage about 2 percent annually since 2005. Although it seems generally assumed that autonomous vehicles, when widespread, will be battery powered, autonomous ICE vehicles might also be able to realize improved efficiency via better driving styles and route planning. It may be notable that Aramco is working with two start-up firms, Achates Power and INNengine, on the opposed piston engines, rather than with incumbent automakers, many of which have switched their research and development attention to electric vehicles (and in Toyota's case, hydrogen[79]). These efforts have been underway for at least 10 years, suggesting caution as to how soon they might appear in commercial vehicles.

A major improvement in ICE efficiency would defend oil demand in the transport sector in two ways: it would extend the competitiveness and environmental acceptability of ICEs versus electric vehicles, and it would lower the cost of transport and thus increase demand for mobility overall. As a simple illustration, using a long-run elasticity of vehicle miles traveled to fuel price[80] of –0.71,[81] as found for the US, the improvement in efficiency from 30 to 40 percent would boost vehicle miles traveled by 18 percent. The combined effect is that fuel consumption would drop 12 percent, and an overall gain in consumption would therefore rely on defending the ICE's market share against battery vehicles. However, the effect might be different in emerging markets with high sensitivity to fuel costs, where elasticity might be greater than 1.

With an increasingly light crude output slate (due to shale oil and to natural gas liquids, or NGLs, and condensate derived from growing natural gas production), there is also a benefit in boosting gasoline demand from the light fraction of the barrel versus diesel. This would be part of the attraction of a gasoline compression-ignition engine.

Another approach being taken by Aramco is to improve the environmental acceptability of the ICE by pioneering onboard CCS, which could be applied to cars, ships, and trains to reduce CO_2 emissions (and probably other pollutants). Aramco states its technology can cut CO_2 by 25 percent, with a target for a 50 percent reduction.[82] In December 2019, it unveiled a

Class 8 heavy truck with a laboratory capture of rate over 40 percent.[83] Given the reduction in engine efficiency and the need to carry around a tank of CO_2 until it can be discharged, application to ships, trains, and trucks may seem more likely than to light vehicles. (Aramco has demonstrated it on a midsize passenger vehicle, a pickup truck, and a heavy-duty truck.) The reduced efficiency and the extra bulk and cost of the system would also make the ICE-CCS vehicle less competitive against a battery vehicle, while it is still far from eliminating emissions entirely.

These research efforts appear to concentrate mostly on ICE ground transport, including light passenger vehicles and heavy commercial vehicles, and are possibly also applicable to buses and diesel rail. There do not seem to be significant similar efforts relating to marine and aviation transport, though onboard CCS for shipping would seem more feasible.[84]

The implementation in January 2020 of new International Maritime Organization (IMO) regulations steeply reducing sulfur emissions from marine fuel, and subsequent regulations expected in 2023 to reduce CO_2 emissions from the shipping fleet (immediate reductions leading to a cut of at least 50 percent in total shipping GHG emissions by 2050 and eventual total decarbonization[85]), create a further threat to oil demand in this sector. Compliant low-sulfur fuel meeting the IMO 2020 standards—whether marine gasoil or very-low-sulfur fuel oil—trades at a premium to the high-sulfur fuel oil bunkers that previously made up the bulk of the marine fuel market. For new-build vessels at least, many shipowners are opting to install scrubbers (which remove sulfur oxides from flue gas) or use ships that run on LNG. For major oil exporters who are not also leading gas exporters, scrubbers clearly seem to be the solution of choice. Alternatively, they can invest in refinery upgrades for fuel oil desulfurization and/or to boost marine gasoil (middle distillate) yields in preference to residual fuel oil. In fact, new refining capacity brought online in the last few years in Saudi Arabia (including the 440,000 bpd joint-venture SATORP refinery with Total in Jubail, opened in 2014 and expanded in 2018, and the 400,000 bpd YASREF joint-venture plant with Sinopec in Yanbu, operational since late 2014/early 2015) is targeted toward diesel output, though shipping was not the primary intended market. The 400,000 bpd Jazan refinery, which was completed in October 2019 and started up on a limited basis in 2021, will produce IMO-compliant low-sulfur bunker fuels.[86] In the longer term, batteries will compete for short-range shipping, and possibly hydrogen, biofuels, ammonia,[87] or other synthetic fuels for long range,[88] with auxiliaries such as sails doubling as solar panels.[89]

Extending the cost-effectiveness of oil-burning engines would still leave fossil fuel oil open to competition from other liquid fuels with lower or zero net CO_2 emissions, including natural gas-to-liquids, synthetic fuels made from captured carbon dioxide,[90] and biofuels.

Power Generation

Oil has largely been squeezed out of utility-scale power generation, supplying just 3 percent of world generation in 2018.[91] The (utility-scale) power sector accounted for about 4.3 million bpd of demand in 2018, which is forecast to fall to 2.9 million bpd by 2040 in the IEA's New Policies scenario (now Stated Policies),[92] and most remaining oil-fired power generation is with major oil producers, often at subsidized prices.[93] This estimate, however, does not

account for distributed power generation, such as off-grid, backup, diesel- or gasoline-fired generators ("gensets"), often ubiquitous in emerging economies to offset the gaps, intermittency, or low quality of grid electricity and increasingly used in developed economies as backup for data servers or to deal with the intermittency of distributed renewable generation. Overall, oil in power is currently expensive, generally undesirable from an environmental standpoint, and faces strong competition from natural gas, coal, renewables (combined with batteries for off-grid or backup roles), and possibly nuclear power. Even the countries still using large quantities of oil in their power plants—notably Saudi Arabia, Kuwait, and Iraq—plan to phase it out in favor of gas and renewables.

However, oil is a relatively cleaner and lower-carbon fuel than coal. Oil products (diesel) burn efficiently in combined-cycle turbines. Oil-burning power plants can be fitted with CCS. Oil is a convenient, easily stored, and energy-dense fuel, convenient for backup power despite its high cost relative to alternative fuels.

If oil demand falls sharply, the price of oil might drop below that of LNG, and it might even become a more desirable fuel than coal in many markets. This provides a likely backstop for residual heavy fuel oil (as its use in shipping is phased out by the IMO regulations). This would be at a low price, though, perhaps in the range of $20 per barrel on an energy-equivalent basis.

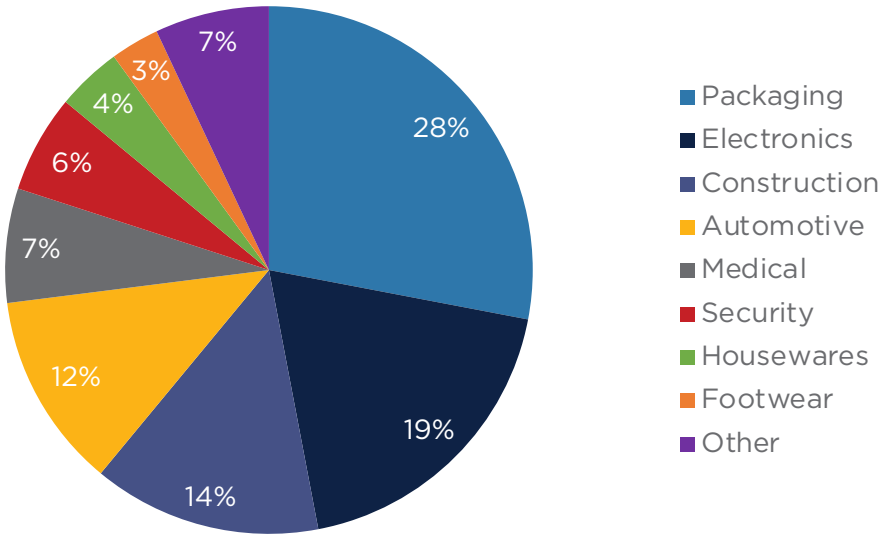
DEMAND CREATION

Beside the opportunities to grow or limit the reduction of their traditional oil markets, Gulf oil producers have also been looking for opportunities to tap into new businesses, including both new geographies and new sectors and products.

Petrochemicals

Major oil producers are already betting on petrochemicals as their big hope for sustaining oil demand.[94] Emerging economies are much more leveraged to petrochemicals demand growth than to fuels, with petrochemicals demand rising at one to two times the rate of gross domestic product, depending on the product. Since 1971, plastics have been the fastest growing of the main bulk materials: with 5.5 percent compound annual growth rate compared to 4.4 percent for cement, 3.7 percent for aluminum, 2.9 percent for ammonia (mostly fertilizers), and 2.4 percent for steel.[95] Demand growth has, if anything, accelerated during the COVID-19 pandemic due to the increased consumption of physical goods, including medical supplies. Figure 3 shows the main areas of demand for plastics.

Figure 3: Plastics use by sector



Source: Data from Nexant as used in Aphinya Khanunthong, "Industry Outlook 2020–2022: Petrochemicals," Krungsri, June 10, 2020, https://www.krungsri.com/en/research/industry/industry-outlook/Petrochemicals/Petrochemicals/IO/io-petrochemicals-20.

Saudi Aramco and Kuwait Petroleum Corporation, more recently joined by the Abu Dhabi National Oil Company (ADNOC),[96] have been particular advocates of the petrochemical-focused approach. To improve competitiveness and efficiency, new petrochemical plants are typically integrated with refineries, as with ADNOC's Ruwais expansion and Saudi Aramco's Petro Rabigh, Rapid (a joint venture refinery in Malaysia with Petronas), and a joint venture with Indian state firms, which ADNOC has joined and is planned for Raigad in Maharashtra. In August 2019, Aramco was in discussions to buy 20 percent of the integrated refining and petrochemicals business of India's Reliance Industries,[97] though this has not yet been consummated.

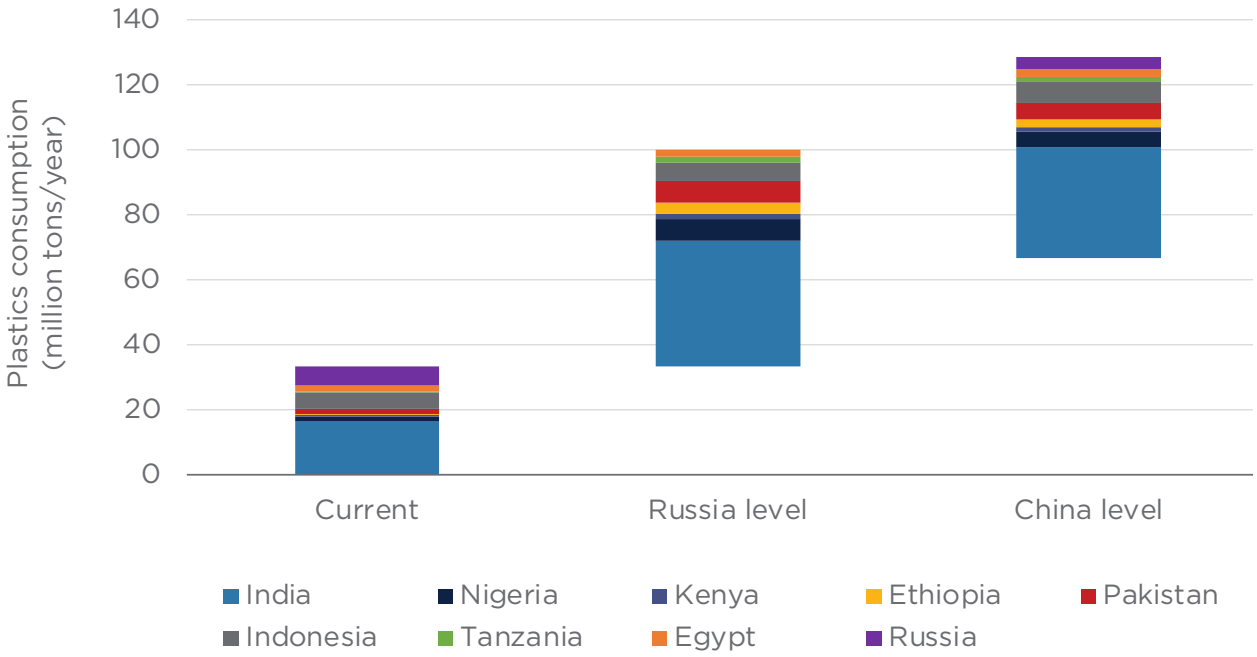
Aramco and Saudi Basic Industries Corporation (SABIC; now 70 percent owned by Aramco) were seeking to ensure the competitiveness of Saudi oil for petrochemicals by pioneering a giant crude-to-chemicals plant, costing $20 billion, to be built in Yanbu' on the Saudi Red Sea coast. This is the logical next step from refinery integration, intended to cut capital costs by 30 percent, and has a conversion rate to chemicals of 45 percent, turning 400,000 bpd of crude input into 200,000 bpd of diesel and 9 million tons of chemicals and base oils.[98] Only one similar, much smaller, plant exists worldwide, operated by ExxonMobil in Singapore. However, like the Raigad and Reliance investments, the plant is now in question due to capital expenditure cuts by Aramco.[99]

Of course, where these plants are developed is also important. SABIC has sought to expand into the US, but plants there would run on American shale oil and gas feedstock, and into China for coal-to-chemicals plants. Except to the extent that they might soak up some hydrocarbons that otherwise would have been exported, these investments encourage rather than reduce competition to major oil exporters. Most new Middle Eastern refining and petrochemicals investments, though, are targeted at Asia,[100] the main growth market and one with limited and declining indigenous hydrocarbons.

Plastic consumption in developed countries is around 55–80 kilograms (kg) per capita per year (generally saturating around 60 kg/capita/year), while developing countries may be as low as 4 kg/capita/year.[101]

Considering some large developing countries that are currently consuming 33.4 million tons per year of plastics, Figure 4 shows how rising to the current Russian level (41.1 kg/capita/year) would add 66.6 megatons/year of consumption, mostly in India, and reaching Chinese levels of 66.5 kg/capita/year would add another 61.8 megatons/year, again with more than half in India. The Indian potential is no surprise (it is just 12.4 kg/capita/year currently), but the potential for growth in populous sub-Saharan African countries with very low usage levels today is also significant and less targeted by investors and marketers. For instance, almost 100 million people in fast-growing Ethiopia use just 2.6 kg/capita/year of plastics today.

Figure 4: Illustrative potential for growth in plastics consumption from nine major emerging economies



Note: Data do not cover some potentially large consuming developing countries, such as Bangladesh.

Source: Data from EUROMAP, "Plastics Resin Production and Consumption in 63 Countries Worldwide," October 2016, http://www.pagder.org/images/files/euromappreview.pdf.

If major oil exporters are seeking guaranteed outlets in mature markets, they could buy existing refineries and petrochemical plants, given the tendency for the supermajors to divest. Aramco restructured its Motiva joint venture with Shell in 2017[102] to take full control of the Port Arthur refinery in Texas, the largest in the US, and it already owns 15 percent of Showa Shell in Japan. Motiva subsequently entered into a deal with Koch Industries unit Flint Hills to acquire a petrochemical plant at Port Arthur.[103] Algeria's Sonatrach bought the 190,000 bpd Augusta refinery in Italy from ExxonMobil in May 2018[104] (though this was more to provide for its own domestic market). However, such an approach risks acquiring large liabilities and expanding exposure to slow-growing or shrinking markets.

Targeting petrochemicals also raises questions of competitors for feedstock. US shale crude and condensate (and possibly other shale basins that may be developed in the future), as well as natural gas producers with by-product ethane and NGLs, are large and often low-cost suppliers. The typically medium-gravity crudes of Middle Eastern OPEC countries and Russia can produce some naphtha (light hydrocarbon) feed for petrochemicals. However, such crudes are better suited to produce middle distillates (diesel/gasoil or kerosene/jet fuel). These are likely to be higher-margin uses once aviation recovers from the COVID-19 pandemic

because the middle distillate available may be squeezed by an excess of light crude feedstock (yielding more naphtha and gasoline), and there will be extra demand from the shipping industry for marine gasoil (a similar fuel to diesel) following the IMO 2020 ban on the use of high-sulfur fuel oil.

The other key issue is whether petrochemical demand growth will be as strong as anticipated. Single-use plastics, particularly packaging, are facing a backlash in developed-country markets because of concerns over waste and pollution.[105] This is leading to bans on plastic bags and replacement by reusable or recyclable materials. Fifty-five percent of polyethylene and 30 percent of polypropylene is used in packaging; they account for 153 million tons of demand in 2015 (compared to a total demand for basic chemicals of about 450 million tons in that year[106]). Only 18 percent of plastic worldwide is recycled, but various companies, including Coca-Cola, PepsiCo, and Unilever, have targets to reuse or recycle all of their packaging by 2025–30.[107] Various processes are under development to convert waste plastics to liquid fuels,[108] which could lead to a faster decline in primary crude oil demand.

Petrochemicals producers can respond by developing more recyclable products and promoting recycling facilities and policies, which would protect their market but reduce primary material inputs and hence demand. Or they could introduce more biodegradable products. If these new products incorporate more nonfossil feedstocks, such as biomaterials or synthetics made from captured CO_2, they will improve environmental acceptability but still reduce growth in oil demand from the petrochemical sector. For instance, Saudi Aramco is working on using waste CO_2 in combination with hydrocarbon feedstock to produce superior-performance polyols (organic chemicals used to make foam, fibers, sealants, adhesives, and other materials) with up to 42 percent CO_2 by weight.[109]

Accenture estimates that recycling and plastic bans could cut petrochemical demand growth to 1.5 percent annually, less than one-third of historical levels.[110] McKinsey estimates 1 percent instead of 4 percent annual growth with reuse rising from 12 percent of plastics currently to 50 percent by 2030,[111] and BP's single-use plastics ban scenario would cut liquid feedstocks by 6.1 million bpd by 2040 versus its base case of 107.7 million bpd total demand.[112]

Nonmetallic Materials

Given the factors of market maturity and environmental pressures mentioned above, sustaining petrochemical demand growth requires creating new bulk markets.

Saudi Aramco has been developing petrochemical-based nonmetallic materials that can replace metals in certain applications. This includes polyacetal (polyoxymethylene), a thermoplastic, for which global demand is expected to reach 1.6 million tons annually by 2023.[113] SABIC opened a joint-venture polyacetal plant in Jubail in January 2018.[114]

Aramco has begun replacing its oil and some of its natural gas flow lines with reinforced thermoplastic pipe (RTP) to reduce corrosion, and it has also proved to be quicker and safer to install than traditional steel pipe. RTP is made from high-density polyethylene and polyethylene of raised temperature resins reinforced with glass fiber, glass fiber-reinforced epoxy laminate, aramid fiber (aromatic polyamide), steel strip, and steel cord.[115] These

materials depend on petrochemical precursors including ethylene, propylene, and benzene. The Middle East's use of RTP is expected by Aramco to increase from 2,523 km in 2018 to 5,257 km in 2030.[116]

Carbon fiber is another increasingly important material for high-performance racing cars, boats, bikes, sports equipment, body armor, aerospace technologies, wind turbine blades, and drones, with an estimated growth of 10–12 percent annually over the next few years.[117] It is five times stronger than steel for half the weight, as well as being noncorroding. The Boeing 787 Dreamliner is almost half carbon fiber, totaling 23 tons. Carbon fiber is not yet widely used for conventional cars, but that could change as factories retool, with pressure for lightness and fuel efficiency. It is primarily (90 percent) made from polyacrylonitrile, itself produced via acrylonitrile from propylene. But global carbon fiber demand of a projected 117,000 tons in 2022[118] represents only a modest market. Most acrylonitrile (6 million tons worldwide output) is used for acrylonitrile butadiene styrene, a common thermoplastic. Graphene and carbon nanotubes also have unique properties and interesting applications in medicine, electronics, membranes, batteries, corrosion-resistant coatings, and other areas and are currently mostly made from hydrocarbons,[119] but they are expensive and made in very small quantities (with a forecast of 3,800 tons of graphene worldwide by 2023). They can also be synthesized from nonhydrocarbons (such as atmospheric CO_2).

Nonmetallic materials may find further applications if combined with 3D printing (additive manufacturing). So far, applications to hostile environments (high temperatures and acids) are limited by the endurance of the glues rather than the thermoplastic.[120] Developing, certifying, and marketing new products is likely to be a lengthy and intensive process.

Despite their advantages, nonmetallic materials will face new challenges from advanced metallic products, which are also under development and include ultralightweight structures and custom dissolvable metals.

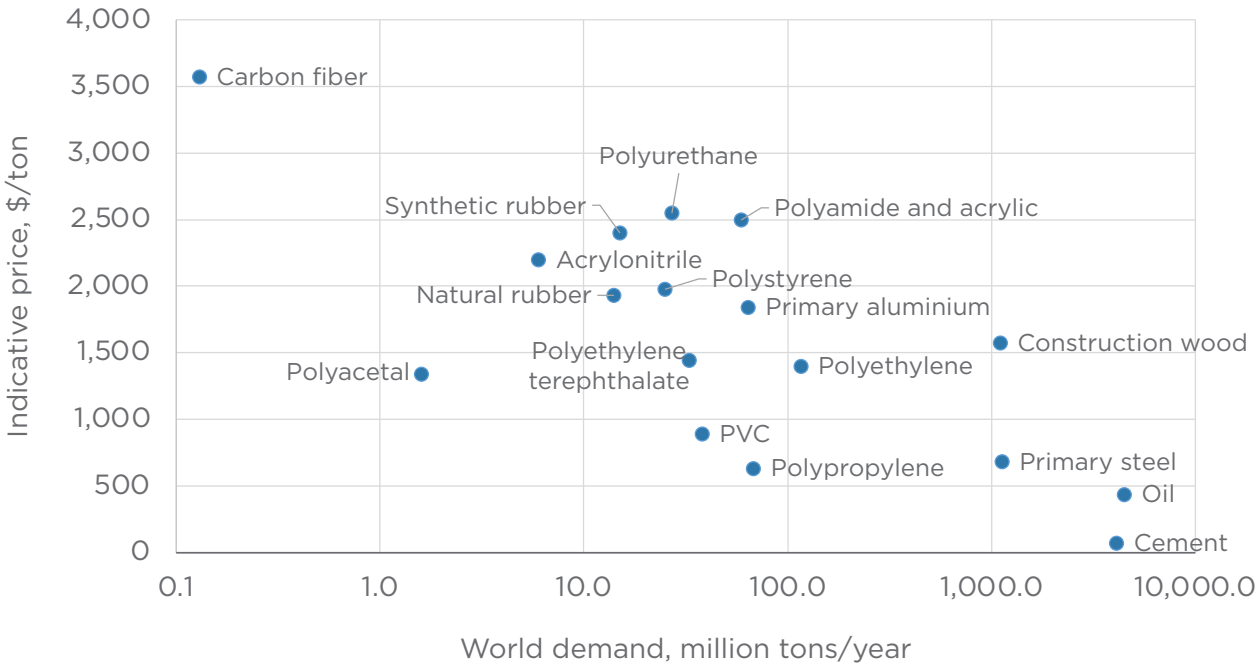
Bulk uses of petrochemicals that would represent a volumetrically significant market would probably have to compete with construction, structural, and industrial materials such as steel, aluminum, concrete, and wood. For instance, there is some room for growth in rubber, where an estimated 14.0 million tons of synthetic rubber and 12.4 million tons of natural rubber were produced in 2020.[121] Saudi Aramco established a synthetic rubber joint venture, Arlanxeo, in 2016[122] and took full control of it in late 2018.

As an illustration, Figure 5 shows the market size and price for some major construction and industrial materials, including the main polymer types. Oil is, by mass, the most used material worldwide (excluding coal and lower-grade construction materials such as brick, sand, and road aggregate). Of course, most of this oil (about 84 percent[123]) is used as fuel. But to absorb a significant amount of oil use, an alternative material must have high potential for replacement or a very large market size. For instance, the entire world market for primary aluminum is equal to about 1.5 percent of the oil market by mass. This is a crude comparison because oil-derived polymers do not have to replace other materials at a 1:1 mass ratio, but it is illustrative of the required orders of magnitude.

Some materials used in large quantities, such as cement and steel, have prices lower per ton, or only a little higher, than oil, and so are likely to remain preferred unless the performance of

the oil-based alternative is far superior. Polymers might be environmentally superior where they replace energy/CO_2-intensive materials such as steel, aluminum, cement, and bricks or where their light weights reduce energy consumption in transportation and use.

Figure 5: Price and market size of major polymers and other materials



Source: See note 124.

Hydrogen

Hydrogen has been advanced as a possible energy carrier that could be used, for instance, to store energy (including variable renewable energy at times of surplus), to fuel vehicles (ground transport, planes, and ships), and as a clean supplement or replacement for natural gas, particularly in home heating and cooking. Hydrogen is typically produced by steam reforming of natural gas from coal (mostly in China[125]) or is more expensively produced by the electrolysis of water ("green" hydrogen). Kawasaki Heavy Industries is currently working with Australian utility AGL Energy to trial the production of hydrogen from Victoria's large lignite (brown coal) resources.[126] The production of hydrogen from oil, natural gas, or coal is not low carbon unless combined with carbon capture and storage (which is relatively readily done) to yield "blue" hydrogen. ADNOC and Aramco have, especially since late 2020, begun developing strategies and projects for blue hydrogen or derivatives such as blue ammonia,[127] while other entities in the Gulf are aiming to progress green hydrogen ventures. Perhaps surprisingly given its low-cost gas resources, Qatar has not yet announced any advanced plans in hydrogen.

Hydrogen can be produced from oil, with CCS to sequester CO_2 emissions. This could be competitive with production from natural gas or coal if the oil price were sufficiently low. This represents another potential backstop for oil use. Saudi Aramco has begun piloting hydrogen fueling stations with hydrogen delivered by truck or generated on-site from heavy naphtha, liquefied petroleum gas (LPG), or natural gas.[128] In March 2021, it signed an agreement with Hyundai Oilbank to provide LPG that would be reformed to hydrogen in South Korea, with the resultant CO_2 shipped back to Saudi Arabia for sequestration.[129]

New Geographies and Sectors

Most peak-oil demand scenarios envision continued growth in oil demand in the emerging and developing economies of South and Southeast Asia and sub-Saharan Africa, offset by contraction in more mature markets in Europe, North America, and Northeast Asia. Producing countries, including those in the Gulf, have been aggressively investing to lock in downstream (refining and petrochemical) capacity in Asia.

Aramco has a number of longer-established joint ventures in the mature markets of Japan and South Korea. For some time, though, China has been the focus. Aramco agreed in 2007 to triple the capacity of its Fujian refinery with ExxonMobil and Sinopec. It has held talks to develop a refining and petrochemical complex with defense conglomerate Norinco in the northeastern city of Panjin and to acquire 9 percent of Zhejiang Petrochemical, which operates an 800,000 bpd refinery in Zhoushan, south of Shanghai. Long talks with PetroChina for a refinery in the southeastern province of Yunnan appear to have led nowhere.[130] As with its ventures in India, discussed above, new business in China may be hampered by Aramco's capital expenditure constraints.

Other Gulf countries have not been as active or successful in establishing a Chinese presence, though ADNOC has looked into refining partnerships with China National Offshore Oil Corporation[131] and Wanhua.[132] Aramco and Kuwait Petroleum have given up on joint refineries in Indonesia,[133] but Kuwait's Nghi Son refinery (a partnership with Idemitsu and PetroVietnam) started up in 2018.[134] Abu Dhabi, through Mubadala, owns 40 percent of the Pak-Arab Refinery in Karachi, Pakistan, and is considering a 250,000 bpd greenfield refinery at Gwadar,[135] though this would probably be export oriented.

Investments in the Indian subcontinent, expected to overtake China in oil demand growth, accelerated in 2019 before the pandemic, and a rethink on spending plans slowed progress again more recently. Thus in August 2019, Aramco discussed taking a 20 percent share in Indian refining and petrochemical giant Reliance Industries in a deal that would see Reliance buy up to 500,000 bpd of crude oil from Aramco, more than double its current Saudi imports.[136] In September 2019, Aramco also completed the acquisition of Shell's 50 percent share in their SASREF joint venture in Jubail Industrial City,[137] on the kingdom's eastern coast, which is well placed to reach Indian and other Asian markets. As noted above, in 2019, Saudi Aramco and Abu Dhabi's ADNOC announced a planned 1.2 million bpd, 18 million ton/year joint-venture, grassroots refinery and petrochemical plant in the Indian state of Maharashtra, south of Mumbai, alongside domestic refiners Indian Oil Corporation, Bharat Petroleum, and Hindustan Petroleum.[138] Two years earlier, Russia's Rosneft had teamed up with global trading

Trafigura and Russian fund UCP to buy a 98.26 percent stake in Reliance's Indian rival Essar Oil, since renamed Nayara Energy,[139] apparently beating out competition from Aramco.[140] ADNOC has also agreed to store oil in India's strategic stocks, giving a measure of supply and demand security to both sides. With India likely to be the world's leading source of oil demand growth after the effects of the COVID-19 pandemic are overcome, it is likely that India will return as a key focus for Gulf NOCs. MBS's April 2021 mention of a sale of a further 1 percent of Aramco to an investor from a large oil-consuming country[141] could have referred to China or India.

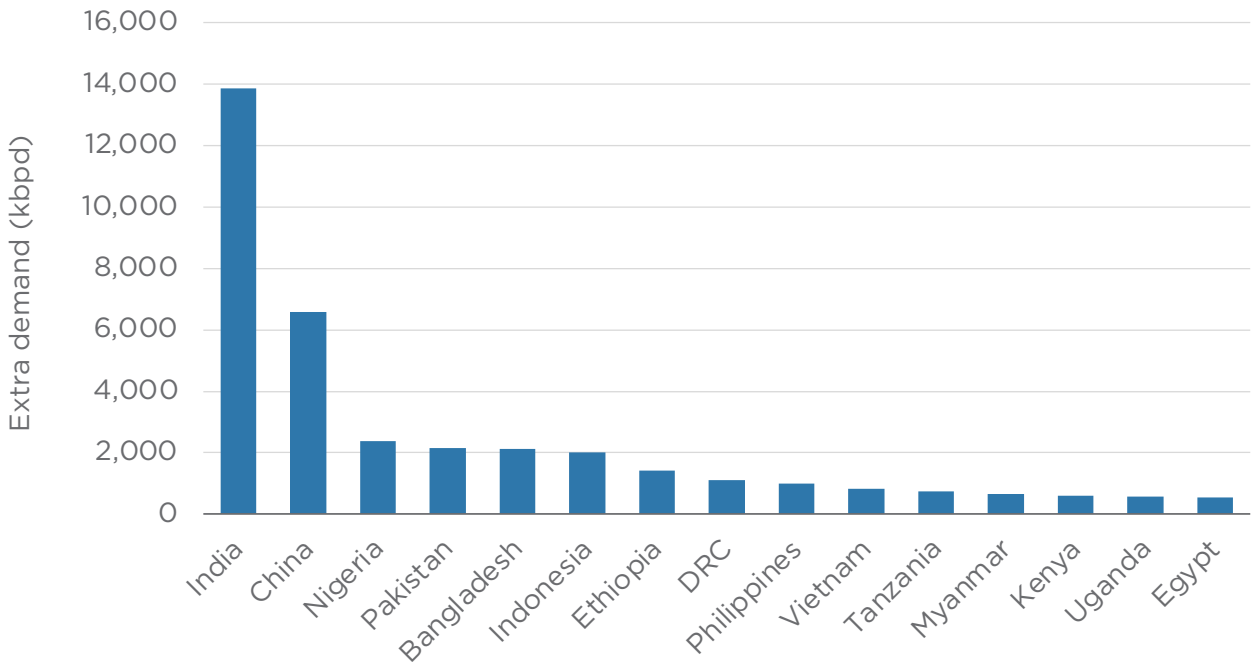
The flow of investment has run both ways, with Abu Dhabi in particular awarding equity stakes in oil and gas fields to a variety of Chinese, South Korean, Thai, and Indian firms, along with the traditional European, Japanese, and American partners. This may also be a way to ensure preferential access for Gulf hydrocarbons to those markets. As shown by these examples, Aramco, ADNOC, and to some extent Kuwait Petroleum Corporation have been the most active in downstream Asian investments, in line with their oil outputs; Oman, Qatar, and Bahrain have been mostly inactive.

In these areas, though, Gulf countries are investing in countries that already have substantial petroleum use and infrastructure and robust growth. For demand creation, rather than demand capture, one would have to look elsewhere. Many countries, and large populations within certain countries, mostly in Africa and parts of South Asia, live in energy poverty and are reliant on traditional fuels, namely animal dung, gathered wood, and charcoal. These produce poor-quality energy, result in serious indoor and outdoor air pollution, contribute to deforestation and desertification, and require exhausting, low-productivity labor to collect.

Small amounts of modern fuels, enough to run a stove, heating (where the climate requires), lighting, and some motorized transport (for instance, a motorcycle taxi) dramatically improve health, quality of life, and economic opportunity. Some of these needs can increasingly be supplied by modern cookstoves, solar cookers, and solar or other renewable microgrids with battery backup. However there is still considerable potential for increased demand for LPG and kerosene (for cooking and lighting) and diesel and gasoline (for generators and motor transport). Even in small quantities per person, these can add up to sizeable extra demand. If modern energy substitutes for unsustainably harvested biomass, it can have a positive environmental and climate impact.

Larger-scale demand can be generated by the development of local industries (bricks, cement, and agricultural processing) and improved transport networks for road, rail, shipping, and, with rising incomes, air travel.

Figure 6: Extra demand from large countries



Source: Authors' calculations based on data from The World Bank, "Population, total," https://data.worldbank.org/indicator/SP.POP.TOTL.

Figure 6 shows the extra demand that would be created if oil demand were to reach 5 barrels per year per person, about the level of Mexico, in large countries—countries shown would gain 0.5 million bpd each or more in demand by reaching that level. For example, China currently consumes 3.3 bbl/year/person, India 1.26 bbl/year/person, Bangladesh 0.32 bbl/year/person, and the Democratic Republic of Congo 0.13 bbl/day/person. Excluding China and India, the countries in Figure 6 total a potential 16 million bpd of extra demand.

Although not shown on the chart, some midsize landlocked African countries also have room for quite significant gains in demand—for instance, Uganda consumes only 0.22 bbl/year/person, Niger 0.21, Mali 0.14, and Chad 0.05. In these cases, consumption may be partly constrained by lack of infrastructure and ready fuel availability, with the delivered price of fuel being high because of difficult logistics.

These markets have to be examined in individual detail, of course. In some, economic and oil demand growth is hampered by structural factors, corruption, incumbents, and insecurity. Congestion in densely populated countries such as Bangladesh may constrain mass take-up of personal cars. Local oil production may be sufficient to meet domestic needs, as in countries such as Chad, Niger, and Uganda, in which case increased demand may not translate into increased need for imports. Oil-exporting states do not have the financial and organizational

resources alone to transform countries where the broader international community has worked for decades.

Nevertheless, the provision of local oil refineries and fuel distribution infrastructure (trucking, pipelines, storage tanks and depots, and retail stations), marine fueling stations, LPG distribution, and better road, marine port, airport, and rail networks would support demand growth for fuel, asphalt, and lubricants.

This should be an opportunity for cooperation with China, given its well-known strengths in construction and infrastructure.[142] This applies to Africa and to countries along China's Belt and Road Initiative (BRI), such as Pakistan, Afghanistan, Tajikistan, and Uzbekistan. The BRI stresses transport, trade, and connectivity, including roads, rail lines, ports, airports, pipelines, and electricity grids. Alternatively, the October 2019 global infrastructure partnership between the EU and Japan,[143] backed by €60 billion of European money, may be appropriate for Africa, though it's unlikely that projects overtly targeted at hydrocarbon use would be supported.[144]

Of course, some of these investments would also support greater use of non-oil transport using natural gas or electricity. Oil-exporting countries would therefore want to be sure that their investments in transport infrastructure were commercially viable in their own right and not solely predicated on boosting oil demand.

In the transport space, some emerging new technologies can support oil demand. For instance, ride-hailing services such as Uber have been linked to a drop in public transport ridership: for every year after they enter a market, rail ridership drops by 1.3 percent and bus ridership 1.7 percent.[145] Autonomous vehicles, if not electric, would probably boost demand in the long run by making road transport safer, easier, and open to a wider group of users. Drones, air taxis,[146] hypersonic flight, and space travel are more speculative but also offer the possibility of greatly expanded travel that is at least in some part fueled by oil.[147]

Saudi Arabia's Public Investment Fund has invested in Uber[148] and expressed interest in investing $1 billion in Virgin Galactic, a space tourism venture, though founder Richard Branson suspended talks after the murder of Jamal Khashoggi.[149] King Abdulaziz City for Science and Technology is said to have funded a Ukrainian hypersonic spaceplane project for launching satellites.[150] The Public Investment Fund, though, also has a stake in Tesla (most of which it sold, however, in late 2019),[151] and there is no sign its investments were part of any strategy to boost oil demand rather than being commercial deals and/or part of attempts to diversify its economy toward high tech. If anything, Uber likely acts more as a hedge against future transport trends if it moves to autonomous and electric vehicles.

IMPLICATIONS

With the exception of demand creation in Africa and other low energy-consuming countries, these strategies are already well into implementation by at least some of the leading NOCs. If put into practice on a large scale, they could have significant implications in global energy markets, for climate, and for the risks undertaken by the countries and companies.

Competition

It's likely that only select GCC countries (for oil, really Saudi Arabia, the UAE, and perhaps Kuwait) have the combination of large resources, relative political stability, and long-term outlook to give them both the ability and the incentive to pursue such ambitious strategies to cope with peak oil demand.

Countries that are both large oil and gas exporters will wish to preserve markets for both these fuels. They compete in some markets—largely petrochemicals, to a small but growing extent in transport, and in the past (and perhaps again in the future) in power generation. This most obviously applies to Qatar and Russia. In the case of Qatar, its gas reserves and exports are much more important than its crude oil, which is in decline, but condensate and NGLs are major sources of revenues. For Russia, its gas reserves are about twice its oil in energy equivalence, and of course are lower carbon in end use, but net oil exports are about 2.5 times larger than net gas exports, and it earns much more from its oil exports than gas exports.

Major oil producers that are currently not significant gas exporters do have ambitions to expand their gas exports, either from domestic resources, international projects, or a combination of both. This applies particularly to Abu Dhabi[152] and Saudi Arabia.[153] If achieved, or even if domestic gas output supplied to industry increases, this becomes a more effective diversification. It would be following in the footsteps of international oil companies such as Shell, BP, Total, and Equinor.[154]

Climate

A policy of sustaining oil demand obviously raises difficult climate questions. To the extent that it is offset by climate policy elsewhere (see Section 5.2), the effect would be neutral. Oil that is converted into durable plastics or other products,[155] combusted with CCUS, or offset by DAC or biosequestration does not contribute to net CO_2 emissions.

But newly created oil demand in transport or much of the power sector will contribute to carbon dioxide emissions; it is much more carbon intensive than natural gas, though less than coal (estimated life cycle emissions factors are 0.305 tons CO_2/megawatt-hour [MWh] for diesel, 0.393 tons/MWh for coal, and 0.237 tons/MWh for natural gas[156]). Such transport emissions could be offset by land-use changes, direct air capture, or carbon-negative CCS using biomass. But except for aviation and perhaps some shipping, this is likely to be more costly than zero-emissions transport (battery vehicles and electric rail).

It thus appears inescapable that a policy of encouraging higher oil demand would lead to higher CO_2 emissions, particularly in the near term (and potentially necessitating a faster decline in overall emissions thereafter). This is likely to draw strong opposition in international climate negotiations; from environmental organizations and many international investors, financial institutions, and tourists; and, the authors assume, even from a growing number of policy makers within the oil-exporting countries themselves.

Causing carbon emissions to increase would in turn expose GCC oil producers to a number of risks, including trade restrictions or even boycotts, as well as raise the impact of climate change overall. This in turn is likely to damage a number of leading oil-exporting countries through factors such as drought and desertification, the flooding of low-lying coastal areas (including important energy facilities), the loss of fisheries, heat waves, political destabilization, and refugee flows.

Therefore any policy of encouraging oil demand would have to be accompanied by a robust and realistic set of measures to offset increased emissions or reduce them in other sectors, along with a clear communication campaign. This suite of policies would include an assessment of the other benefits of that oil use, such as producing products with environmentally superior characteristics and reducing energy poverty in lower-income countries.

Risks

A policy of aggressively attempting to secure demand in growing consumers or to boost or sustain global oil demand has risks as well as benefits. Investments in refineries, petrochemical facilities, and improved ICE vehicles are tantamount to doubling down on an oil-fueled future. Refining margins are correlated with oil prices in the case of negative demand shocks;[157] a sustained fall in oil demand will require many refineries to be decommissioned and reduce margins for those that remain.

Major oil exporters could be content to export oil while they can, allow consuming countries to build refineries as required, and put the surplus earnings into non-oil savings or even actively into hedges against peak oil demand, such as LNG, biomaterials, battery technologies, and related minerals (lithium, cobalt, rare earth metals, etc.); electric vehicles themselves (including research and development, design, components, manufacture, and software); charging stations (and associated retail); and the required enhanced electricity distribution and marketing.

Some major nonstate oil companies, including Shell, BP, and Total, and majority state-owned Equinor, are already following strategies of a gradual shift toward new mobility, electrification, batteries, wind and solar power, and similar business areas.[158] A major oil exporter or state-owned oil company would therefore face competition in such a strategy from private peers as well as “new energy” specialists.

In alignment with this trend, Saudi Arabia has invested in Uber and in SoftBank’s Vision Fund, which has various on-demand transport investments, while Aramco has expressed its interest in investing in other parts of transportation.

To recycle the capital outlay while still achieving the effect of anchoring oil demand, oil exporters could construct refineries and petrochemical plants (which are already usually in joint ventures with a consuming national oil company and/or a leading international refining or petrochemical firm such as ExxonMobil, Total, or Dow Chemical), then sell down most of their stakes while retaining the rights to supply oil to the plants on a long-term basis. A number of NOCs, including Aramco, Petroleum Development Oman, and units of ADNOC, have issued bonds. Meanwhile, ADNOC has brought outside equity capital into its refining, drilling, fuel retail, pipeline, and real estate units, and Aramco has done the same with its oil pipelines, effectively through securitizing tariff payments.

Oil exporters could also seek to reduce their exposure by privatizing their resources, reversing the process of the 1970s. In a small way, the planned IPO of 5 percent of Saudi Aramco, which eventually became a 1.7 percent offering on the local Saudi market,[159] could be seen in this light. Of course, the government would still retain the vast bulk of the rents via taxes and royalties,[160] but it could shift the investment risk to private investors. This strategy could still be pursued concurrently with attempts to sustain oil demand, which indeed would boost the value of the stakes being privatized.

CONCLUSION

Peak oil demand—as opposed to the now largely discredited idea of peak oil supply—has become a growing topic of discussion and concern for major oil-producing companies and countries. The concept is that world oil demand is set to peak and decline in the near future—say within the 2020s or 2030s—due to some combination of the rise of non-oil technologies (notably electric vehicles), improvements in energy and resource efficiency, and tightening policies on the environment and greenhouse gas emissions. This prospect is of particular concern for Gulf countries because of their heavy dependence on oil for gross domestic product, government revenues and exports, and hence the maintenance of their citizens' high standard of living, which is in turn usually linked to the survival of their political systems.[161] Nevertheless, given the threat of climate change to the infrastructure, economy, livability, and political stability of the Gulf region and its immediate neighbors, as well as those of their economic partners, Gulf countries have a clear interest in avoiding the worst global warming outcomes, however painful the transition may be.

These countries' oil revenues might at times benefit somewhat counterintuitively from contracting global oil demand if changing strategies by international oil companies and the unwillingness of investors to finance the industry leads to periods of underinvestment and high prices. Overall, however, the consensus view is that declining demand will ultimately result in falling prices and shrinking revenues.

The major oil exporters have responded to the fall in oil prices since 2014, the challenge from US shale oil, and the COVID-19 demand shock by **market management**—so far, curbs on production. To respond to the prospect of peak demand and loss of market share, they may at some point be faced with a move to expand production in a bid to stimulate demand and deter competitors and alternative energy sources.

But even if oil exporters do not necessarily subscribe to the idea that peak oil demand is imminent, they have also responded by repeating and intensifying previous plans for **economic diversification**. As well as fortifying their non-oil investments, they have stepped up strengthening their oil industries by diversifying their activities within the oil value chain itself, with a particular focus on bolstering their downstream sectors: refining and petrochemicals. This is understandable given their competitive strengths. But building on the current pillars of their economies, particularly those not closely correlated to crude oil prices, without overinvesting in areas that are exposed to peak oil demand is a delicate balancing act.

Targeted investments in the oil and petrochemical sectors do make financial and strategic sense for the Gulf monarchies even in the context of a global transition to nonhydrocarbon fuels, and such investments are not necessarily incompatible with plans to diversify their own economies away from the oil sector. Just as oil will continue to be needed in the global fuel mix even in a deep decarbonization scenario, so too will oil revenues be needed by Gulf countries to finance their transitions toward a more diversified form of economic development. Yet the pitfalls are considerable.

To **defend their sales**, major oil exporters need to improve oil's economic and environmental credentials and show how the oil sector itself can contribute to the transition to a lower-carbon economy. Aramco and ADNOC have already taken steps to reduce their carbon footprint via CCUS projects that have so far focused on enhanced oil recovery. Petroleum Development Oman has constructed a large solar thermal plant to generate steam for enhanced heavy oil recovery at the Amal field while saving on gas fuel,[162] and the project is to be extended to the Mukhaizna field.[163] Aramco credibly touts its low upstream (Scope 1) carbon footprint,[164] and most Middle Eastern NOCs have sought to improve their environmental credentials by upgrading refineries to produce cleaner (lower-sulfur) fuels, improving energy efficiency, and reducing routine methane flaring and venting as well as fugitive methane leaks.

Saudi Aramco, in particular, has invested in research and development to improve the cleanliness and efficiency of internal combustion engines, allowing them to better compete with battery vehicles. This is challenging, though, given the growing policy push in Europe, China, and some US states for entirely zero-emission[165] vehicles. The successful demonstration of DAC at reasonable costs would at least remove the climate argument against oil—if combustion is charged a carbon price equivalent to the cost of removing the resulting emissions—and allow it to maintain its competitiveness in the heavy-trucking, shipping, and aviation markets.

In the space of **creating demand**, the main target so far has been petrochemicals, which are seen as having the most room for growth. Middle Eastern NOCs have invested heavily in joint ventures in refining and petrochemicals in Asia, the fastest-growing large market. As China slows, India and other markets such as Indonesia and Vietnam have attracted attention. There is synergy between the desire of China and India for energy security and the GCC's need for demand security. So far, Middle Eastern NOCs have spent relatively little effort on Africa, though this could be the next big growth story given its geographic proximity, fast-expanding populations, and very low per capita petrochemical use today.

New petrochemical products, including nonmetallic derivatives substituting for traditional materials, are an active area of research, again for Aramco in particular, though developing these to bulk materials is a lengthy process.

Finally, instead of passively waiting for economic and energy demand growth, Gulf states can develop the required infrastructure to unlock demand in lower-income countries, perhaps in collaboration with China's BRI. The risk, however, is that a country could be perceived as reducing their own direct greenhouse gas emissions but at the same time increasing those of other countries—a challenge already faced by China's BRI in the coal sector.

Dealing with the prospect of peak oil demand—uncertain in the timing, the level of the peak, the speed of the postpeak decline, and the accompanying price shifts—is a complex strategic challenge made all the more difficult by the interaction with shorter-term market cycles and climate policies. The Gulf oil exporters have to focus their relatively limited financial, research, and diplomatic resources where they can be most effectual. This paper has described various elements of their current approaches to safeguarding their oil exports and suggested other areas that may be promising.

Significant changes in energy and economic governance and even in domestic political arrangements will likely be required to ensure that oil revenues are efficiently reinvested in the non-oil sector and supporting infrastructure rather than simply redistributed according to the traditional patronage networks of rentier oil states. Oil producers have generally had a poor track record of managing the resource curse. The Gulf monarchies are in many ways an exception to the rule among rentier oil states but will nevertheless need to blaze a new trail to channel oil revenues successfully into the non-oil sector in relatively short order.

While oil demand will not vanish overnight, investments in the oil sector do carry significant risk for Gulf countries, given considerable uncertainties as to the pace and scope of the energy transition, the outlook for oil demand, and the prospects of oil supply from outside of the Gulf, notably from US tight oil basins. Stranded-asset risks loom large. But even profitable investments could have their downsides. The more successful Gulf countries turn out to be at preserving or even growing their oil revenues, the more daunting the challenge of ploughing their oil profits into the non-oil economy and jump-starting their national transformations may be as a result.

of complacency in the face of seemingly sustained oil revenues may be as high as that of failure in the face of shrinking demand.

On a global scale, there is also a significant risk that the rapid adoption of new petroleum products such as nonmetallic materials by high-tech industries and growing demand for plastics from developing economies will result in large outflows of heavier, discounted by-products that will swamp the market and slow the pace of the energy transition.

While the uncertainties of the energy transition thus carry considerable risks for the Gulf's oil-producing countries' adaptation efforts, simply ignoring the transition or aiming to muddle through would be even more perilous. How Gulf producers respond to both changes in demand expectations and actual shifts in oil demand patterns will generate feedback effects that will in turn impact the pace and scope of the clean energy transformation itself. On the one hand, by expanding their share of the oil and gas market while continuing to reduce their own net emissions, Gulf countries have an important role to play in reducing the global climate footprint of the overall global oil and gas supply chain. Given the potentially long lead times needed to reduce the role of oil and gas in the energy mix and the urgency of climate action, this could go a long way to buy the world needed carbon space until longer-term solutions can be worked out.

On the other hand, most oil and petrochemical projects also have relatively long lead times and carry high costs. That means high risks, especially in the event of accelerated developments and breakthroughs in battery research and clean energy supply. For better or worse, the long-term effects of today's investment decisions could be felt for decades. The risks of miscalculation loom large in both directions.

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66. One of the authors of this report, Antoine Halff, is a founding partner of Kayrros SAS and serves as its chief analyst.

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